Identifying Agile Requirements Engineering Patterns in Industry

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Agile Software Development (ASD) is gaining in popularity in today´s business world. Industry is adopting agile methodologies both to accelerate value delivery and to enhance the ability to deal with changing requirements. However, ASD has a great impact on how Requirements Engineering (RE) is carried out in agile environments. The integration of Human-Centered Design (HCD) plays an important role due to the focus on user and stakeholder involvement. To this end, we aim to introduce agile RE patterns as main objective of this paper. On the one hand, we will describe our pattern mining process based on empirical research in literature and industry. On the other hand, we will discuss our results and provide two examples of agile RE patterns. In sum, the pattern mining process identifies 41 agile RE patterns. The accumulated knowledge will be shared by means of a web application.

1. INTRODUCTION

Agile Software Development (ASD) is adopted by industry both to reduce time to market and to increase value delivery for customers and users. Agile methodologies like Scrum (Schwaber, 2004), Extreme Programming (XP) (Beck, 2000) or Kanban (Anderson, 2010) share an environment which is continuously improving in terms of collaboration, processes and tools by using mechanisms like retrospectives (Schwaber, 2004) or kaizen (Anderson, 2010). In industry, new trends emerge quickly and agile techniques and tools are volatile. The continuous improvement of the environment lead to a quickly evolving as well as rapidly changing knowledge base in this field of research.

The conditions ASD comes with have an impact on the way Requirements Engineering (RE) is carried out in agile environments. On the one hand, sequential approaches to RE (Sommerville and Sawyer, 1997) need to be adapted due to the iterative and incremental approach. On the other hand, additional methodologies like Human-Centered Design (HCD) (International Organization for Standardization, 2010) are integrated due to the strong focus on user and stakeholder involvement (Schön, Thomaschewski and Escalona, 2017a). HCD is defined by ISO 9241-210 (International Organization for Standardization, 2010) and describes an approach to interactive product development where the ergonomics of human-system interaction plays an important role. The concept of HCD is elaborated on User-Centered Design (UCD) (International Organization for Standardization, 1999) and covers a broader view on human needs. Compared to UCD, HCD emphasizes the impacts on further stakeholders besides the user. The User Experience (UX) is a *"person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service"* (International Organization for Standardization, 2010).

However, we can observe recurring problems in agile environments that are solved by means of similar solutions. For instance, user stories (Cohn, 2004) are utilized in order to describe requirements from a user´s perspective and to refine requirements in a collaborative manner among the whole team.

This paper describes the pattern mining process and its output related to agile RE patterns by means of empirical research in literature and industry. Firstly, we will present the three phases of the pattern mining process and secondly, we will provide the results comprising two examples of agile RE patterns: *a) evaluation and testing* and *b) story map.* The derived agile RE patterns will cause strong impact on practitioners since we gathered the data with an iterative expert judgement process rooted in a Delphi study, which consisted of a panel of 26 experts in the field of ASD.

The paper is structured as follows: section 2 briefly summarizes the background of agile RE. Section 3 deals with the three phases of our pattern mining process. Then, section 4 summarizes the results of our approach and presents two examples of agile RE patterns. To finish, section 5 states conclusions and proposes future lines of research.

2. AGILE REQUIREMENTS ENGINEERING

Agile RE is a cross-functional research area comprising areas like HCD, ASD, RE (see Fig. 1). Contributing to the body of knowledge of agile RE implies considering research from all aforementioned areas.

