# A Quality Criteria Framework for Pattern Validation

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***Abstract*—Patterns represent an important tool for communicating, documenting, and looking up best practices for both novice and expert system developers and designers. Working in the field of patterns not only requires a well-structured approach to develop new patterns but also a guidance to validate patterns in order to ensure a high quality. Although there are a number of different patterns and pattern languages available, it is still unclear how to validate patterns in a structured way. Within this paper, we aim to fill this gap by introducing a Quality Criteria Framework developed on the basis of existing pattern research. Particularly, five main quality criteria for patterns will be presented and discussed in detail. The idea of our framework is to provide structured guidance for validating patterns in a comprehensive way by using quality criteria. In order to show the applicability of the quality criteria framework in practice, a case study using selected criteria from the framework for validating an existing pattern collection was conducted. This case study showed the appropriateness of our framework for validating patterns and iterating them on the basis of the validation results.**

***Keywords*-patterns; validation; quality framework; validation methods; case study.**

## I. INTRODUCTION

This paper aims to give a detailed overview on current research on the validation of patterns and to thoroughly introduce a comprehensive framework for validating patterns based on our previous work presented at the PATTERNS 2009 conference [1]. This work is part of our research towards contextual user experience patterns within the Christian Doppler Laboratory for "Contextual Interfaces". The framework was already applied in a specific context, namely the case study presented in this paper (audiovisual systems) and is currently explored in other contexts. Thereby, knowledge gained on contextual user experience [2] is preserved by using the pattern approach.

In general, patterns are characterised by capturing useful design solutions and generalizing them to address similar problems [3]. Borchers [4] defines design patterns as a structured textual and graphical description of a proven solution to a recurring design problem. This also underpins the reusability of patterns which was especially emphasized by Martin, Rouncefield, and Sommerville, [5]. Tidwell [6] stresses the fact that patterns are neither heuristics nor complete step-by-step descriptions of how to solve a problem but descriptions of best practices.

Since patterns have been introduced in urban architecture in the 1970s by Christopher Alexander [7], they have turned out to be an important tool for communicating, documenting, and looking up best practices for both novices and experts in different domains. According to van Welie [8], documenting and looking up best practices improves the quality of design solutions and can reduce time and effort for designing new projects considerably, provided that the patterns themselves are of high quality. Moreover, patterns facilitate communication between different stakeholders (e.g., designers and programmers) as they support the forming of a collective vocabulary and thus avoid misunderstandings and ambiguities [9].

Patterns have become popular in different domains, involving architecture [10], software engineering (e.g., [11][12][13]), human-computer interaction and interface design (e.g., [14][15][16][6][17][18][19]), ubiquitous computing [20], game design [21], and pedagogics [22].

Despite the broad application range of patterns, there is still a lack of research on the validation of patterns. In particular, there is a lack of consistent quality criteria for patterns and pattern languages as well as appropriate validation methods. According to Dearden & Finlay [23], the evaluation of how useful selected patterns are in practice is important but has been hardly considered up to now. Similarly, McGee [21] claims that there is a need for materials to support the creation and revision of patterns. Although there have been some attempts to validate patterns, these validations have focused on specific application domains or have only regarded selected aspects. Thus, a comprehensive framework for validating patterns in different application areas involving all relevant criteria which account for the quality of a pattern is still missing.

Within this paper we aim to fill this gap by presenting a common and comprehensive validation approach for patterns. By introducing a so-called quality criteria framework, a novel way of validating patterns based on clearly defined quality criteria is described. In order to define a

comprehensive framework, we first collected and analyzed existing criteria, guidelines and requirements for patterns. Based on this extensive desktop research, we developed our own validation framework. To prove the applicability of our framework in practice, we finally applied it for improving an existing pattern collection. Therefore, we conducted a case study with an existing pattern collection. On the basis of quality criteria chosen from our framework, selected patterns of the collection were iterated and improved using both qualitative (interactive pattern workshop) and quantitative (pattern checklist) methods.

The present paper is structured as follows: In the first part of the paper we will introduce related work and discuss existing criteria, guidelines, and requirements for the patterns we use for clustering and developing a comprehensive quality criteria framework. The second part of the paper is dedicated to the development and description of our quality criteria framework, in which each component is presented in detail. Next, we show how we applied the developed quality criteria framework for validating and improving an existing pattern collection. Finally, we discuss insights gathered from the validations done on the basis of our framework and give an outlook for future work.

## II. Related Work

Patterns have to be evaluated to prove their quality. However, the question of how to evaluate patterns profoundly is still vague and remains a challenge for those who develop and improve patterns and pattern languages.

### A. Quality Criteria for Patterns

There are several collections of criteria, guidelines, and requirements available which aim at defining what makes patterns and pattern languages high-quality. The five presented collections range from a focus on single patterns themselves to an overall view on pattern languages and frameworks, deriving from different pattern domains, e.g., design, human-computer interaction (HCI), and software development. We have analyzed these collections with regard to differences and similarities of the used quality criteria as presented in Table I. Based on the related work, we have clustered the collected criteria for patterns and/or pattern languages and used them as a starting point for our quality criteria framework.

One collection of quality requirements for pattern languages was compiled by Niebuhr, Kohler, and Graf [24]. Based on the challenges they experienced when identifying and developing patterns, they state four successive quality criteria which should be considered. The *"problem fit"* criterion is achieved when a pattern has successfully been identified as appropriate to a design or development problem. A high-quality pattern makes it easy to understand its content, and consequently the idea of the pattern (*"understandability"*). Once the pattern has been discovered and understood, it needs to offer a valid solution to the problem (*"correctness"*). The final challenge for the pattern user lies in realizing the pattern solution to solve the design or development problem (*"concretization"*).

Another attempt to describe requirements for the quality of patterns comes from McGee [21], who described general characteristics of patterns. A pattern is required to be *"operational and precise"* in order to be transferable to a concrete solution and to be *"positive"*, which means that it demonstrates 'good practices' instead of bad ones. Further, a pattern should be *"flexible"* in such a way as to offer several solutions to a problem and *"debatable"*, meaning that it is comprehensible enough to be discussed. Furthermore, a *"testable"* pattern allows an empirical confirmation of improvements through pattern implementation and an *"end-user oriented"* pattern strives for a consideration of end-users' perspectives. McGee [21] also introduced the characteristic *"positive"* for patterns, which we have not considered as valuable as a quality criterion for our framework, since patterns represent best practices and are therefore positive by definition.

