Exploring the User's View on Design Patterns for Technology-Enhanced Learning

Michael Derntl, Renate Motschnig-Pitrik

Research Lab for Educational Technologies, University of Vienna, Austria
michael.derntl@univie.ac.at , renate.motschnig@univie.ac.at

Abstract

While design patterns have their roots in architecture, they have successfully been adopted for software design and analysis. In the field of pedagogy and technology-enhanced learning, some recent design pattern initiatives have raised several questions regarding features, notations, scopes, languages, reuse and usability of patterns and pattern repositories. In this paper we address the question what qualities and features patterns and repositories need to have in order to be usable and reusable from the users' perspective. The reasoning will be illustrated by tracing a concrete pedagogical goal/request through the phases and steps of the proposed pattern application cycle. The users' view as illuminated in the paper is intended to enrich pattern providers by experiences and insights resulting from considering the users' perspective.

Keywords

Technology-enhanced learning, design patterns, learning design, usability, requirements, Action Research

Introduction

> 'Things you learned in your past form a silent repertoire of knowledge. It awakens unexpectedly if triggered by something familiar or analogous, even though it seemed at the time to be useless for future work. This provides an opportunity to […] synthesize the different types of knowledge from disciplined territory.' (Hornecker, 2004, p. 239)

The use of design patterns for creating technology-enhanced learning (TEL) environments has gained significant momentum in recent years. In the TEL community the concept of patterns was introduced and spread, among others, by Goodyear and colleagues (2004; 2005), the European project E-LEN (2003), Derntl and Motschnig (2005), as well as Retalis and Garzotto (2004), to name a few. It is meanwhile a widely familiar concept for both researchers and practitioners. Essentially, a pattern gives a description of a reusable solution to a common design problem in some context (Alexander et al., 1977). In the context of TEL and in pedagogy, patterns are typically used to describe effective teaching methods, situations or teaching/learning activities. Even with a significant number of e-learning and TEL design patterns available today, there is still only little evidence of actual usage and usability of that knowledge base in the TEL domain. The past focus has been on introducing patterns to the field and creating patterns from existing design and application experience. But any innovation needs to show its qualities and benefits to the users (note that we use the 'user' role to represent any person involved with the application of patterns, i.e. primarily learning designers and instructors, but also pattern authors) if it is intended to succeed; patterns without users working with them are, literally, useless artefacts.

Therefore, in this paper, we aim to provide a thorough exploration of the user's view on design patterns for TEL. We intend to investigate qualities and features of patterns and pattern collections which we consider essential for raising the usability of patterns. Thereby we consulted several sources: on the one hand, the body of literature on pattern qualities, requirements, life cycle and use cases as found in the original pattern work by Alexander et al. (1977), as well as in more recent research by Fincher (1999), Fincher and Utting (2002), Buschmann et al. (1996), Lea (1994), or Derntl and Botturi (2006). On the

other hand, we draw from own experience and research during several years of finding, writing and applying patterns in higher-education TEL settings.

The paper is structured as follows. The next section describes pattern application embedded in a cyclic process; for each phase of the cycle we discuss essential aspects of pattern usability. Then we give an example of the pattern application cycle in the context of involving students in the evaluation of their learning at the end of a concrete course. The final section concludes the paper and gives an outlook on further work.

The Pattern Application Cycle

To enable continuing research and improvement based on findings, insights and lessons learned during TEL pattern application, we propose a cyclic model of the pattern application process. As courses are typically repeated periodically (each semester or year, for example) we investigate the application of design patterns along the five phases of Action Research proposed by Susman and Evered (1978). These phases are: diagnosing, action planning, action taking, evaluating, and specifying learning. This cyclic phase arrangement seems particularly suited for pattern application, as we believe that the quality of patterns and the success of their application heavily rely on the user's ability to integrate lessons learned and experiences drawn into future application cycles. Furthermore, pattern application and research often are participative settings that fit the action research approach well. The researcher is co-shaping the environment while researching her actions and their outcomes within the environment (Lewin, 1946). For instance, there would be no point in seeing pattern mining from a detached perspective; every single pattern typically contains personal insights and advice that are, amongst others, attributable to insights derived from experience.

A sketch of the proposed pattern application cycle is given in Figure 1. The cycle is not intended to prescribe some rigid process; its primary purpose is to facilitate understanding of actions related to pattern application. Note that each cycle starts with diagnosing in the target context of pattern application and ends with specifying lessons learned during application, handing over to a new cycle re-starting with diagnosing. Regarding the application of patterns, each phase comprises a number of essential steps, e.g., understanding the patterns under consideration in the diagnosing phase. From the user's point of view, each phase and step poses requirements and issues to be addressed by the patterns. For instance, these include critical success factors, as well as pitfalls and other aspects of relevance to pattern users.