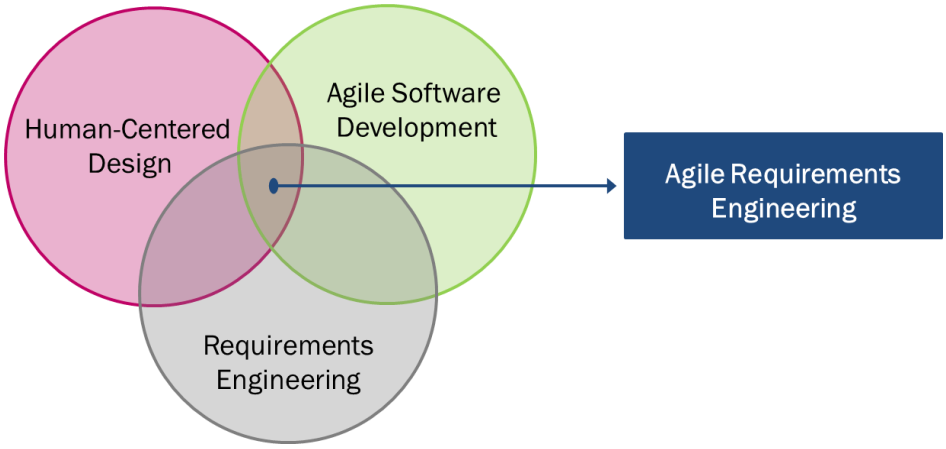

Fig. 1 Agile RE is a cross-functional research area comprising areas like HCD, ASD, and RE

Moreover, agile RE is different compared to RE in sequential approaches to software development due to the iterative and incremental character of agile methodologies (e.g. Scrum, XP, Kanban). Comparing existing agile RE process models (e.g. (Memmel, Gundelsweiler and Reiterer, 2007), (Maguire, 2013), (Rivero *et al.*, 2014), or (Olsson and Bosch, 2015)), we can observe a heterogeneity among them. For instance, authors recommend different types of roles, meetings, artifacts or agile methodologies. This heterogeneity is caused by the diversity of the environments, among other aspects, to which the process models are applied. Hybrid process models consisting of an integration of different agile methodologies are applied in industry (Komus *et al.*, 2017), (VersionOne, 2016).

Nevertheless, there are some commonalities among process models for agile RE. A just-in-time model is often used to refine high level requirements into low level requirements where business people, stakeholders, users and developers work together. This is an artifact-based model and starts with capturing requirements by means of epics. An epic is a large user story (Cohn, 2004), that can be refined by utilizing story maps (Patton, 2014). A story map includes user stories that are split into tasks. The whole workflow can be managed by means of Kanban boards for design, development and delivery (Schön et al., 2016).

3. PATTERN MINING PROCESS

We carried out a systematic pattern mining process comprising three phases (see Fig. 2) for identifying the agile RE patterns. In the following subsections, we will discuss each of the three phases and the utilized research method.

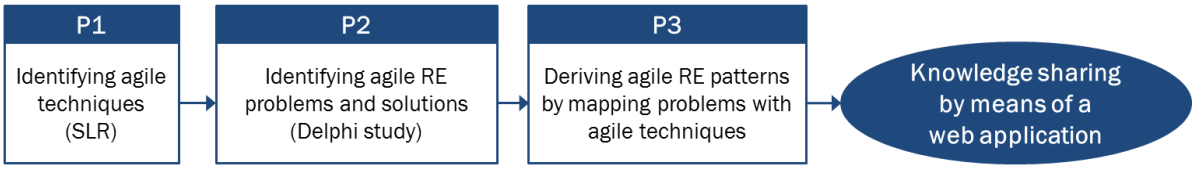

Fig. 2 Pattern mining process and knowledge sharing

3.1 P1: Identifying agile techniques

We conducted a Systematic Literature Review (SLR) with the aim to capture the current state of the art related to agile RE with focus on stakeholder and user involvement (Schön, Thomaschewski and Escalona, 2017a). For that aim, we followed the appropriate guidelines by Kitchenham and Charters (Kitchenham and Charters, 2007). A SLR is a means of applying evidence-based research in various domains. Therefore, all available research relevant to particular research questions or a specific topic area is evaluated and interpreted. A SLR can be classified as secondary study (Kitchenham and Charters, 2007).