Furthermore, Khazanchi, Murphy, and Petter [25] defined the following guidelines for evaluating patterns according to Christopher Alexander's vision of a 'quality without a name'. The *"plausibility"* criterion is related to the consistency of knowledge embedded in the pattern of existing knowledge in the field of design or development. Thus, the pattern has to reach a level of believability among the pattern users. When a pattern achieves the *"feasibility"* criterion it can be operationalized and applied to a problem. Further, the description of a pattern has to be understandable (*"effectiveness"*) which comprises qualities like e.g., comprehensiveness, consistency, and completeness. Consistency is not only necessary among parts of a pattern, but also within patterns which belong to the same problem area (*"pragmatic"*). Furthermore, pattern descriptions need to include *"empirical"* evidence in order to verify the intended pattern output. Finally, Khazanchi, Murphy, and Petter [25] consider a pattern to be *"predictive"* by nature, when it is reliable in its effect every time it is applied.

A great deal of the previously described criteria is examining in detail the structural quality of patterns and pattern languages, but misses a broader view on the context of their usage. Borchers [4] defined a set of requirements for an interdisciplinary pattern language framework for the design of interactive systems, which also includes domain-specific aspects. He emphasizes that a pattern framework requires to be understandable for people from different disciplines (*"cross-discipline readability"*). The involvement of different domains (e.g., HCI, software engineering) additionally leads to the necessity of a *"domain-independent, uniform, well-defined format"* for pattern languages. Again, *"empirical evidence"* of the pattern is regarded as important to prove the pattern's validity. Further, the collection of patterns should

Table I
COLLECTION OF QUALITY CRITERIA FOR PATTERNS AND/OR PATTERN LANGUAGES BASED ON A LITERATURE REVIEW AS WELL AS THE DERIVED CRITERIA USED WITHIN THIS PAPER (ON THE RIGHT COLUMN).

| **Niebuhr et al. (2008)** | **McGee (2007)** | **Khazanchi et al. (2008)** | **Borchers (2001)** | **Dearden et al. (2008)** | ***This Paper*** |
|---|---|---|---|---|---|
| Problem Fit | | | | | *Findability* |
| | | | Domain-appropriate, design-supporting hierarchy | | |
| | | Pragmatic | | | |
| Understandability | Debatable | Effectiveness | | | *Understandability* |
| | Flexible | | | | |
| | | | Cross-discipline readability | | |
| | | | Design dimension coverage | | |
| | | | Domain-independent, uniform, well-defined format | | |
| Concretisation | Operational and precise | Feasibility | | Generative design | *Helpfulness* |
| | | | Lifecycle integration | | |
| Correctness | Testable | Empirical | Empirical evidence | | *Empirical verification* |
| | | Predictive | | | |
| | | Plausibility | | | *Overall acceptability* |
| | End-user oriented | | | | |
| | Positive | | | | |
| | | | | Empowering users | |
| | | | | Life-enhancing outcomes | |

be arranged in a hierarchical order, following the logic of the design/development process (*"domain-appropriate, design-supporting hierarchy"*). The next criterion, *"design dimension coverage"*, is used to consider domain-specific dimensions for the pattern language. The descriptions of interaction patterns, for example require the inclusion of a temporal dimension as an important characteristic of interactions. Furthermore, a pattern language framework requires to give hints on how it can be integrated into the software development lifecycle (*"lifecycle integration"*).

The last criteria collection of Table I refers to the stakeholders who deploy patterns. The two main stakeholders are usually designers and developers who have to be supported by patterns in specific ways [26]. In addressing a participatory design approach, Dearden, Finlay, Allgar, and McManus focused on the suitability of pattern languages as design tools for users acting as non-professional designers [27]. In other words, patterns and pattern languages do not only have to be valuable for professional designers and developers, but also be comprehensible for non-professionals. In line with the position of Christopher Alexander, Dearden, Finlay, Allgar, and McManus discussed three criteria for evaluating patterns. First, pattern languages have to be written in a way which enables users to generate complete designs (*"generative design"*). Second, the pattern language needs to be valuable for *"empowering users"* to participate in a design process and third, the deployment of the pattern should lead to *"life-enhancing outcomes"* for the users.

As shown in Table I, quality criteria of patterns and/or pattern languages from different sources and theories sometimes overlap, and sometimes they put their focus on different aspects.

In this paper, we aim at a conflation of the different aspects into a unified quality criteria framework, which should aid the validation of patterns and pattern languages and thereby the iterative development/improvement of the patterns. Based on the related work we have identified five types of quality criteria, which are listed in the right column of Table I and discussed in detail in the following sections. A further challenge is how to apply these criteria for the validation of patterns and pattern languages, namely finding the right methodological validation approach.

### *B. Validation of Patterns*

For validating patterns against certain quality aspects, mainly two approaches are considered:

1) Expert/stakeholder based evaluation of patterns fusing for instance heuristics, checklists, workshops, etc.
2) Practical usage and evaluation of patterns with stakeholders, such as designers and developers.

The first approach is based on heuristics, guidelines, and peer-reviewing. An established way of investigating the quality of patterns together with peers (designers, developers of a system) is to conduct shepherding and writer's workshops (see [28][29]). Specific requirements and as well as checklists were also used for validating patterns.

Borchers [4] evaluated whether the developed interaction pattern framework meets a set of requirements. In order to get insights about the didactic usefulness of patterns, he

additionally distributed a survey to HCI design students. This survey revealed information about the amount of memorized patterns as well as the patterns' usefulness for their project and for reuse in future design projects [4]. It turned out that the students considered patterns as useful and easy to use. However, a constraint of this study is the fact that it lacks comparison with other types of design advices.

Similar to Borchers [4], McGee [21] provided his design students with a game design pattern guideline as well as a so-called evaluation checklist in the form of questions. These materials were intended to support the pattern creation as well as to find weaknesses of existing patterns. In general, they can support developers in creating and improving innovative games.

Dearden, Finlay, Allgar, and McManus [27] evaluated the usefulness of patterns as tools for participatory design. Therefore, they defined three criteria and investigated these criteria by involving six participants in a participatory design task. According to the authors, the results of their study show that patterns can have a benefit in empowering users to participate in the design process. A comparison with alternative methods was not made.

The second approach of empirical evidence is based on many researchers' claim (e.g., [30]) that it is important to put patterns into use to judge their quality. For example, Chung et al. [20] conduced a controlled study with designers to evaluate the helpfulness of design patterns for ubiquitous computing. Two groups of designers had to complete tasks, one with and the other one without the help of design patterns. Afterwards, the results from both groups were analyzed comparing the quality differences in the design output and investigating the usefulness of the patterns for design. From their findings the authors conclude that the patterns supported both new and experienced designers who are not familiar with ubiquitous computing. In particular, their patterns facilitated the generation and communication of ideas and avoided design problems early in the design process.

