

Pattern-oriented approaches for design-based research in collaborative research projects: A knowledge maturing perspective

CHRISTINE KUNZMANN, Pontydysgu Ltd., Germany

ANDREAS SCHMIDT, Karlsruhe University of Applied Sciences, Germany

JOHANNA PIRKER, Graz University of Technology

Design-based research has become increasingly popular in collaborative cross-disciplinary research projects. Based on the experience in several European research projects, this research methodology allows for more agile research approaches. However, it is still a challenge to turn design experiences into a sound body of evidence that can be transferred to future design problems. In this paper, we want to describe an approach to collaborative research projects that extends design-based research with the use of design patterns. We particularly focus on how emergent knowledge can be captured as proto-patterns, how the knowledge develops along the research process, and how such projects can be geared towards pattern outcomes. Towards that end, we present a pattern maturing process describing phases of pattern development that is based on knowledge maturing phase model.

CCS Concepts: • **Social and professional topics~Project management techniques** • **Software and its engineering~Design patterns**

General Terms:

Additional Key Words and Phrases: Design-based Research, Knowledge Maturing, Socio-Technical Patterns., Collaborative Research Projects, Agile Project Management

ACM Reference Format:

Kunzmann, C., Schmidt A.P., Pirker, J. 2017. Pattern-oriented approaches for design-based research in collaborative research projects: A knowledge maturing perspective. HILLSIDE Proc. of Europ. Conf. on Pattern Lang. of Prog. 21 (July 2016), 8 pages.

1. INTRODUCTION

Design-based research approaches have been found to be a useful methodology for applied research in fields that evolve rapidly and are inherently inter-disciplinary and, hence, collaborative across research teams. This has been particularly observed in fields such as technology-enhanced learning (Plomp 2009) in the context of European research initiatives over the last 15 years. Instead of following a research methodology that is waterfall-like (investigate requirements, design solution and evaluate it in the target context), design-based research emphasizes the incremental nature, interleaving these activities similar to, and inspired by, agile methodologies.

In the focus, however, is still the result of the design – it is the goal and object of evaluation. This often misses out a major share of the insights gained as part of the collaborative research process. It remains a challenge to create body of evidence from the design process that is both scientifically sound and transferrable to future design problems. More specifically, the challenge is that a lot of the

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from Permissions@acm.org.

EuroPLoP '16, July 06 - 10, 2016, Kaufbeuren, Germany

Copyright is held by the owner/author(s). Publication rights licensed to ACM.

ACM 978-1-4503-4074-8/16/07...\$15.00

DOI: <http://dx.doi.org/10.1145/3011784.3011805>

knowledge that has been accumulated in the design process is experiential and tacit knowledge and often hard to decontextualize. Furthermore, it is not only experiential knowledge, but also knowledge in-between disciplines, combining technical and human-centred, social perspectives (“socio-technical”), which has required the establishment of a shared language among the respective disciplines. As publication channels are often specific to certain disciplines, scientific papers cover only a fraction of the outcome of such research projects.

As part of our activities to capture the motivational and affective design aspects in the MATEL workshop series¹, it has been realized that we need methods and artifacts to derive and collect generalizable knowledge from design processes in technology-enhanced learning. Design patterns have been found to be a useful way of (similar to Gamma et al, 1995; Riehle 2011);

- capturing design experiences in a systematic way,
- making experiences accessible beyond the context they have been acquired in,
- establishing a professional language and shared experience base,
- supporting understanding and communication.

In this paper, we investigate how pattern-based approaches to collaborative research projects can enhance design-based research in the field of technology enhanced learning. This is based on project management experiences in several major European research projects in this field, most notably MATURE², LAYERS³, and EmployID⁴. While patterns are not new to the field of educational technologies, e.g., (Mor, et al. 2014, Kohls 2014, Goodyear & Retalis 2010, Kohls & Wedekind 2010), what we propose is a novel approach to orient not only single design activities, but large-scale collaborative research projects towards design patterns and their evolution to make its outcomes transferrable.

In section 2, we present design-based research as the underlying research methodology and how pattern-based approaches contribute to design-based research.