In the first phase of our search process we found 42,808 papers based on our predefined search string. In sum, this process comprised six phases and snowballing (Jalali and Wohlin, 2012). After applying the selection process, we selected 27 studies that were analyzed in depth. In terms of the studies´ underlying research method we can state that 19 papers (70%) used case studies. Therefore, we can conclude that agile RE is often investigated in real life context and the research field is very close to existing work practices in industry.

With regard to the results of the SLR, we identified agile techniques for stakeholder and user involvement, data gathering, integrating HCD and ASD, building shared understanding, requirements management, documentation of requirements or non-functional requirements (NFR). In particular, we identified 20 artifacts, that were used by more than two of the included papers. The artifacts are: user story, prototype, use case, scenario, story card, persona, vision, UML diagram, storyboard, task, Kanban board, UI pattern, essential use case, picture, video, mind map and UI specification. We found that HCD, Design Thinking, Contextual Inquiry and Participatory Design are commonly used methodologies that are useful in order to make ASD more human-centric.

The agile techniques can be classified as methods (e.g. mind mapping or participatory design), artifacts (e.g. user story, prototype) or roles (e.g. Agile-UCD specialist or NRF stakeholder). We can point out that the included studies rarely mentioned classical agile artifacts (e.g. product backlog or sprint goal) or meetings (e.g. daily standup or retrospective). The full results can be found in (Schön, Thomaschewski and Escalona, 2017a).

3.2 P2: Identifying agile RE problems and appropriate solutions

Subsequent to the identification of agile techniques, we carried out an empirical evaluation with the aim to identify the most important problems in agile RE that the industry has to face up today (Schön *et al.*, 2017). For that purpose, we conducted an iterative expert judgement process rooted in a Delphi study (Dalkey and Helmer, 1963), (Diamond *et al.*, 2014), performed in three complementary rounds. The questionnaire of round 1 comprised open questions, whereas the one in round 2 covered close questions and comments. Additionally, in round 3 we combined close questions, open questions and comments. The main benefit of the process was that we could use the learnings from a previous iteration for carrying out the subsequent iterations. The panel consisted of 26 experts in the field of ASD, working for 19 different companies located in Germany and Switzerland. On average, the experts had 6.14 years of experience working in ASD and 6.65 years of experience with RE.

Once the last round was completed, we identified in sum 20 problems where six out of them are defined as key problems of agile RE, as Table 1 shows. Based on the results of our study, we have provided solutions for dealing with those key problems by means of agile techniques and tools recommended by the panel of experts. Results reveal that organizations still struggle with agile transition and understanding agile values, in particular, in terms of stakeholder and user involvement. The full results are available in (Schön *et al.*, 2017).

Table 1 Key problems in agile RE (see (Schön *et al.*, 2017))

ID	PROBLEM NAME	PROBLEM DESCRIPTION
KP1	Technical or functional dependencies to other teams	In ASD, functional or technical dependencies with other teams constitute a challenge because a considerable coordination effort is required.
KP2	Understanding of agile values of the stakeholders	In ASD, it is a challenge that stakeholders understand that the development team can make independent (detailed) decisions.
KP3	Staying focused on the big picture	In ASD, it is a challenge not to lose sight of the big picture during the implementation of complex requirements.
KP4	Continuous requirements management	In ASD, continuous management of requirements represents a challenge since not all of them are fixed at the beginning and consequently, they may change over the course of the project.
KP5	Refine requirements in collaboration with users	In ASD, it is a challenge to work out user requirements and quality of use in cooperation with direct users (end users) of the product.
KP6	Involve stakeholder iteratively	In ASD, it is a challenge to involve stakeholders throughout the whole development process in regular iterations, so that product development will succeed.