Cowley and Wesson [31] conducted an experimental study on the usefulness of patterns, investigating the use of design patterns in comparison to the use of guidelines. The task was to evaluate and redesign an existing website. For this task, an experimental group used a selection of patterns, whereas a control group used guidelines similar to the selected patterns. Based on their preliminary results, the authors concluded that developers were more positive about design patterns than guidelines with respect to potential for evaluation, redesign, and new design.

Kotzé, Renaud, and Biljon [22] compared the effectiveness of patterns and anti-patterns in education. In order to identify the differences, they conducted two studies. According to their findings the authors claim that patterns are easier to learn from than anti-patterns. Thus, they consider the pattern-approach as more promising for educational purposes. In a more general way, their results can also be interpreted as evidence that negatively framed guidance is harder to learn from than positively framed guidance.

In a qualitative case study, Segerståhl and Jokela [32] investigated and compared the usability of two popular pattern collections. In the practical context of an industrial development project, they explored and compared Tidwell's 'Common Ground" collection, and Van Welie's pattern collection. As a result of their study, the researchers gave suggestions on how to improve collections of design patterns and thus make them easier to use.

In our paper we address the challenge of how to apply the criteria for the validation of patterns, namely finding the right methodological validation approach, and to validate selected UX patterns using our quality criteria framework.

## III. Quality Criteria Framework

In order to have a theoretical basis for the validation of patterns, we developed a quality criteria framework based on existing research as presented in the previous section. The framework aims to summarize and extend knowledge in this area and therefore represents a "meta-view" on what constitutes a high-quality pattern.

As shown in Table I, five superior quality criteria representing the most important characteristics of high-quality patterns were defined. The following superior criteria were identified for the quality criteria framework and further divided into sub-criteria if appropriate - see overview in Figure 1. Clearly, the present categorization is not always selective, i.e. some sub-criteria could also be subsumed under another criterion. This particularly applies to the sub-criteria of understandability and helpfulness. For example, the sub-criterion problem-centeredness (subsumed under the criterion understandability) could also be subsumed under the criterion helpfulness. In the following sections, each criterion will be described in more detail.

### A. Findability

Our criterion called *"findability"* states that a pattern has to be found easily and quickly within a pattern collection/pattern language. It is based on the assumption that if it takes too much time or effort for a potential pattern user to find a suitable pattern for a specific problem, the adoption of patterns fails already at the beginning. Therefore, the fact that a pattern can be easily found within a set of patterns seems to be an essential indicator for the quality of a pattern collection/language. When investigating this criterion, it could, for instance, be checked if the patterns of a pattern collection/pattern language are organized in a hierachical manner, guiding the user top-down to a suitable pattern.

The findability criterion is in line with a requirement for an interdisciplinary pattern language framework defined by

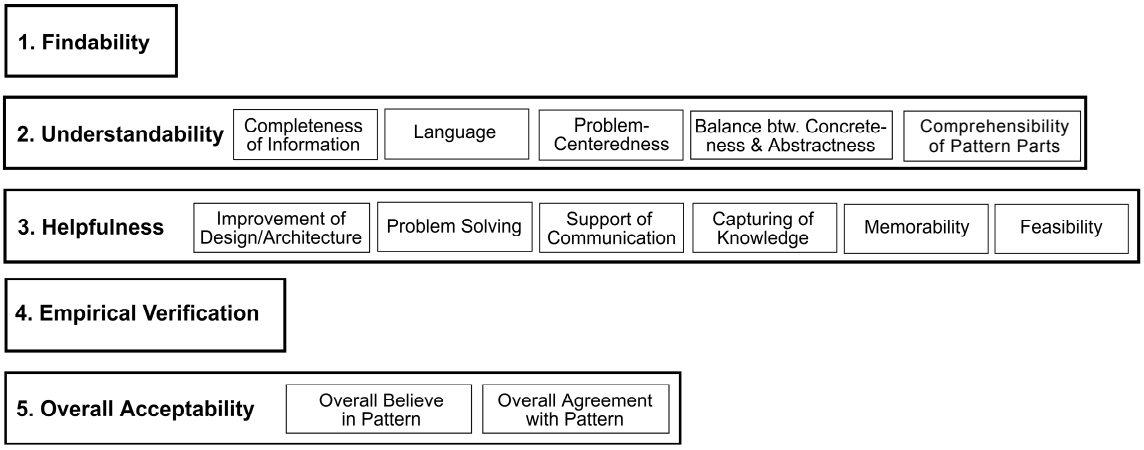


Figure 1. Overview on Components of the Quality Criteria Framework.

Borchers [4], namely the requirement asking for a "domain-appropriate, design-supporting hierarchy". Similarly, Khazanchi, Murphy, and Petter [25] consider the consistency of a pattern within other patterns in a problem class as "pragmatic", and Niebuhr, Kohler, and Graf [24] mention a quality requirement for patterns called "problem fit". The identified *"findability"* quality criteria stands for its own and does not comprise sub-criteria.

### B. Understandability

Our criterion *"understandability"* deals with the fact that the pattern must be easily understood by its users. Ensuring the comprehensibility of every pattern part (name, problem, forces, etc.) improves the applicability of the pattern in practice. For assessing this criterion, it could be asked if one finds the name of the pattern meaningful and can figure out the main idea of the pattern (when reading its name). This mainly addresses the quality of the sub-criterion comprehensibility of pattern parts (see enumeration below).

Niebuhr, Kohler, and Graf [24] state that the wording and notation of the pattern description must be understandable in order to successfully identify and apply the pattern. McGee [21] indicates that a pattern should be debatable as well as flexible in the sense that there is more than one solution. According to Khazanchi, Murphy, and Petter [25], a guideline for evaluating patterns is to prove the pattern's effectiveness. In line with this, Borchers [4] poses the requirements of a "cross-discipline readability", "design dimension coverage", and "domain-independent, uniform and well-defined format". In order to describe the understandability criterion as well as possible and thus provide a basis for the operationalization of this criterion, we defined the following sub-criteria:

a) *Completeness of Information*
A pattern should contain all relevant description of forces, problems, solutions, and examples to clarify its notion. The quality of a pattern therefore depends on its completeness. A pattern should be considered as "complete" when the necessary information is given in the pattern.

b) *Language*
A pattern should use a language which is easy to understand. For example, the terms used should be well-known and the sentences should not be too complex. Overall, patterns should be written in a way which is acceptable and appealing to every user, regardless of the discipline he comes from. The clearness of a pattern as well as a well-readable writing style are thus indicators for the quality of a pattern/pattern language.