2. PATTERNS FOR DESIGN-BASED RESEARCH

Design-based research is a research methodology that takes an iterative approach to research activities (for a general introduction, see Plomp 2009), picking up on (and requiring) agile project methodologies. Instead of strict phases of exploring – designing – evaluating, it emphasizes the necessity for repeated cycles of investigation, designing solutions, and evaluating the design artefacts. Along these iterations, scientific theories and concepts evolve. So design-based research produces both a practical design outcome and a general scientific contribution (e.g., methodology or framework). As (Ravenscroft, et al. 2012) emphasize, it is of particular importance to focus on a conceptual model at the center of design-based research processes which is shared by all participants of the process when it comes to collaborative, multi-disciplinary research. In our work, we have used pattern artefacts as part of the conceptual model.

¹ <http://matel.professional-learning.eu>

² <http://mature-ip.eu/>

³ <http://learning-layers.eu/>

⁴ <https://employid.eu/>

2.1 Background: Pattern-based approaches

Pattern-based approaches are characterized by a structured description of design and intervention experiences along a core set of elements (while the structure varies in different domains and approaches). As part of our work, we have identified the following core elements:

- **Name** as an easy-to-reference label.
- **Problem** which is to be solved
- **Solution** to the problem
- **Context** in which the solution is a solution to the problem
- **Evidence** or examples that the solution is a solution to a specific real-world instance of the problem

These have been selected as they are (i) easy to understand and (ii) capture the essentials of pattern-based thinking. However, along the process of refining them further (see section 3), two additional sections have been useful to include:

- **forces** as a more structured description of elements of the problem as a conflict of forces
- **consequences** as the wider impact of applying the solution and often expressed as resolving the forces

2.2 Patterns in the design-based research process

Apart from describing problem and solutions at an appropriate level of abstraction, most effort in the pattern development process is related to accumulating sound evidence about the pairing of problem and solutions in specific contexts. This evidence allows for extracting the relevant characteristics of a context, and as a consequence, to transfer the results to other contexts that share the same characteristics. While in practice the overhead of sound evaluation is often neglected, research projects provide ideal environments, as evaluation activities are an integral part of the planned work.

Along those lines, the patterns can form part of the shared conceptual model that glues together the various activities in a design-based research process (as depicted in Figure 1). The patterns are a specific representation of the knowledge constructed collaboratively:

- Each cycle of a design-based research process starts with identifying the key objectives of the cycle (“Prioritize”). This can be guided by an already existing proto-pattern or just pattern candidate (see section 3) by focussing research on gaining evidence and closing gaps.
- “Investigate” involves in-depth research (e.g., empirical research such as interviews, or ethnographic methods) to deepen the understanding of the problem or research question that has been prioritized. This helps to clarify *problem* and *context* sections as well as *forces*.
- Based on these results, “design” activities create solutions (mostly as socio-technical solutions).
- These are then tested in an evaluation setting (or, preferably, multiple ones) to collect *evidence*.