3.3 P3: Deriving agile RE patterns

Following the approach by Wellhausen and Fießer (Wellhausen and Fiesser, 2011), we distinguish between problem domain and solution domain. In this work, the problem domain is explored by an empirical study (Schön *et al.*, 2017) where we identified six key problems for agile RE (Table 1). As part of this study, we also analyze the solution domain and we identify agile techniques that can be applied in order to solve the identified problems. Together with the agile techniques known from our SLR, we can derive agile RE patterns. Fig. 3 shows the relation between agile RE problems and agile techniques. One agile RE problem can be solved by one or more agile techniques. On the contrary, one agile technique can solve one or more agile RE problems.

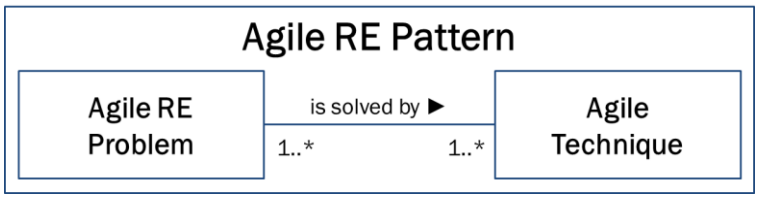

Fig. 3 Relation between agile RE problem and agile technique

The mapping process between problem domain and solution domain is iterative and still ongoing. It comprised three steps:

i. Experts carried out the first mapping between problem domain and solution domain during the empirical study (see section 3.2).
ii. Moreover, we mapped the identified agile techniques known from the SLR to the agile RE problems.
iii. Afterwards, we made a cross check with agile techniques proposed by agile methodologies (e.g. Scrum, XP, Kanban) and related patterns (e.g. (Bertholdo *et al.*, 2014), (Salah, Paige and Cairns, 2015), (Bertholdo, Kon and Gerosa, 2016)).

Table 2 shows the results of this mapping.

As mentioned before, the experts participating in our Delphi study (see section 3.2) recommended solutions to cope with agile RE problems. One of these solutions is description of tasks that are carried out by specific roles proposed by agile methodologies. We mapped such tasks to the responsibilities of the roles in order to derive the agile RE patterns. For instance, the experts recommended the solution continuous coordination and presenting possible solutions to stakeholder. We accumulated this solution to the pattern Product Owner since he/she is responsible for engaging stakeholders. Another recommended solution was strengthening product owner with competency in decision making. We added this task to the pattern Agile Coach/Scrum Master since he/she is in charge of helping people understand the role of Product Owner.

4. PATTERNS FOR INSPECTION AND ADAPTION OF AGILE RE

Patterns are a common way for sharing knowledge concerning a specific topic. The concept of pattern relies on the work by Alexander et al. (Alexander *et al.*, 1977). In the following subsections, we will present the identified list of agile RE patterns. In addition, we will provide two examples of patterns: *a) evaluation and testing* and *b) story map.* As noticed, we used appropriate guidelines for pattern writing provided by (Wellhausen and Fiesser, 2011). The knowledge concerning agile RE presented by agile RE patterns will be distributed by means of a web application.

4.1 Overview agile RE patterns

Table 2 presents the results from the pattern mining process. The agile RE patterns are classified according to their agile technique referred to as pattern category (*artifacts, meetings, methods or roles*). Moreover, we mapped the agile RE patterns to agile RE problems. There are some patterns that can either be classified as methods or artifacts thus, we decided to classify them in terms of the resulting artifact, which is created while using the method. For instance, *story mapping* would be classified as *method*, whereas the result (*story map*) is classified as *artifact*. In sum, we discovered 41 agile RE patterns: 14 patterns classified as artifacts, 5 patterns classified as meetings, 17 patterns classified as methods and 5 patterns classified as roles.

Below, we will present two examples of Agile RE patterns and will discuss how the knowledge can be shared with the community by means of a web application. The full set of agile RE patterns presented in Table 2 can be found in the web application (Schön, Thomaschewski and Escalona, 2017b).