ISBN No: 978-1-86220-206-1

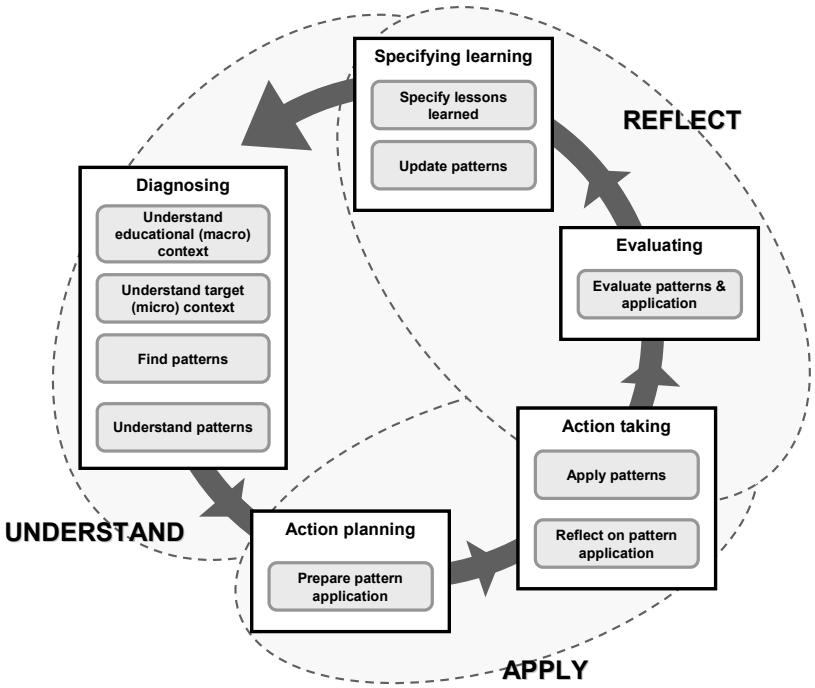

Figure 1: The pattern application cycle.

In Figure 1, the application cycle is additionally embedded into an overlapping triplet of areas representing the three core activities of each cycle: understand, apply, and reflect. The result of the diagnosing phase is an *understanding* of the application context and the patterns by the user; via action planning the user prepares the patterns for *application* in the action taking phase; during application and evaluation the user *reflects* on the application and specifies lessons learned and issues to be explicitly fed back as additional knowledge into the pattern base and into successive application cycles.

Note that in proposing this feedback cycle we are in line with one of Alexander's claims about patterns: in his approach to architectural patterns, he was striving to capture the 'timeless way of building'. That is, capturing good practices of using available design options and tools to create environments that meet the demand and requirements of the users. The design of these environments is based on qualities and values that characterise 'well-being'. Particularly the TEL domain with its high rate of innovation requires the underlying qualities and philosophy to provide some stable base to build upon, because tools used in TEL are constantly changing, innovating, and improving. For example, a few years ago the concept of a blog was widely unrecognised. Nowadays, TEL practitioners are adopting this tool for educational purposes and employ them in innovative scenarios. TEL patterns would have to allow for accommodating such innovations, either by adapting existing patterns or by adding new ones. Furthermore, TEL is a 'young' field with an active, world-wide research community that constantly produces new findings, pedagogic strategies and application scenarios. To accommodate such new findings from research, pattern repositories need to be open to feedback and improvement. In this respect, the value base underlying the pattern repository would help avoiding 'chaos' during pattern evolution.

The proposal of a stepwise process of design pattern application in the TEL domain allows for definition and analysis of critical factors of the user's perspective for each step as well as input and output elements of each phase. In this section we explore the practitioner's perspective focusing on the two main roles involved in design pattern practice: the pattern user and the pattern author. Requirements on the user side are highlighted and complemented with advice on how to satisfy the requirements from the author's perspective. For a more general account on functional and non-functional requirements for pattern systems, readers are referred to Derntl and Butturi (2006), Fincher (1999), and Fincher and Utting (2002).

The pattern user role represents the 'clients' of pattern authors. Essentially, design patterns are explicitly expressed guidelines that should provide added value to the clients, i.e., expert design advice for TEL. We

hope that the following sections allow pattern practitioners to derive inputs and insights that enrich their own practice/work.