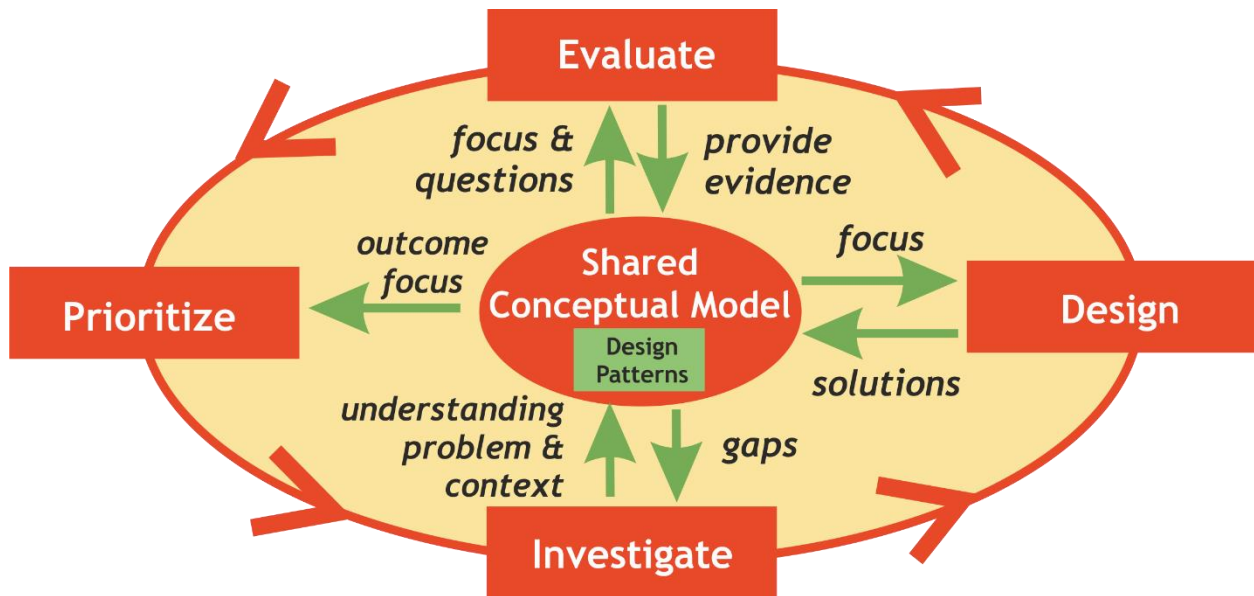


Fig. 1. Role of Design Patterns in a Design-based Research cycle from (Ravenscroft et al. 2012)

The main benefits can be summarized as:

- (i) the practice and solution-oriented nature of the representation (which makes it accessible to a wider audience because it also includes the how to implement aspect) in contrast to often rather explanatory theories (just stating the what),
- (ii) the explicit separation of problem & solution and the context in which this association holds (as this makes the selection of possible applicable patterns much easier, separating problem and context similarity), and
- (iii) a clear focus and purpose for the evaluation activities to support the accumulation of evidence and corroboration of a pattern.

Furthermore, research projects need a vehicle for making their results transferrable. While this works well for theoretical and conceptual results, this is much harder for design results beyond the (ephemeral) actual tool implementations, This is a major obstacle for design-based research approaches such as described in (Ravenscroft, et al. 2012). Patterns provide an excellent way to produce transferable design results. However, the project activities need to be geared towards producing these kinds of results.

Patterns are just the end of a journey in that respect. What remains open: how can they grow in a collaborative research project? How can the development process be facilitated? In the following section, we outline an approach to research project management that specifically investigates the development process.

3. PATTERN MATURING PROCESS

The key idea that has been developed in the EmployID project (<http://employid.eu/>), which develops social learning approaches for professional identity transformation, is a method that uses narratives in the form of learning scenarios as a precursor to patterns. These narratives are the result of extensive user engagement activities and have been collected from working with users from the prospective target groups and their management. These narratives are to be considered as pattern candidates and developed further as a central part of the design process.

This design process is a knowledge development process along which it becomes clearer what the problem is, how the solution looks like, and under which contextual conditions these fit together. All of that gets substantiated by evidence. Some narratives may get discarded, others emerge, yet others get merged or – more likely - split up into a family of patterns, which themselves evolve further. Such a knowledge development process has been studied by (Maier und Schmidt 2014) in different domains as a knowledge maturing process with characteristic phases and transition barriers. This model also points out that artefacts used in this process have certain characteristics with a huge impact on how to deal with them.

The following description of a pattern maturing process (for a visual summary see fig. 3) is described based on the knowledge maturing model and is an adaptation of (Kunzmann, Schmidt & Wolf 2015):

- **I. Emergence.** In early phases of the project (such as the initial contextual investigation phase), the needs and constraints are explored. Findings and ideas of the various stakeholders are amalgamated into learning scenarios if they are considered significant and promising. In this phase, these narratives act as an important boundary object between different perspectives in a collaborative research project (see fig. 2): they describe (a) the contextual need of users (“initial situation”), (b) the interpretation of the situation through a theoretical lens (“learning challenges”), (c) design options and ideas (“proposed solutions”), and (d) an anchor for evaluation (“evidence”). This already corresponds to the basic structure of a pattern: problem = initial situation and interpretation (a first de-contextualization step), proposed solution, and evidence. It has been found that identifying forces and consequences is not yet possible in this phase. In future, also methods developed for pattern mining workshops, such as Iba & Isaku (2012) appear to be promising instruments to facilitate this phase.
- **II. Collaborative solution development.** The learning scenarios (in other domains also referred to as “pattern candidates”) are used to focus (socio-technical) development activities in a concrete context. In the course of those activities, the learning scenarios are becoming more specific and detailed, which applies both to the problem, but also to the solution part. Through formative evaluation activities (which are rather exploratory), evidence is gathered, which in turn influences the problem and solution understanding.
- **III. Transformation into proto patterns.** With solutions stabilizing, the research process enters a phase in which evaluation is used in more confirmatory way to gather sound evidence of problem-solution pairs and its elements, aiming, e.g., at fulfilling the rule of three. Towards that end, the concrete experiences are decontextualized, and the main propositions are put into hypotheses. Also, the structure of pattern descriptions is refined – forces are identified from the undifferentiated context description, and consequences can be descriptions from the solutions part.

