Talking about Implications for Design in Pattern Language

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ABSTRACT
In this paper we present our approach to capture and share knowledge from field studies using pattern language and thereby inform the design of ubiquitous computing. In our case, we studied frontline firefighting by observing the existing practice, by developing empathy through participation and by introducing new technology as triggering artifacts. Applying grounded theory, we distilled our findings into pattern language describing core aspects of this practice and their interaction. In a workshop, we introduced the pattern language to developers who had no previous knowledge of this practice and, in follow-up interviews, confronted them with new technology proposals for firefighters. Our study shows that pattern language, while not to be confused with an immutable description of the status quo or a direct path from contextual analysis to design, supports a reflective discussion of novel technology and the fit with and potential impact on existing practice.

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Pattern Language; Ethnography; Design; Ubiquitous Computing; Firefighting

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INTRODUCTION
The relation between human practice and novel computing artifacts is a continuous concern for researchers and practitioners in the field of Human Computer Interaction (HCI). Resulting from the growing interweavement of technology and human life, ubiquitous computing has further increased the need to understand this relation. The interaction between humans and computers is a situated [26, 33] or embodied [18] activity where universal measures for efficiency and effectiveness as well as task- or process-oriented perspectives do not include important parts of the overall socio-technical configuration. Instead of picking out only certain aspects or requirements relevant to a particular envisioned technology, instead of creating artificial scenarios in which technology is supposedly useful, there is the necessity to build a broader understanding of the lived practice. We need to “expand the frame, to metaphorically zoom out to a wider view that at once acknowledges the magic of the effects created while explicating the hidden labors and unruly contingencies” [33, p. 283-284], we need to understand “what it means for a system to be ‘good’ in a particular context” [26].

Ethnographic research provides insights into human practice; it is a means to zoom-out to a wider view. Yet, formulating implications for design is not straightforward and is not the primary concern of ethnographic research [17]. Beyond descriptions of existing practice, we also have to take into account that novel computing, once introduced, has an impact on existing practice. With a focus on this impact, more and less formal research approaches have been taken to start with and learn from the introduction of novel computing artifacts (e.g. [23, 37]). Along with these design-driven approaches, by which technology designers address the specific, situated needs of a given context, comes an epistemological discussion about the role of theories and the possibility of capturing findings and growing a shareable body of sound academic knowledge [8] so that future technology designers can benefit from previous research.

With this paper, we add to this discussion a case report of how a combination of approaches, centered on the creation and use of pattern language, allowed us to share knowledge from a number of field studies for a specific context of use and discuss implications for design with developers who had no previous knowledge of this field.

RELATED WORK
Erickson [20, 21] suggests pattern languages, a collection of related patterns, as a lingua franca, a linguistic common ground that allows people from different disciplines to communicate with each other, for the interdisciplinary work of human-computer interaction design. Erickson calls for site-specific pattern languages to be developed before forming a more general lingua franca in the long term. These patterns and their relationships should not be used to reject or approve aspects of design, but instead “can be
used as a language for discussing changes and reflecting on their possible impacts, both in terms of the activities of the organization, and in terms of the qualities of work life which its members value.” [20, p. 366]

Erickson’s proposal is inspired by the work of architect Alexander [1-3] who, concerned with the question “Under what circumstances is the environment good?” [1, p. 74], proposes pattern languages to share architectural solutions to common design problems. Patterns, for Alexander, in their interaction, create an overall, socio-spatial configuration that thrives social harmony and the well-being of individuals. Erickson’s proposal is also inspired by Hester [27] who presents a case in which pattern language allowed citizens of a local town to have a voice in the process of city planning.

Earlier, Alexander’s work had been brought to computer science. Patterns for software engineering focused on collecting design solutions for common problems in developing object-oriented software [22], patterns for interaction design focused at collecting design solutions for common problems in designing interfaces [5, 34]. Erickson’s proposal is, however, different in nature. Rather than focusing on sharing design solutions, he sees the chance to use pattern language as a means to capture human practice and allow people from different disciplines to communicate about human practice and design.