Phase 1: Diagnosing

Understanding the context. Patterns offer solutions to problems in specific contexts. Therefore, the shared context of the patterns offered in a collection needs to be explicitly and unambiguously communicated to users. This is supported by building the pattern collection upon a clearly stated value base. As an exaggerated example consider a pattern user searching for drill-and-practice design patterns for military education. The user is certainly wasting time when browsing a pattern collection intended for higher education contexts and built upon some humanistic educational value base.

Browsing and finding patterns. Given a match between the pattern user's target context and the patterns' target context, we need to support users in finding an appropriate pattern or family of patterns for a specific design problem. *Therefore, a pattern collection needs to expose some structure that guides users in finding and selecting patterns for design problems.* This can be supported, for example, by structuring and layering the pattern collection according to the steps in the course design process. For example, if a user is searching for collaborative learning tasks in the early stages of a course, she can be supported by a filter or search facility offered by the pattern collection. In this respect, hyperlinked electronic pattern collections (e.g., online pattern webs) have tremendous usability advantages over paper-based or document-based pattern organisation. The links among patterns support exploring patterns in more intuitive ways.

Understanding patterns. Assuming that the user found an appropriate pattern for her design problem, *we need to make sure that each pattern conveys its advice in an efficient, generative way*. Success in this aspect is determined by a number of factors such as the following.

- *Patterns in a collection need to be expressed using some uniform template*. Design pattern history has produced different approaches, for example Alexander's semi-structured prose style in architecture (Alexander et al., 1977) exposing more of a narrative pattern template vs. highly-structured software design patterns (Gamma, Helm, Johnson, & Vlissides, 1995) based on a template of named sections exposing more of a comparative pattern template. Most pedagogical pattern approaches (e.g., Pedagogical Patterns Project, 2002) rely on the Alexandrian form of pattern description. However, to the best of the authors' knowledge, this decision has never been contested, even though it might be worthwhile to consider alternatives.
- *Each pattern must support understanding about how it is embedded into a network of related patterns in the collection*. Solving a design problem might trigger effects that require subsequent application of additional patterns. Understanding of relationships and dependencies among patterns can for instance be supported by visual modelling of relationships.
- Finally, in line with Alexander's ideas, patterns must be generative, i.e., they must support the user in the creation of a pattern-based design in their domain. *Therefore, language used and advice presented in a pattern should not be overly descriptive*; based on the underlying value base patterns can be formulated in a prescriptive, generative way.

Phase 2: Action Planning

In this phase, the main objective is to prepare application of selected patterns. The difficulty here is translating the generic design solution of a pattern into some feasible real-world plan and configuration of actions, tools, and resources. It is also necessary to consider related and dependent patterns. For example, some project-based learning pattern might require that students team up in small groups to function effectively. The generativity of patterns selected for application is a critical factor here; all relevant aspects of a pattern's implementation need to be covered by the pattern's description.

From the feedback-cycle viewpoint, the pattern user should document any assumptions and decisions made during action planning. These documentations can potentially be used later in the process to explain effects of the pattern's proposed design solution and to update the pattern description with new examples and insights.

To help the pattern user during action planning, pattern authors should pay particular attention to the following aspects in TEL pattern description:

- Details on required *technology support* (e.g., configuration of message boards, access rights, etc.); we have already experienced that even minor problems with tools and software can instantly evoke reserved attitudes toward the whole learning activity. Flawless technology integration and operation are minimum requirements in any TEL scenario today. This is not always easy to achieve given the different and often cumbersome configuration processes of standard learning platforms.
- Hints to essential actions and *critical success factors* to be considered by the instructor or other involved teaching staff (e.g., student tutors) during implementation. A typical example would be the explanation of the motivation for some learning activity that is relatively new to students (e.g., evaluation of their peers' project outcomes).
- *Potential pitfalls* as known from previous application examples of the pattern.

Phase 3: Action Taking

At this stage most of the planning should be completed. However, even a deep understanding of a pattern's content and thorough preparation need not necessarily be sufficient for successful application. During the implementation of a pattern's design solution the responsibility of the pattern user lies not only in providing a seamless learning experience to students. In our view, *the pattern user is also responsible for reflecting on his/her actions and feeding experiences, insights and lessons learned back into the pattern description*. The aim here is to distil explicit links between pattern description and pattern implementation, and vice versa. We believe that this is one of the keys to effective pattern evolution. The emergence of ideas about new or derived patterns of TEL practice is another important aspect of the action taking phase.