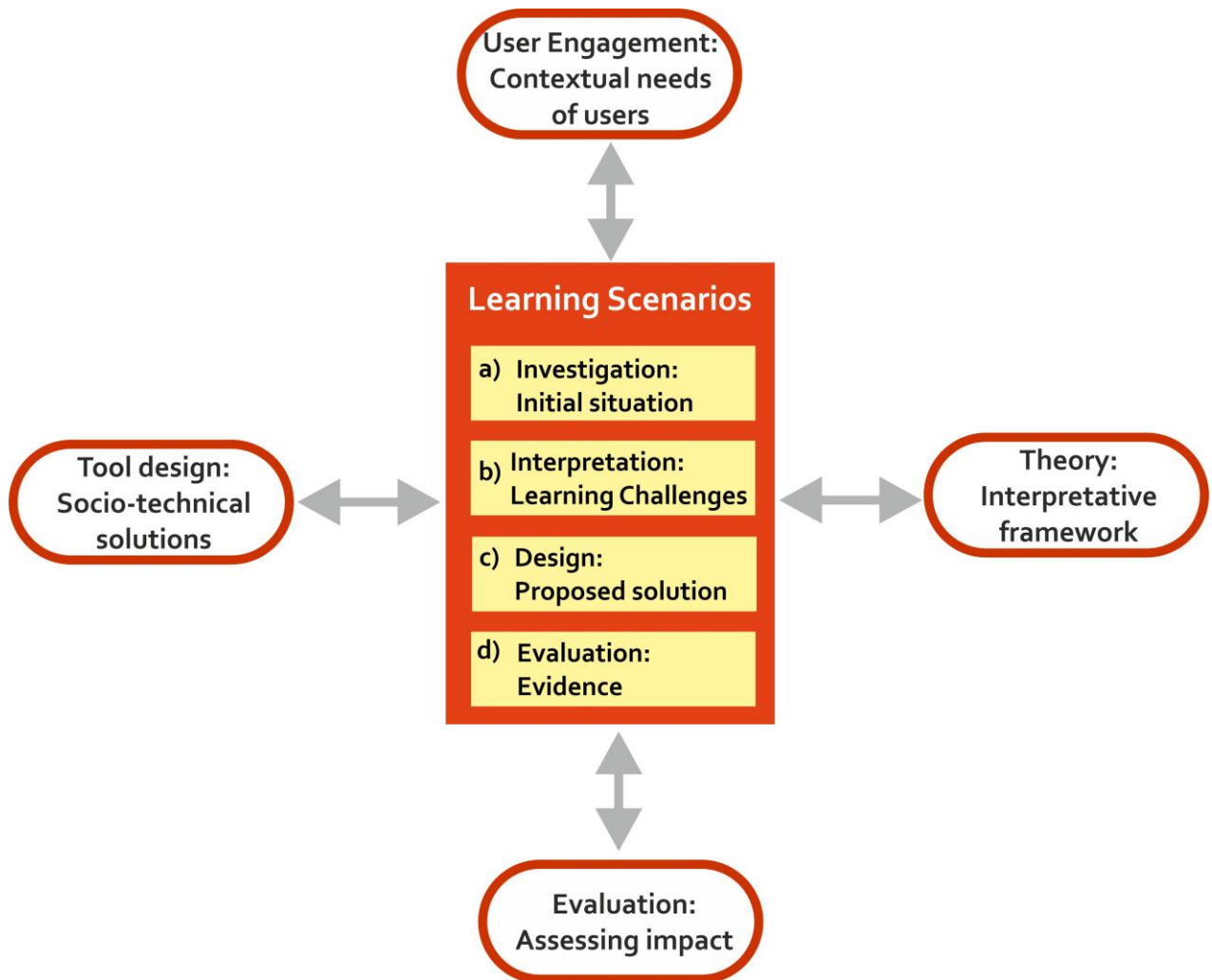


Fig. 2. Emergence of proto-patterns as boundary objects in collaborative research projects in technology-enhanced learning (phase I of the pattern maturing process)