Table 2 Agile RE patterns matched to agile RE problems

AGILE RE PATTERN NAME	PATTERN CATEGORY	KP1	KP2	KP3	KP4	KP5	KP6
Minimum Viable Product (MVP)	Artifacts		x	x		x	
Kanban board	Artifacts	x		x	x	x	
Prototypes	Artifacts	x		x		x	x
Definition of ready and definition of done	Artifacts				x		
User stories	Artifacts			x	x		
Product backlog	Artifacts	x		x	x		
Roadmap	Artifacts	x		x	x		
System models	Artifacts			x			
Story map	Artifacts			x	x		
Process models	Artifacts			x			
Value stream	Artifacts			x			
Customer journey map	Artifacts			x	x		
Product vision	Artifacts			x	x		
Impact map	Artifacts			x	x		x
Refinement meeting	Meetings		x	x	x		x
Planning meeting	Meetings	x		x			x
Review meeting	Meetings		x	x	x		x
Daily standup meeting	Meetings	x			x		
Retrospective	Meetings	x		x			
Evaluation and testing	Methods			x	x	x	
Launch of product features	Methods					x	x
Lean user research	Methods				x	x	
Users time is valuable	Methods					x	
Co-design	Methods				x	x	x
Define agile RE process model	Methods			x	x		x
Transparency of decisions	Methods		x		x		x
Weighing up various solution proposals	Methods		x		x		
Coaching	Methods		x		x		
Lifecycle managements by means of tools	Methods	x			x		
Shared understanding	Methods	x	x	x	x		
Scaling agile	Methods	x					
Continuous integration	Methods	x					
API-driven Development	Methods	x					
Micro services	Methods	x					
Community of practices	Methods	x					
Pairing	Methods	x					
Product Owner	Roles		x	x	x		x
Agile Coach/Scrum Master	Roles	x	x	x			
Development team	Roles	x	x	x			
Expert	Roles	x	x	x	x	x	
Stakeholder	Roles		x				x

4.2 Examples of agile RE patterns

As illustrative examples, we will present two of the 41 identified agile RE patterns: *a) evaluation and testing* and *b) story map*. Both agile RE patterns solve the problem concerning not to lose sight of the big picture during the implementation of complex requirements. The pattern *evaluation and testing* is classified as method, whereas *story map* is classified as artifact.

Pattern name	**Evaluation and testing**
Context	Working in a Kanban system make people focus on small tasks. This can cause the problem of leaving out sight of the big picture during the implementation of complex requirements. Hence, it is hard to design a positive User Experience (UX) for the user.
Problem	Staying focused on the big picture (see KP3, Table 1).
Forces	— providing a positive UX to the user. — carrying out a release evaluation continuously. — not interrupting the workflow due to scheduling testing activities and organization. — reducing costs for long-term UX testing.
Solution	Carrying out a regular release evaluation (Schön *et al.*, 2016) by means of Usability and UX testing (Hartson and Pyla, 2012), (Schrepp, Hinderks and Thomaschewski, 2014). Therefore, a work in progress (WIP) limit to the last column (*"Done",* see Fig. 4) of the Kanban board should be introduced. The release evaluation should start, once the WIP limit is reached.