Phase 4: Evaluating

Patterns need to include evidence on their effectiveness. This should optimally include evidence collected outside of a pattern's original context, that is, outside of the pattern author's context. Pattern evaluation can be supported by including guidance on collecting empirical data (qualitative and quantitative) during a pattern's application. This can be difficult, as analysis of empirical data needs to be separated into successes and failures related to the pattern description (abstract) and successes and failures related to a specific implementation of the pattern (concrete).

Initial research efforts into this issue show that the human factor in applying TEL patterns is extremely important: for example, we found that in a course that was held in the same mode/design by four different instructors in the same semester, there were numerous statistically significant differences regarding the perception of the course style by students (Motschnig-Pitrik & Mallich, 2004): only instructors who were rated high on interpersonal competencies by their students managed to receive high values on scales related to course style, motivation to participate, and perceived subjective effects on learning and technical skills.

A general problem with evaluating patterns relates to the notion of 'effectiveness' of a pattern. Some pattern users might look only for patterns that are likely to reduce their efforts and/or increase student learning on the intellectual level. However, other users might look for similar patterns (designs) that are capable of fostering personal development (skills, attitudes) of students. Still other users might look for similar patterns with the primary intent of reducing organisational overhead (e.g., easier communication). In those exemplary cases, the users would expect very different manifestations of effectiveness. *Therefore, patterns need to express their intended and expected effects clearly*.

Phase 5: Specifying Learning

Experiences and insights gathered by users during pattern application are the most valuable resource for improvement and extension of patterns. They give a realistic picture of what actually happened by

following a pattern. However, most of these insights are lost as there either is no documentation of these experiences by users and/or no available feedback channel from pattern users to pattern authors. *Therefore, we should exploit network effects by sharing advice and feedback in design patterns*.

An Example: Blended Evaluation in Project-Based Learning

In this section we exemplify the pattern application cycle by walking through its steps for a concrete design problem. The problem deals with involvement of students in the evaluation of student learning. It is simplified based on real cases in the authors' context.

Diagnosing – understanding the context. The educational target context is a computer science course at a higher education institution. The course takes a blended learning approach based on project-based learning; students team up to solve some software design problem from scratch to achieve a prototypical implementation. Previously the facilitators/instructors used to be the sole evaluators of project outcomes. We now intend to more actively involve project contributors to evaluate their own learning during the project and to give constructive feedback on the contributions of other project teams. The goal is finding a pattern collection that addresses these needs; we find that the Person-Centered e-Learning (PCeL) pattern repository (http://elearn.pri.univie.ac.at/patterns) might be appropriate, as the primary goal of PCeL is to actively involve students in all aspects of learning.

Diagnosing – browsing and finding patterns. The PCeL pattern repository is organised into pattern packages, and patterns are arranged at different levels of detail and scope. The entry pattern is called *Course*; it arranges three phases in chronological order: the preliminary phase, the main course phase, and the assessment phase. Obviously, our design problem is located in the latter phase. Patterns dealing with design problems in this phase are located in the *Evaluation* package. The structure of patterns in this package is given in Figure 2. The package suggests using blended evaluation in the assessment phase. The *Blended evaluation* pattern intends to 'use a mix of self-, peer- and instructor-evaluation to actively involve participants in the assessment phase of learning activities and courses […] It enables the collection of multiple views on contributions and can be applied in any learning activity through which participants produce contributions that are open for review by their peers'. Se we have found a matching family of patterns for the given design problem.

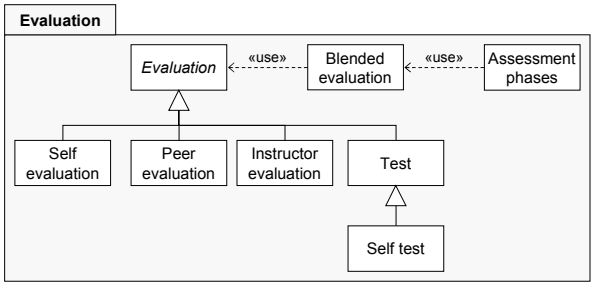

Figure 2: Evaluation pattern package.

Diagnosing – understanding patterns. PCeL patterns are described using a uniform template including (among others) intent, motivation, scenario, and examples. The descriptions of activities in the scenarios are complemented with visual activity models to enhance understanding of the patterns. The high-level visual model of the blended evaluation pattern is given in Figure 3.