c) *Problem-Centeredness*
A pattern should be centered around a problem. Therefore, all parts of a pattern (e.g., name, forces, solution) should be derived from the problem. For example, the relationship between the problem and the solution should be clear. A pattern in which all parts are related to the problem description therefore represents a pattern of high quality.

d) *Balance between Concreteness and Abstractness*
A pattern should neither be too abstract nor too concrete. If it is too abstract, one can not figure out how to apply the pattern to other applications/systems. If it is too concrete, the solutions can not be generalized. A high-quality pattern should therefore have a good balance between concreteness and abstractness.

e) *Comprehensibility of Pattern Parts*
All parts of a pattern description should be comprehensible to the pattern users. One should know what

is meant by them. For example, the name of the pattern should be meaningful so that the main idea of the pattern can be figured out instantly. The stated forces should provide enough background information, and the context of application should be clear. The provided solutions should be concrete enough and should not impose new questions. The examples given should be comprehensible and plausible. A high-quality pattern should therefore be characterized by a high comprehensibility of each single pattern part.

### C. Helpfulness

This category implies that the pattern has to be (or is supposed to be) helpful for the pattern user. For being helpful, the implementation of the pattern has to be feasible for the pattern user, meaning that the pattern description gives the user sufficient information about how to realize the pattern in practice. The category helpfulness can be further divided into "subjective" and "objective" helpfulness, differentiating between the supposed and the actual helpfulness (objectively measured by case studies, etc). Therefore, this category is based on the assumption that if the pattern/pattern collection is not supposed to be helpful, it will not be used (subjective helpfulness) or that if the pattern/pattern collection has not been helpful, it will not be reused (objective helpfulness). The helpfulness criterion could be investigated for example by letting participants summarize the main content of a pattern which was presented to them some time ago, in one sentence. The results give insight about the quality of the sub-criterion memorability (see enumeration below).

In their paper, Khazanchi, Murphy, and Petter [25] refer to this characteristic as "feasibility". Similarly, Niebuhr, Kohler, and Graf [24] identify the process of transferring a rather abstract pattern description to a concrete solution as "concretization". Borchers [4] claims that a pattern language has to specify a way how the patterns can be integrated in the development lifecycle. McGee [21] characterizes a good pattern as "operational and precise", and Dearden, Finlay, Allgar, and McManus [27] state that pattern languages should support "generative design".

In order to describe the helpfulness criterion as comprehensive as possible and thus provide a basis for the operationalization of this criterion, we defined the following sub-criteria:

a) *Improvement of Design/Architecture*
   A pattern should serve as a design or development aid. With the help of a pattern, the development of new applications and the improvement of existing applications is supported. Therefore, the high quality of a pattern is indicated by the fact that the pattern helps to improve the design or development of systems (depending on the application area of the patterns).
b) *Problem Solving*
   A pattern should be able to provide best practices and solutions to common problems. Upon knowing proven solutions or best practices beforehand, one can avoid certain problems. Therefore, a pattern which helps to avoid common problems represents a pattern of high quality concerning this criterion.
c) *Support of Communication*
   Designers, developers, and researchers do not always speak the same "language". Patterns should therefore serve as a common ground for discussions about design and development issues. A pattern of high quality should therefore provide a common basis for designers, developers, and researchers and thus support (interdisciplinary) communication.
d) *Capturing of Knowledge*
   A pattern represents a tool for capturing previously gained knowledge. The knowledge described in a pattern should appear relevant to the pattern user. A pattern which captures relevant knowledge about its application domain thus represents high quality regarding this criterion.
e) *Memorability*
   A pattern has to be easy to remember in terms of both recognition and recall. When talking about a pattern, its content should be memorized thoroughly in order to support efficient communication and usage of the pattern. A pattern whose main idea can be retrieved in a quick and easy way therefore represents a pattern of high quality.
f) *Feasibility*
   A pattern should be easy to realize or implement in practice. In order to support the right implementation of a pattern, particularly the solution must be clear for the pattern user. A pattern which can be easily applied in real situations accounts for the high quality of a pattern.

### D. Empirical Verification

Our criterion *"empirical verification"* describes the fact that a pattern is approved by empirical data. This can be either achieved by creating patterns which are based on results of empirical studies or by verifying existing pattern collections empirically.

We claim that an empirically verified pattern is of higher quality than a pattern which is "only" based on a person's experiences and observations. For example, if there is empirical evidence which approves the "correctness" of the pattern, the quality of the pattern is high.

Niebuhr, Kohler, and Graf [24] ask for empirical or theoretical evidence in order to ensure the "correctness" of a pattern. In line with Niebuhr et al., McGee [21] claims that a pattern should be "testable", i.e. offer the possibility to empirically test the effects of using a certain pattern. Khazanchi, Murphy, and Petter [25] claim that patterns should have an empirical nature in order to make them

verifiable. Moreover, they claim that a pattern should be "predictive", meaning that it produces the same general effect every time it is applied. Borchers [4] points out that the examples given within a pattern should contain empirical evidence of the validity of the solution whenever possible. For this criteria we defined no further sub-criteria.

### E. Overall Acceptability

The criterion *"overall acceptability"* describes to what extent a pattern user believes in the pattern, meaning how much he agrees with its content. This category is based on the assumption that if a potential pattern user does not agree with the content of a pattern at all (for example because it completely conflicts with previous experiences), he will not accept the pattern and thus will not use it. Therefore, the quality of a pattern is also affected by an individual's subjective acceptance of a pattern/pattern language. In order to investigate the overall acceptability of a pattern, one could ask if the reader of a pattern finds himself nodding in agreement as he reads the pattern description. Assessing this question would be an indicator for the sub-criterion "overall agreement with pattern" (see enumeration below).

Khazanchi, Murphy, and Petter [25] refer to the term "plausibility", which means that a pattern should be coherent and consistent with the knowledge of a particular domain. According to McGee [21], a pattern should be "end-user oriented", meaning that not only developers or designers appreciate a pattern, but also end-users who interact with the system to be developed/designed. In order to describe this criterion in a more focused way and thus provide a basis for the operationalization of this criterion, we defined the following sub-criteria:

a) *Overall Believe in Pattern*
   This sub-criterion deals with the overall believe in a certain pattern. A high belief in a pattern represents a high (subjectively experienced) quality of a pattern.
b) *Overall Agreement with Pattern*
   This sub-criterion deals with the fact that a user should be convinced of a pattern, i.e. the user should "find himself nodding in agreement as he reads the pattern description" [21]. High (subjectively experienced) quality of a pattern is therefore affected by a high overall agreement with its content.