- **IV. Introduction to new usage contexts and collection of additional experiences.** Through applying the solution to other usage contexts (or the collection of similar solutions developed in parallel), it becomes possible to understand which contextual factors have an influence on the applicability of the solution. This then leads to patterns for which usually three different cases are required as empirical support. In this phase, the pattern structure gets refined.
- **V. Standardisation of pattern collections.** Usually, the usefulness of patterns for a certain area of application does not lie in the single pattern, but rather in a collection of different patterns and how they link to each other. As part of that, a language emerges that makes the discussion more efficient. Eventually, such collections and their language become part of curricula.

Along this process, patterns evolve in a highly dynamic way. (Proto) patterns get discarded, new ones emerge, and others get transformed, decomposed or merged, which may lead to jumping backwards in the knowledge maturing phases. Furthermore, the structure of the pattern descriptions gets refined, more decomposed into separate elements. It is important to note that patterns are not intended to constrain the creative design process, but to facilitate it. They help to focus activities, make decisions, plan evaluation etc.

While several approaches to mining design patterns exist which also concentrate on the process how patterns are developed, these mining approaches usually assume that most of the knowledge that is to be expressed in patterns has been the result of prior research and practice. In contrast to that, the maturing perspective described in this paper focuses on the development of patterns in parallel to the development of the knowledge that is captured in patterns, which opens the possibility for interaction between the artefacts (patterns), such as steering the research process towards patterns as result artefacts and patterns acting as a boundary object in the collaborative research process.

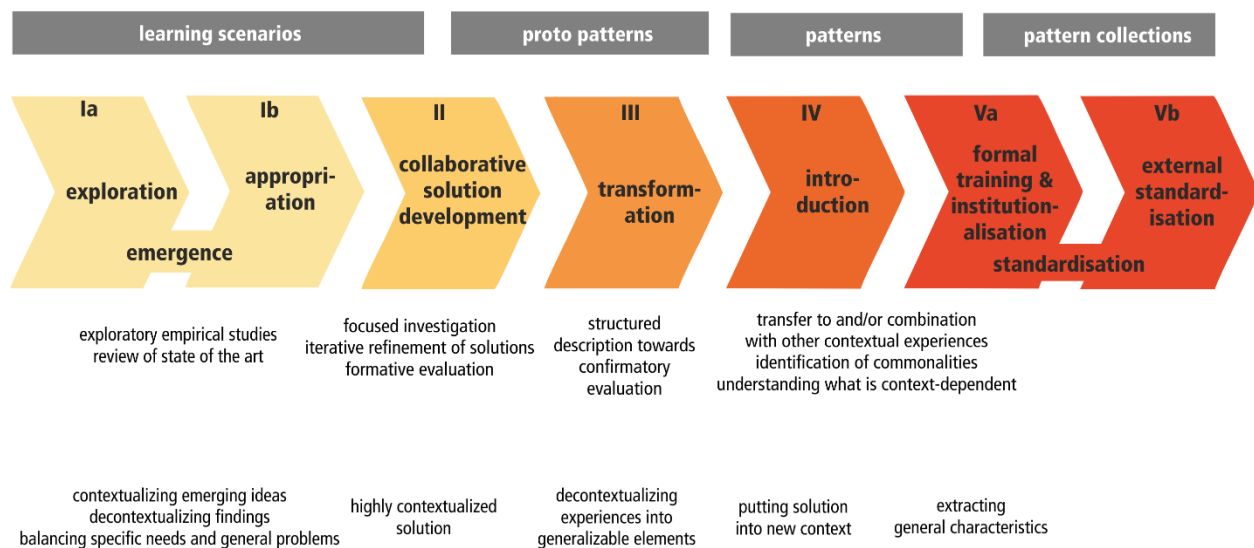


Fig. 3. Pattern maturing process based on the knowledge maturing process model (Maier & Schmid 2014)