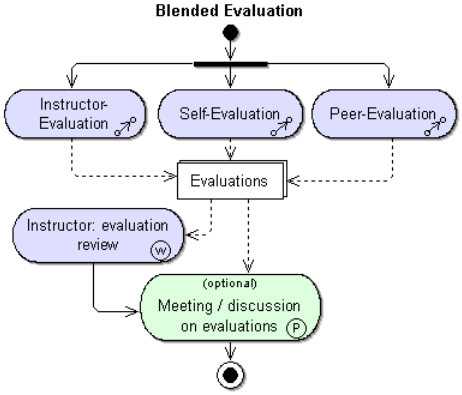

Figure 3: Visual activity model of the blended evaluation pattern.

It suggests collecting evaluations online from the viewpoints of the instructor, the student herself, and the peers. Evaluations provided are subsequently reviewed by the instructor, and the scenario is concluded by an optional face-to-face meeting where results of the process are shared and discussed. For the self evaluation, peer evaluation and instructor evaluation activities the repository provides separate pattern descriptions. The facilitator planning to use this pattern should now have the big picture of what to do.

Action planning and action taking. The task now is to put the generic design solution into practice. This mainly includes decisions on the implementation of self evaluation and peer evaluation for the given project based setting.

- The *self evaluation* pattern suggests collecting evaluations through an online web form. It provides an example of collecting self evaluations in a learning-contracts setting, which is somehow similar to project-based settings. The form includes a large textbox where the student is asked to respond to the following questions in an unstructured way (adapted to the given project setting): 'What have I contributed in the project? What and how did I learn in the project? To what extent was I capable of drawing value from the project activities? Did I contribute equally, or above/below average when compared with my team mates?' Additionally the form includes two quantitative items, asking for an estimation of the own contribution and the own learning on a scale from 1 to 10.
- The *peer evaluation* pattern offers more design options. It requires decisions on: who evaluates whom, what is evaluated, and which evaluation criteria are given. In the given case, we decide that each team evaluates the final project report of one other team. The reviews are done in written form based on a handful of criteria (completeness, compliance with guidelines, quality of solution and presentation, and overall rating). The review document is uploaded and made visible to all participants after the deadline.

We decide to motivate students for the evaluation activities during one of the final face-to-face meetings before the projects are completed. Both evaluations are considered when negotiating the final grade for each contributing student. Upon project completion students are given one week to submit their self evaluations and peer evaluations. In addition, we intend to collect online reaction sheets asking for opinions and open feedback regarding the blended evaluation procedure (this is suggested by the *Assessment phase* pattern).

Evaluating. After the course is completed, we read and analyse the reaction sheets submitted by students. The most salient aspects students pointed out are: students generally showed a positive attitude towards self evaluation, but many of them noted that it was a very difficult task to evaluate their own learning (it was a new experience to most of the students). Regarding the peer evaluations, there were a considerable number of students who did not see any benefit in it. Others made positive comments on the fact that they were able to review solutions to similar problems done by their peers, and that they could compare their own evaluation of a project with that of the instructor.

Specifying learning. Given the patterns' underlying pedagogical baseline (humanistic educational principles), this application of the *Blended evaluation* pattern can be considered 'successful'. However, the reaction sheets revealed some aspects that should receive attention in the pattern descriptions as well. In particular: (a) stressing the importance of motivating students for self and peer evaluation tasks.

Instructors need to outline the benefits of these tasks (especially to students who are not really accustomed to these evaluation methods). Also, results of evaluations should be followed up in a face-to-face meeting or in a dedicated online discussion board, for example; (b) it might be useful to provide more guidance for the self evaluation task, e.g., more detailed questions to be considered in the written self evaluation; (c) it must be clearly stated to what extent these evaluations contribute to the overall evaluation of each participating student.

Conclusions

Our experiences as pattern designers as well as users indicate that considering the users' perspective has the potential to throw light and provide significant insight into several aspects regarding patterns and their organisation into pattern repositories. Continuous information flow and cooperation between pattern designers and users has been found essential in equipping patterns with the features and components needed to facilitate their finding, selection, application, evolution, and organisation. On this experiential basis and from our appreciation of the action research phases introduced by Susman and Evered (1978), we proposed a pattern application and evolution cycle. It is aimed at capturing the phases and steps that users typically pass through when applying patterns. It is also intended to raise the awareness of the cooperation between pattern authors/designers and users/educators that is required in order to ensure the usability, reuse and, in our view, the survival and evolution of any approach to patterns for technology enhanced learning.