Based on the framework and its criteria defined above, a case study showing its practicability was conducted.

## IV. Case Study UX Patterns: Pattern Validation based on the Framework

In the three-year CITIZEN MEDIA research project, focusing on the user experience (UX) of audiovisual networked applications, we used the pattern approach to develop so-called user experience patterns [33].

Our UX patterns are intended to show best practices for common problems in the area of audiovisual systems, providing designers and developers of audiovisual systems with proven solutions on how to improve a user's experience when interacting with an audiovisual system.

Based on user evaluation data collected in three different European testbeds (Germany, Austria, Norway) involving over 8000 users, we developed about 30 UX patterns. An actual version of the UX patterns can be found on the UX pattern website[1].

In Figure 2 the iterative development process of our UX patterns is visualized. An initial pattern collection was defined based on the results of the first evaluation phase of the research project. This collection of patterns was then iterated by conducting a writer's workshop with researchers, resulting in an extended UX pattern collection. Another iteration was made on the basis of new results achieved during the second evaluation phase as well as based on feedback given by an independent expert, resulting in a revised UX pattern collection.

Next, we wanted to make a validation of our pattern collection in order to improve its quality. However, we had to realize that there is still a lack of a common validation approach for patterns. Therefore, we aimed to fill this gap by introducing a comprehensive quality criteria framework for validating patterns in general. By means of this quality criteria framework we made two more iterations of our UX pattern collection, showing that this framework is applicable in practice.

In the following, the case study should exemplify how our quality criteria framework allows the structured operationalization and investigation of a pattern's/pattern language's quality. The following UX patterns were selected for validation from our collection of 30 UX patterns:

- Pattern 1: Self Presentation
- Pattern 2: Fun Factor
- Pattern 3: Initial Support
- Pattern 4: Real-Life Integration
- Pattern 5: Privacy Management

In order to describe the application of the framework in practice, we shortly present the two methods we used - the pattern workshop and the pattern checklist - following the expert/stakeholder based validation approach (see Section II, B). Table II gives an overview on the two conducted validation sessions.

Due to time constraints during the validation sessions, we focused on the (for us) most important criteria to improve the existing UX patterns. Moreover, not all components of our quality framework were applicable in the sessions. For instance, exploring "findability" or "empirical verification" require practical usage of the patterns.

[1] http://hciunit.org/uxpatterns/

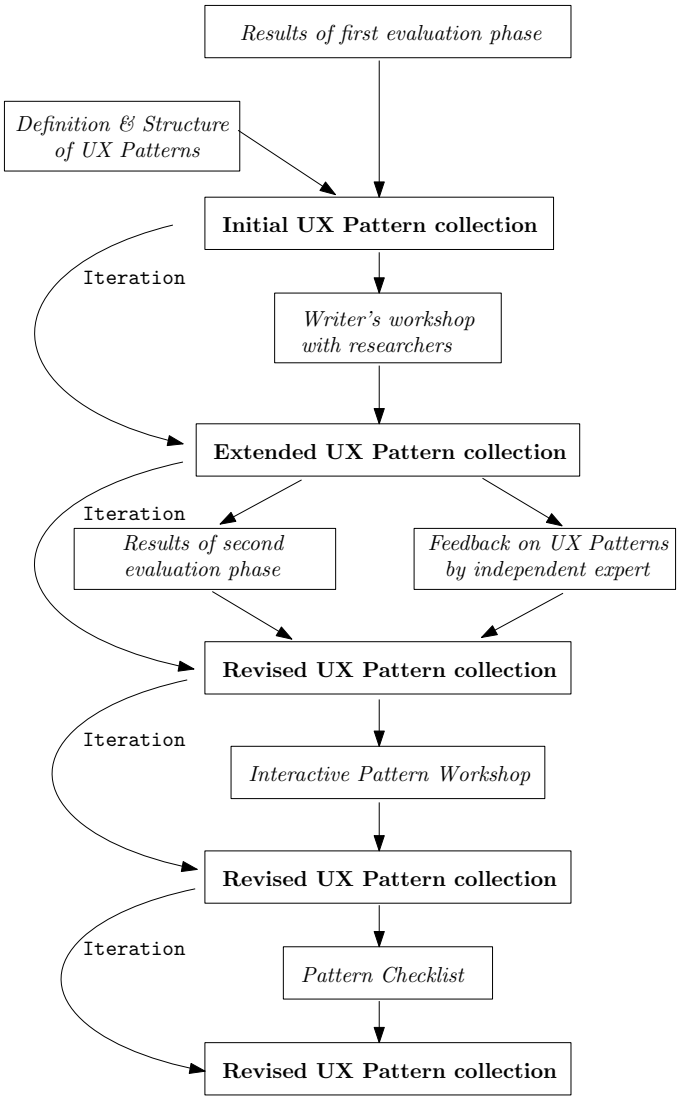


Figure 2. Steps in the UX Pattern Creation Process.

*1) Interactive Pattern Workshop:* In order to validate and improve the quality of our UX patterns, an interactive pattern workshop was conducted in April 2009.

*Set-up:* For the validation of the UX patterns, five patterns were selected from the collection and analyzed in detail during the workshop. Figure 3 presents the criteria from the quality criteria framework which were chosen to be validated in the workshop. Thus, the UX patterns were validated with regard to their understandability, helpfulness and overall acceptability.

The workshop was conducted at a stage in the pattern development process where all defined elements of a UX pattern description were available (name, problem, solution, examples). Familiarity with media design processes as well as good command of English were defined as prerequisites for the workshop participants. The participants of the workshop were six multimedia design students (5 females, 1 male) with a mean age of 22. The participants had about five years of design experience on average. Four of the participants did not know design patterns, and two of the participants knew design patterns but never used them so far.

*Procedure:* For each of the five patterns, the following questions were addressed in detail:

1) Is the pattern easy to understand? Especially: Is the pattern comprehensible?
2) Is the pattern helpful for the designers? Especially: Is the pattern easy to remember?
3) Do the participants accept the presented patterns?

In order to address the questions presented above, the following procedure was deployed: At first, the participants were welcomed and invited to shortly introduce themselves. Next, the workshop leaders gave a short introduction about the workshop goals, the role of patterns within the design process, and the specific role of UX patterns. Then, the workshop participants were asked to do several exercises, addressing the questions presented above.