Similar to Erickson, McCullough, in his work on a typology for ubiquitous computing and architecture, suggests patterns of human practice to support the design process. “Repeating relationships embody workable conventions. These are not rigid rules, but transformable configurations.” [29, p. 55] Crabtree et al. [9] propose the use pattern language “for structuring and presenting ethnographic fieldwork.” [9, p. 265] They also suggest that patterns can make “unsupported use practices available to the design of future technological arrangements in place.” [9, p. 269]

While these authors describe the potential of pattern languages of human practice for the purpose of interaction design, they do not include actually developed pattern languages or case studies for the field of HCI that would substantiate their claim.

**CREATING A PATTERN LANGUAGE**

During the past years, we have conducted research on designing ubiquitous computing for firefighters working on the frontline of an intervention. In two projects we have been working with French and German firefighters to design systems that could support them for their work in burning buildings. To study this practice, that usually takes place in hazardous environments that are very different from daily experiences and very difficult to access for the purpose of research, we organized a range of workshops in professional training facilities that simulate conditions similar to those in real interventions.

Our workshops [14, 15, 19] comprised studies in which we observed and interviewed firefighters while performing their work. We studied their practice and the tools that they use. In empathic exercises, we performed search and rescue missions and entered burning buildings ourselves to develop an insider’s perspective of the work on the frontline. Following an action research approach, we also introduced new computing systems and changed the existing practice to learn from the effects about the inner workings of the practice. In close participation with users, industry stakeholders and researchers, we focused our design efforts on a system to support navigation in low visibility conditions [31]. All workshops were captured using photos, videos, audio recordings and notes. The results from 25 workshops over a period of three years produced a large corpus of empirical data.

To distill our findings, we sought to develop a pattern language. To solidify Alexander’s methods we drew a connection between his approach and a combination of action research and grounded theory [13], as suggested by Baskerville [4]. Following these methods, we analyzed our empirical data in an open coding process [24] and constructed the pattern language by comparing incidents in the workshops, statements by the officers, properties of their tools, etc.

In a number of revisions, we identified patterns and their relation in an overall pattern language. In 16 linked patterns (Figure 1), we describe different aspects firefighting frontline practice [11]. Following Alexander’s proposal, each pattern describes a certain problem and solution to it. The patterns are summarized in brief abstracts and with photos that show firefighters acting, as described in the patterns. For every pattern, the detailed description, some pages long, provides exemplary cases from the workshops, interview statements or stories from the introduction of new technology. Also in each pattern, a separate paragraph describes the relation to other patterns. While we cannot fit the entire pattern language [11] into this paper, we provide short summaries for all patterns to provide the reader an overview of the language. In the summaries, we describe a problem firefighters face and then, following the word ‘therefore’, describe firefighters’ solutions.

**A pattern Language of Frontline Firefighting**

**FLUID ORDER:** Firefighters are called when systems are out of control. Therefore, firefighters respond to the challenge they face in a fluid manner. They apply pre-defined structures and tactics to restore order yet are aware of the uniqueness of the incident and improvise according to the situation at-hand. The incident shapes the operation and the operation is shaped according to previous experience.

**RIGID STRUCTURE:** firefighter operations face unknown, often chaotic situations. Nevertheless, firefighters have to act promptly and decisively. Therefore, a rigid organizing structure forms the backbone of the operation. Roles are clearly defined and visible at all levels. Beyond fixed roles
and hierarchies, the structure serves as a means for mutual responsibility and trust.

INDEPENDENT UNITS: As a result of the extreme conditions of the environment, frontline firefighting is an isolated activity that does not allow giving detailed instructions top-down in a RIGID STRUCTURE, as the perceived situation in a burning building is eminently unique and difficult to anticipate. Therefore, units of two or three firefighters work very close with each other and only receive general missions. Detailed decisions are left to the unit itself.