4. CONCLUSIONS AND OUTLOOK

Patterns are a good companion to an agile design-based research process as they provide accessible representations of the current understanding and complement theoretical and technical results. To use patterns in collaborative research projects efficiently, it is important that patterns are not used as a report-like description of an outcome. They have to evolve along-side the research activities as their structure (and the categories expressed in this structure) interacts with the research process:

- Patterns focus on (innovative) contributions while designs usually consist of more elements that are prerequisites, e.g., for deployment in practice. They therefore help to prioritize design activities in a research project.

- Patterns capture investigative results as part of better problem and context descriptions, and the difficulties in describing pattern highlight gaps in the current understanding that should be the focus of further empirical analysis. The most difficult part usually is identifying the context characteristics for the class of contexts in which the problem/solution pair is valid.
- As patterns establish a design language, they give focus to the design activities and capture the solutions.
- Evaluation, both formative and summative, yield evidence to the problem/solution pairs and in turn should be also geared towards that, which can be an important prioritizing factor in selecting the most important evaluation questions.

Towards that end, an evolutionary perspective is required that especially focuses on the early phases of the knowledge development process that underlies the creation of patterns. The knowledge maturing model has used to explain the characteristics of knowledge development along different phases, and allowed for describing the artefacts that support this process. Along these lines, future work will include investigating existing pattern writing methods with respect to the knowledge maturing perspective and evaluating the pattern-based approach in two running research projects.

Acknowledgments. This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 619619 (EmployID) and 318209 (Learning Layers). We wish to thank our shepherd and the participants of the EuroPLoP workshop for their suggestions on considerably improving the paper.

REFERENCES

- Gamma, Erich, Vlissides, John, Johnson, Ralph, Helm, Richard 1995. Design patterns: elements of reusable object-oriented software. Addison Wesley
- Goodyear, Peter, Simos Retalis (Eds.) 2010. Technology-enhanced learning: Design Patterns and Pattern Languages. Sense Publishers, Rotterdam, The Netherlands.
- Iba, Takashi, Isaku, Taichi 2012. Holistic Pattern-Mining Patterns, Proc. of PLoP 2012
- Kohls; Christian Wedekind; Joachim 2010. Investigations of E-Learning Patterns: Context Factors, Problems and Solutions, IGI Global.
- Iba, Takashi, Kimura, Norihiko, Honda, Takuya, Nakamura, Sumire, Kogure, Sakurako, Yoshikawa, Ayaka 2015. Agile Design Process with Patterns for Campus Building The Keio-SFC Experiment. Proceedings of EuroPLoP 2015, ACM.
- Kohls, Christian 2010. The theories of design patterns and their practical implications exemplified for e-learning patterns, Dissertation.
- Kunzmann, Christine, Schmidt, Andreas Wolf. Carmen 2015. „Facilitating maturing of socio-technical patterns through social learning approaches.“ Proceedings of I-KNOW 2015. ACM.
- Maier, Ronald, und Andreas Schmidt. 2014. „Explaining organizational knowledge creation with a knowledge maturing model“ Knowledge Management Research & Practice, 1: 1-20.
- Mor, Yishay, Harvey Mellar, Steven Warburton, Niall Winters. 2014. Practical Design Patterns for Teaching and Learning with Technology. Rotterdam, NL: Sense Publishers.
- Plomp, T. 2009. Educational design research: an introduction. In T. Plomp & N. Nieveen (Eds), An introduction to educational design research (pp. 9–35). Enschede, the Netherlands: SLO.
- Ravenscroft, Andrew, Andreas P Schmidt, John Cook, und Claire Bradley. 2012. „Designing social media for informal learning and knowledge maturing in the digital workplace.“ Journal of Computer Assisted Learning, 28. 3: 235-249.
- Riehle, Dirk 2011. Lessons Learned from Using Design Patterns in Industry Projects. Transactions on Pattern Languages of Programming II, LNCS 6510. Springer, pp. 1-15
- Schümmer; Till, Lukosch, Stephan 2007. Patterns for Computer-Mediated Interaction, Wiley, Chichester, UK.