The first question presented above (understandability) aims at investigating if the wording and the descriptive text of the UX pattern are easy to understand by the designers. Therefore, the comprehensibility of the UX pattern name was investigated in detail using the so-called "name guessing exercise". In general, the name of a pattern should be short and meaningful, expressing the aim of the pattern clearly. To investigate the comprehensibility of a pattern's name, the participants were presented the name of the pattern and then had to write one sentence about its supposed aim. After guessing about the aim, the actual aim of the pattern was presented, and the naming as well as suggestions for improvement of the naming were discussed with the participants.

Next, the comprehensibility of the other parts of the UX pattern description was evaluated by the participants. Therefore, the participants were given a so-called "comprehensibility questionnaire" (see Figure 5) to rate the comprehensibility of the pattern parts (problem, forces, solution) on a five-point scale (from "absolutely agree" to "don't agree at all"). The participants had to read through the pattern descriptions displayed on the beamer and fill in the comprehensibility questionnaire. After each pattern round, the incomprehensible parts were discussed and suggestions for improvement were collected. Additionally, the questionnaire contained two items asking the participants for an overall rating of the pattern (see Figure 7) addressing the overall acceptability (third question presented above).

In order to address the memorability of the selected UX patterns (second question presented above), a so-called "remembrance exercise" was conducted. Therefore, the participants were handed out a sheet of paper containing

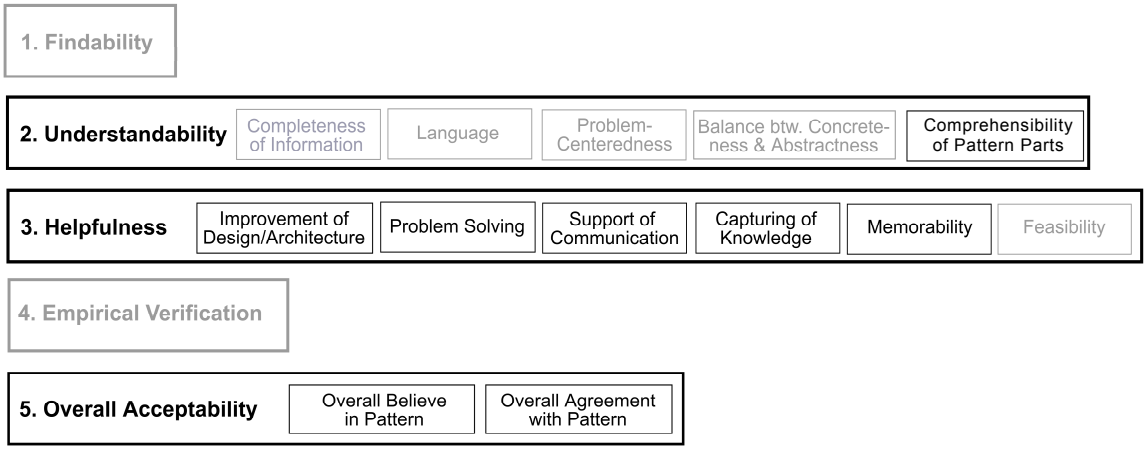


Figure 3. Overview on Components of the Quality Criteria Framework covered by the Workshop.

Table II
OVERVIEW ON THE VALIDATION SESSIONS OF THE CASE STUDY

| Validation method | No. of participants | Participants' expertise | Type of feedback | Date of conduction |
|---|---|---|---|---|
| Interactive Pattern Workshop | 6 | Multimedia Design Students | Qualitative | April 2009 |
| Pattern Checklist | 6 | Computer Science Students | Quantitative | June 2009 |

(again) only the name of a pattern. Having the name of one of the five selected UX patterns, the participants were requested to write down the main characteristics of the pattern in one or two sentences. To get insights into the supposed helpfulness in general, an open discussion about the participants' opinion on the helpfulness of the presented UX patterns was conducted. Amongst others, the participants were asked to discuss about the question if patterns can support designers in giving users a more positive experience and to describe the advantages and disadvantages of patterns. Moreover, possible difficulties in the usage of patterns as well as the usage of patterns for real application design were discussed. Additionally, the participants were asked to compare patterns with any other type of design advice (design guidelines, UI Design Principles) to judge their value. Furthermore, suggestions for improvement were also subject of the discussion.

*2) Pattern Checklist:* In order to validate the quality of the UX patterns a second time and thus further improve their quality, a follow-up validation session using a so-called "pattern checklist" was conducted in June 2009.

*Set-up:* Based on the first validation (interactive pattern workshop), a checklist covering selected criteria from the quality criteria framework was composed; the selected criteria are shown in Figure 4. For this follow-up validation, the same UX patterns as in the interactive pattern workshop were used. Overall, the UX patterns were validated with regard to their understandability, helpfulness, and acceptability. At the point of time when this follow-up validation was conducted, the UX pattern description was complete and already iterated on the basis of the first validation (see Figure 2). In order to cover the target group of designers as well as developers, the intended participants were developers this time (first validation was conducted with designers). As the UX patterns are written in English, another prerequisite for the participant selection was a good command of English. The follow-up validation was then conducted with six students of computer science.

*Procedure:* The main research question of the follow-up validation was if the presented UX patterns would meet the selected quality criteria. In more detail, the following questions were addressed:

1) Is the pattern easy to understand? (Covering all sub-criteria)
2) Is the pattern helpful for developers? (Covering sub-criteria a)-d))
3) Do the participants accept the presented patterns?

In order to address these questions, a checklist was composed. This checklist was intended to find quality problems in (selected) patterns, similar to a traditional heuristic evaluation in the field of usability engineering. By reading the pattern description and going through the heuristics, the evaluators (participants) should judge the patterns' compli-

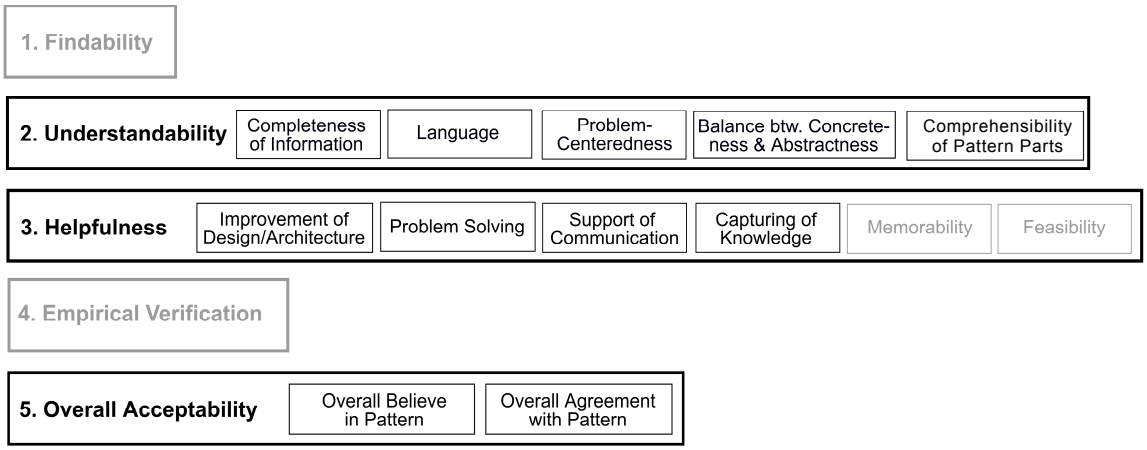


Figure 4. Overview on Components of the Quality Criteria Framework covered by the Checklist.

ance with the quality criteria.