References

Alexander, C. (1979). *The Timeless Way of Building*. New York: Oxford University Press.

Alexander, C., Ishikawa, S., Silverstein, M., Jacobson, M., Fiksdahl-King, I., & Angel, S. (1977). *A Pattern Language – Towns, Buildings, Construction*. New York: Oxford University Press.

Buschmann, F., Meunier, R., Rohnert, H., Sommerlad, P., & Stal, M. (1996). *Pattern-Oriented Software Architecture: A System of Patterns*. Chichester, U.K.: John Wiley & Sons.

Derntl, M., & Botturi, L. (2006). Essential Use Cases for Pedagogical Patterns. *Journal of Computer Science Education, 16*(2), 137-156.

Derntl, M., & Motschnig-Pitrik, R. (2005). The Role of Structure, Patterns, and People in Blended Learning. *The Internet and Higher Education, 8*(2), 111-130.

E-LEN Project. (2003). *E-LEN project homepage* [Online]. Retrieved Jan 14, 2004, from http://www.tisip.no/E-LEN/

Fincher, S. (1999). Analysis of Design: An exploration of Patterns and Pattern Languages for Pedagogy. *Journal of Computers in Mathematics and Science Teaching: Special Issue on CS-ED Research, 18*(3), 331-348.

Fincher, S., & Utting, I. (2002). *Pedagogical Patterns: Their Place in the Genre.* Proceedings of 7th Annual Conference on Innovation and Technology in Computer Science Education (ITiCSE'02), Aarhus, Denmark, pp. 199-202.

Gamma, E., Helm, R., Johnson, R., & Vlissides, J. (1995). *Design Patterns - Elements of Reusable Object-Oriented Software*. Reading, MA: Addison-Wesley.

Goodyear, P. (2005). Educational design and networked learning: Patterns, pattern languages and design practice. *Australasian Journal of Educational Technology, 21*(1), 82-101.

Goodyear, P., Avgeriou, P., Baggetun, R., Bartoluzzi, S., Retalis, S., Ronteltap, F., et al. (2004). *Towards a Pattern Lanugage for Networked Learning.* Proceedings of 4th International Conference on Networked Learning (NLC'04), Lancaster, England, pp. 449-455.

Hornecker, E. (2004). Analogies from didactics and moderation/facilitation methods: designing spaces for interaction and experience. *Digital Creativity, 15*(4), 239-244.

Lea, D. (1994). Christopher Alexander: An Introduction for Object-Oriented Designers. *ACM Software Engineering Notes, 19*(1), 39-46.

Lewin, K. (1946). Action Research and Minority Problems. *Journal of Social Issues, 2*(4), 34-46.

Motschnig-Pitrik, R., & Mallich, K. (2004). Effects of Person-Centered Attitudes on Professional and Social Competence in a Blended Learning Paradigm. *Journal of Educational Technology & Society, 7*(4), 176-192.

Pedagogical Patterns Project. (2002). *Pedagogical Patterns Project homepage* [Online]. Retrieved Nov 5, 2002, from http://www.pedagogicalpatterns.org

Retalis, S., & Garzotto, F. (2004). *Design Patterns for E-Learning (Symposium).* Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2004, Lugano, Switzerland, pp. 4262-4270.

Susman, G. I., & Evered, R. D. (1978). An assessment of the scientific merits of action research. *Administrative Science Quarterly, 23*(4), 582-603.

Dr. Michael Derntl is researcher, lecturer, and vice-head of the Research Lab for Educational Technologies (University of Vienna). His interdisciplinary doctoral research and his thesis were focused on finding, modeling, and describing design patterns for blended learning. He is currently working as postdoctoral researcher for the 'Technology Enhanced Learning' project at the University of Vienna, where he can bring in and further his educational technology research experience and interests, which include blended learning, design patterns, conceptual modeling, and socio-technical aspects of ICT.

Prof. Dr. Renate Motschnig is professor of computer science at the University of Vienna and heads the Research Lab for Educational Technologies at the Faculty of Computer Science. Her research goals center in the discovery of principles and the development of methods and techniques to improve the development, effectiveness, and the quality of socio-technical systems. Her current research interests include conceptual modeling, the Person Centered Approach, humanistic education, process models, group and team processes, technology enhanced learning, motivation, development of transferable competencies, cognitions and emotions in learning, communication and New Media. Currently, Renate Motschnig coordinates the design and the implementation of the e-learning strategy at the Faculty of Computer Science.