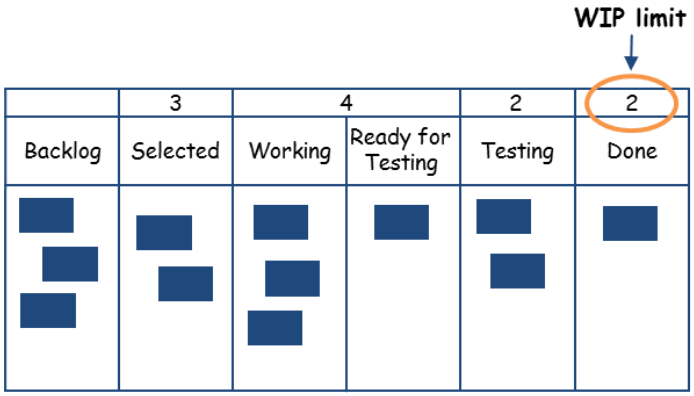

Fig. 4 Example of a Kanban board

Consequences	The regular release evaluation helps you stay focused on the big picture. In addition, it enables improving the overall UX of the product. Introducing a WIP limit to the last column of the Kanban board reduces the complexity of finding the starting point for a release evaluation. Moreover, it allows carrying out UX testing continuously.
Related Patterns	The agile RE pattern *evaluation and testing* is related to the pattern *Sprint Zero* by Bertholdo et al. (Bertholdo *et al.*, 2014), since both patterns address the same problem in different stages. *Sprint Zero* is utilized as a stage before starting the project implementation, whereas *evaluation and testing* is a recurring task during the development of a product. Besides, the solution of the pattern *evaluation and testing* is related to the pattern *Usability Testing Sessions Alongside Agile Development Tests* by Salah et al. (Salah, Paige and Cairns, 2015) since it may also solve the problem of scheduling Usability and UX testing in an agile environment.

Pattern name	**Story map**
Context	User stories let people focus on developing small increments. This leads to the problem of losing sight of the big picture. In addition, prioritizing user stories is difficult due to the open question of what the user really needs.
Problem	Staying focused on the big picture (see KP3, Table 1).
Forces	— it is hard to find out what the user needs and what product to build. — agile teams and stakeholder struggle with prioritizing requirements for different releases. — it is tough to identify the scope of the MVP, so it is uncertain when a first version of a product should be released.
Solution	Managing user stories by means of a story map. Story Mapping (Patton, 2014) is an agile technique that can be used to manage user stories. A story map tells the story about the product and its usage from a user´s perspective. Dependencies among user stories can be identified easily and prioritizing requirements becomes simple.

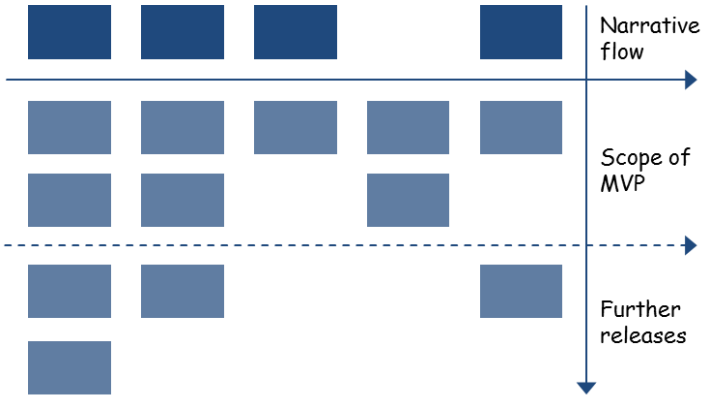

Fig. 5 Example of a story map

Consequences	Story Mapping keep people focused on users and their experiences with the product. In addition, the conversation among agile team members will be more vivid as well as effective due to the storytelling approach. Continuous management of requirements will be a natural activity because of the visual presentation (see Fig. 5) of the prioritized user stories.
Related Patterns	The agile technique Story mapping is introduced by Patton (Patton, 2004), (Patton, 2014). In 2004, Patton (Patton, 2004) presented the idea but he did not call the technique Story Mapping at that time. In the following years, he noticed that other people applied a similar approach to solve problems concerning prioritization of requirements and losing sight of the big picture. Then, Patton (Patton, 2014) started realizing that he discovered a pattern.

We applied the agile RE pattern *evaluation and testing* in one of our case studies related to the integration of HCD and Kanban (Schön *et al.*, 2016). The project was carried out in a medium-sized IT company, located in Germany, specialized in e-commerce, mobile apps and SAAS tools. We aim to relaunch an internet-based newspaper portal in a period of six months along 2013/2014.

Each agile methodology (e.g. Scrum, Kanban, XP) comes with its own requirements that have impact on how RE is carried out. For instance, there is a difference between flow-driven approaches like Kanban or time-boxed approaches like Scrum. To this end, agile RE problems (see Table 1) are combined with different agile techniques, resulting in a set of related agile RE pattern.