The checklist was organized in the following manner (see Figures 5, 6 and 7): The first part of the checklist (see Figure 5) contained the comprehensibility questionnaire already used in the workshop and was intended to give insights about the comprehensibility of all pattern parts. The second part of the checklist (see Figure 6) covered all other sub-criteria selected from the framework. Each item of the checklist was intended to cover one single quality criterion. The items of the checklist were formulated like heuristics and the agreement with each item had to be indicated on a five-point rating scale (ranging from "absolutely agree" to "don't agree at all"). Again, the acceptance of the presented patterns was evaluated via the third part of the checklist (see Figure 7) .

All parts of a pattern description should be comprehensive to the pattern users. One should know what is meant by them.

| | absolutely agree | rather agree | neutral | rather don't agree | don't agree at all | don't know |
|---|---|---|---|---|---|---|
| The **name** of the pattern is meaningful to me. I can figure out the main idea of the pattern. | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] |
| The stated **problem** is clear to me. | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] |
| The stated **forces** provide me enough background information. | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] |
| I know to which **context** the pattern is applicable. | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] |
| The provided **solutions** are concrete enough and don't impose new questions. | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] |
| The given **examples** are comprehensible and plausible. | [ ] | [ ] | [ ] | [ ] | [ ] | [ ] |

Figure 5. Part one of the Pattern Checklist - Comprehensibility Questionnaire.

The procedure of the validation session was the following: First, there was an introduction phase. During this phase, the participants were informed about the goals of the validation, the pattern approach and the specific role of UX patterns. Furthermore, the quality criteria were explained so that the participants were familiar with them before the validation started. Then, the participants were asked to introduce themselves, what they study and how much experience and knowledge they have with patterns.

Next was the pattern review phase. In this phase, the participants were given one of the five selected patterns as well as the pattern checklist. The participants were then asked to rate how much they think the quality criteria applied to each of the patterns. In case of a low rating they were asked to further state a reason. This phase was followed by the discussion phase. After each pattern review, the review ratings per pattern (and found problems) were discussed in the group. Finally, the validation session was closed with an overall discussion on the presented patterns.

*3) Results and Implications of the Validations:* The two approaches for measuring the quality of patterns with regard to certain aspects showed that the quality criteria framework turned out as a valuable method for validating selected UX patterns. Both validations yielded consensus based quality judgements of the selected UX patterns as well as suggestions for improvement of the presented patterns. Both methods complemented each other in a good way and were useful for improving the UX patterns. The workshop yielded more qualitative data and focused on discussion, whereas the checklist enabled a more structured feedback for further refinements of the patterns. The iterative deployment of both methods proved to be helpful, as feedback from the workshop could be integrated into the checklist.

At this point, we will only present the most important implications for the development and restructuring of the UX patterns based on the validations. One issue arising

| | |
|---|---|
| A pattern should contain all relevant description of forces, problems, solutions and examples to make it clear to the user. For example all relevant forces should be considered.<br><br>**I would consider the pattern as "complete", meaning that the necessary information is given in the pattern.** | [ ] absolutely agree<br>[ ] rather agree<br>[ ] neutral<br>[ ] rather don't agree<br>[ ] don't agree at all<br><br>[ ] don't know |
| A pattern should use a language which is easy to understand. For example, the terms used are well-known and the sentences are not too complex. Overall, patterns should be written in a way which is acceptable and appealing to every user (designer, developer ...).<br><br>**The "language" of the pattern is clear to me. The style in which the pattern is written is well-readable to me.** | [ ] absolutely agree<br>[ ] rather agree<br>[ ] neutral<br>[ ] rather don't agree<br>[ ] don't agree at all<br><br>[ ] don't know |
| A pattern should be centered around a problem. Therefore, all parts of a pattern (e.g. name, forces, solution) should be build on the problem. For example, the relationship between the problem and the solution is clear.<br><br>**I think the pattern is problem-centered, i.e. all parts (e.g. name, forces, solution) are related to the problem description.** | [ ] absolutely agree<br>[ ] rather agree<br>[ ] neutral<br>[ ] rather don't agree<br>[ ] don't agree at all<br><br>[ ] don't know |
| A pattern should neither be too abstract nor too concrete. If it is too abstract, one can't figure out how to apply the pattern to other applications/systems. If it is too concrete then the solutions can't be generalized.<br><br>**I think that the balance between concreteness and abstractness is good.** | [ ] absolutely agree<br>[ ] rather agree<br>[ ] neutral<br>[ ] rather don't agree<br>[ ] don't agree at all<br><br>[ ] don't know |
| Overall, a pattern should serve as a design/development aid. With the help of a pattern, the development of new applications and the improvement of existing applications are supported.<br><br>**I think that the presented pattern helps to develop better A/V systems with regard to the user's experience.** | [ ] absolutely agree<br>[ ] rather agree<br>[ ] neutral<br>[ ] rather don't agree<br>[ ] don't agree at all<br><br>[ ] don't know |
| The pattern should be able to provide best practices and solutions to common problems. When knowing these solutions beforehand, one can avoid these problems. E.g. by applying this pattern in the development of A/V systems, one avoids the problem of users not experiencing themselves as part of a community.<br><br>**I think that the presented pattern makes the user's experience while using the system more positive. Common usage problems are avoided.** | [ ] absolutely agree<br>[ ] rather agree<br>[ ] neutral<br>[ ] rather don't agree<br>[ ] don't agree at all<br><br>[ ] don't know |
| Designers, developers and researchers do not always speak the same "language". Patterns serve as a common ground for discussing about design and development issues.<br><br>**I think the presented pattern supports the communication of designers, developers and researchers by providing a common basis.** | [ ] absolutely agree<br>[ ] rather agree<br>[ ] neutral<br>[ ] rather don't agree<br>[ ] don't agree at all<br><br>[ ] don't know |
| A pattern represents a tool for capturing knowledge gained before. Knowledge described in a pattern should appear relevant to the pattern user.<br><br>**I think the presented pattern captures relevant knowledge about user experience.** | [ ] absolutely agree<br>[ ] rather agree<br>[ ] neutral<br>[ ] rather don't agree<br>[ ] don't agree at all<br><br>[ ] don't know |

Figure 6. Part two of the Pattern Checklist - Heuristics for Understandability and Helpfulness.

| | |
|---|---|
| Overall, do you "**believe**" the Pattern?<br><br>[ ] Yes [ ] No [ ] Don't know | Do you find yourself **nodding in agreement** as you read the Pattern description?<br><br>[ ] Yes [ ] No [ ] Don't know |

Figure 7. Part three of the Pattern Checklist - Acceptance Questions.

from the "guessing exercise" and "remembrance exercise" as well as from the discussions was the naming of the UX patterns. The participants indicated that the naming often did not clearly express the aim of the pattern, or that the meaning was not clear. Especially verbs in the name of the patterns (for example "Provide Personal Information") were often confusing for the participants. A poor rating of the comprehensibility of the pattern name always came along with a bad performance of the participants in the remembrance exercise, thus confirming that the name did not express the meaning sufficiently. Based on the participants' suggestions for improvement, their ratings as well as their comments on the questionnaires, the names of all patterns were iterated and verbs were removed from the pattern names.

The "problem" part of the UX patterns was also iterated in detail after the validations. The participants mainly disliked that the problem statement was too general or abstract. Thus, iterated versions of the patterns contain a more concrete problem description.

The overall agreement with the presented patterns was rather good. This confirms the results of the discussions, where the participants stated that they liked and understood the structure and the content of the patterns.

Concerning the helpfulness of the patterns, the participants first did not seem to be convinced. However, after going through some patterns, they changed their opinion and recognized patterns as an important tool for supporting the design/development process. The suggestion of the participants to group the patterns according to more general problems was realized after the first validation.

### *A. Lessons Learned from the Case Study*

When applying our framework in practice, its structure (classification in criteria and more specific sub-criteria) turned out to be helpful for the development of evaluation materials. It allowed us to pick out relevant criteria, which we wanted to investigate within the validation sessions, and supported a more creative approach for investigating specific criteria. For example, we decided to investigate the quality of our patterns regarding their memorability, i.e. how easy they are to remember (sub-criterion five of the criterion helpfulness). The precise definition of memorability given within the framework brought us to the idea of developing a so-called "remembrance exercise". As we benefited from such a structured approach, we will also base the development of future pattern evaluation material on such a framework.

Within the interactive patterns workshop, which was conducted with design students, it turned out that our criteria mostly matched with the requirements on patterns from a designer's point of view. During the discussions, the designers considered findability, understandability and helpfulness as very important for a pattern of high quality. However, the helpfulness criterion was seen somewhat twofold: on the one hand, designers indicated that support in solving common problems by the use of patterns would be beneficial for them. On the other hand, they were critical of too much support, as this could be negative for the designer's creativity, i.e. lowering the creative thinking process.

Comparing the results of the two validation sessions, a fundamental difference can be stated. The first validation session, conducted as an interactive pattern workshop, brought many practically applicable results for improving

the selected patterns but less quantitative judgements about the quality of the patterns. In the second validation session, a pattern checklist was used for rating selected quality criteria. This brought quantitative results, but did hardly deliver suggestions for the improvement of lower ranked patterns. We therefore argue that the ideal way of validating and at the same time improving a pattern is to combine both approaches, i.e. to combine an interactive pattern workshop with a pattern checklist.

## V. Conclusion and Future Work

The development of patterns is an iterative process. As the iteration should lead to an improvement in quality, structured support on how to improve a pattern's quality is needed. In this paper, we aim at giving such a structured support by introducing a so-called quality criteria framework.

To show the framework's practicability, it was applied in a case study for validating the quality of selected User Experience (UX) Patterns. Therefore, relevant criteria were selected from the quality criteria framework and validated by means of an interactive pattern workshop and a pattern checklist. The results of the workshop and the checklist provided important insights on the quality of the patterns and thus helped to improve the patterns' quality. By applying these two methods successively (on the same patterns), an iterative improvement of the patterns was achieved.

The case study indicates that our framework supports the validation of a pattern's quality. On the one hand, the framework provides a structured selection of quality aspects which should be validated and improved, and on the other hand, using the framework ensures that no criterion is ignored unintendedly. Furthermore, the methods applied in the validation sessions (interactive pattern workshop, pattern checklist) turned out to be valuable validation methods, yielding helpful implications for the improvement of a pattern's quality.

An advantage of our validation framework is its broad perspective, which should ensure a broad applicability. Current approaches (see chapter on related work) often focus on single aspects and criteria to judge patterns, but miss a broader view. With our framework we provide a comprehensive view (based on an extensive literature review) on what is important to ensure a high quality for different kinds of patterns. Thus, the risk to forget important issues is lowered.

Moreover, our framework supports the operationalization of the quality criteria by introducing sub-criteria, which can be selected depending on the pattern status and relevance within an iterative validation process. This also influences the selection of the method. Based on the experiences made during our case study we assume that a pattern in its early state benefits more from open discussion and qualitative data (e.g., interactive pattern workshop), whereas a more mature pattern can be better improved based on quantitative feedback (e.g., pattern checklist).

As future work we plan to investigate the components of our quality criteria framework in more detail. As already pointed out, the present categorization is not always selective as some sub-criteria could also be subsumed under other criteria. Therefore, we aim to find out more about the relationship of the criteria and sub-criteria, perhaps resulting in a more hierarchical framework. We further plan to validate our UX patterns on the basis of our quality criteria framework, especially dealing with the criteria not applied so far. For example, criterion 4, "Empirical Validation", should be investigated in real design and development processes. Overall, the second important validation approach, i.e. the practical usage of patterns, should be deployed for validating our patterns.

Additionally, we plan to extend our UX pattern website, not only containing the UX patterns collection but also the quality criteria framework as well as methods and tips for pattern validation.

Furthermore, we currently extend our UX pattern collection to other contexts beyond the presented case study on audiovisual systems. Within the Christian Doppler Laboratory for "Contextual Interfaces" we work on special context areas, namely on the context car and factory. By applying our quality criteria framework to these different contexts, we want to further assure the general applicability of our validation framework.

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