4.3 Knowledge sharing by means of a web application

Typically, agile practitioners do not have time to read full books due to their daily business. The knowledge needs to be presented in chunks in order to be communicated in an effective manner. To this end, we decided to share the knowledge regarding agile RE by means of agile RE patterns. The written agile RE patterns will be distributed by means of a web application (agileRE.org) (Schön, Thomaschewski and Escalona, 2017b). The aim of agileRE.org is to support practitioners as well as researchers improving their agile RE process models.

Fig. 6 presents the landing page of agileRE.org. On the one hand, the user can browse through agile RE problems. On the other hand, the user can browse through agile RE patterns that are classified by their pattern category (*artifacts, meetings, methods or roles*, see Table 2). We created a template for agile RE patterns in order to present them in the same fashion. This has a positive effect on the readability from a user´s perspective. The content is currently written in German, translations will follow.

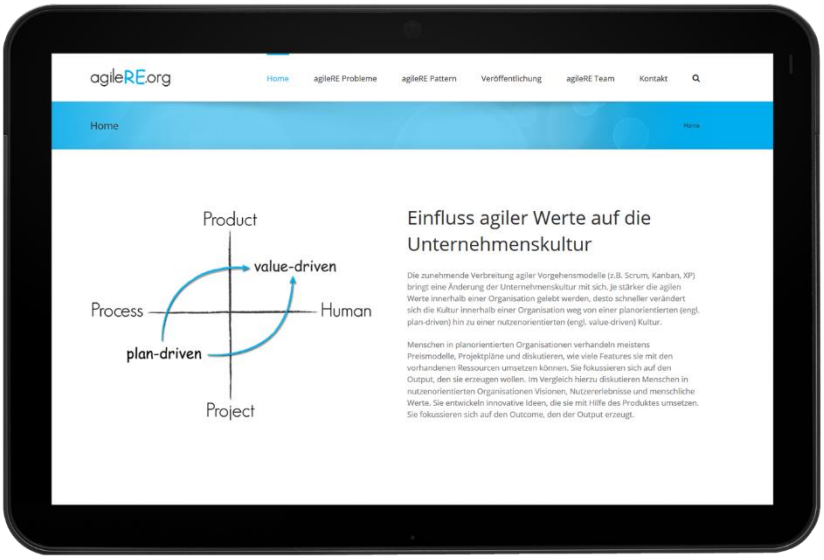

Fig. 6 Landing page agileRE.org

5. CONCLUSIONS AND FUTURE WORK

This paper presents the concept of agile RE patterns. For this purpose, we carried out a pattern mining process comprising three phases by means of empirical research in literature and industry. In the first phase, we identified agile techniques by means of a SLR. Then, we conducted an iterative expert judgement process with 26 experts in the field of ASD to identify the most important problems in agile RE. After that, we derived in sum 41 agile RE patterns. Therefore, we mapped the agile techniques to the agile RE problems. The knowledge about agile RE patterns will be shared my means of a web application.

We can conclude that our agile RE patterns are highly relevant for the industry as well as the research community, since we gathered the data from experts in the field of ASD. Agile RE patterns enable practitioners and researchers to implement their agile RE process models. Thus, our aim is to improve the agile RE patterns continuously. To this end, we appreciate feedback from the community. Moreover, we want to elaborate on the presented agile RE patterns in order to achieve a whole pattern language.

Future research may specifically focus on integrating further tools that support the semi-automatic analysis of requirements in an agile environment, similar to NDT (*Navigational Development Techniques*) (Escalona and Aragon, 2008) which is used for automatic analysis of requirements in sequential approaches to RE. Moreover, we will improve our agile RE patterns by means of further empirical evaluation in industry. In addition, we will analyze whether the identified agile RE patterns are applicable in sequential RE approaches as well as in an agile context, since the identified problems are not limited to ASD.

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