**FLUID ORDER**

![Diagram](image)

**Figure 1: Pattern Language Overview**

PROCEDURES: After their arrival on-site, firefighters have only so much time to decide what to do. The RIGID STRUCTURE distributes responsibility, yet firefighters have to act collaboratively and need to be mutually aware of their actions. Therefore, firefighters rely on procedures that define how to act and the next steps to take.

TAKE GOOD CARE: Even when following PROCEDURES, INDEPENDENT UNITS are not necessarily safe. On the one hand, the environment might radically change within bursts of a second and pose immediate threats. On the other, the actions of firefighters could lead to new life-threatening conditions. Therefore, firefighters always await the unfortunate thing to happen and take means to prevent it.

EVER-CHANGING PUZZLE: An incident changes continuously. As early impressions could be incorrect, following PROCEDURES requires taking emerging information into account. Therefore, firefighters continuously work on aligning chunks of information about the incident to form an overall picture of the situation.

MONITORING: INDEPENDENT UNITS might face situations that need to be recognized when sudden changes and threats put them in danger and they need immediate help. Therefore, dedicated firefighters periodically monitor the teams on the frontline. More than a mere procedure, monitoring means caring for colleagues.

SHARED ESTIMATES: Firefighters need numeric figures to make decisions on using their equipment. However, they lack information and precise measurements. Therefore, firefighters produce estimates that size up the environment and can be shared as part of the EVER-CHANGING PUZZLE.

MASH-UP: The frontline situation is difficult to predict and firefighters need to TAKE GOOD CARE. At the same time, INDEPENDENT UNITS are heavily loaded and only able to carry so much equipment. Therefore, firefighters look for alternative uses of the things that they find along the way. The environment is a grand collection of potential tools to be mixed with PROCEDURES and HANDY MULTI TOOLS.

BIG FAMILY: In a firefighting operation with a RIGID STRUCTURE, tasks and roles have different characteristics. It is however necessary for firefighters to work jointly on an EVER-CHANGING PUZZLE and to interpret theirs and others situations in MONITORING. Therefore, firefighters keep a high level of empathy, they form a close team in which seniors and subordinates know each other well.

THE WAY BACK: When engaging a hazardous environment, firefighters might face immediate threats. Therefore, firefighters always work on maintaining a return path to a safe place and mark the way that they follow. This path also works as a means for a BACKUP TEAM to locate lost teammates.

BACKUP TEAM: As INDEPENDENT UNITS, firefighters might face situations out of which they cannot lift themselves and need immediate outside help. Colleagues might be busy with their own tasks and not be available for quick support. Therefore, firefighters have backup teams on stand-by that provide support to INDEPENDENT UNITS in trouble.

MULTIMODAL ACTS: Working in rooms full of smoke, firefighters cannot visually grasp the environment. Therefore, firefighters use all their senses to feel the environment around them. They rely on tactile feedback from different parts of their body. They look for visual cues, feel the temperature and listen for sounds.

HANDY MULTI TOOLS: Firefighters frequently face problems that require special tools. INDEPENDENT UNITS can neither lift additional load nor have the time and energy to go back to the engine to pick up tools, instead they need to MASH-UP. Therefore, firefighters bring tools that can be used for different purposes and also invent new ways of using the tools.

EXERCISE: Even firefighters do not fight fire all the time. Serious fires are rare. Firefighting missions are one-shot operations, as failures in these interventions risk lives.
Therefore, firefighters need to train a variety of aspects of their work over and over again. Exercises are designed in ways to both include PROCEDURES and expected exceptions.

**LEARN BY MISTAKE:** After all, in interaction with hostile and dynamic environments, mistakes are made and unfortunate things happen. PROCEDURES and EXERCISE may not incorporate all the possible exceptions that could occur. Therefore, firefighters use operations with accidents or near-accidents to reflect and improve PROCEDURES and EXERCISE and prevent thereby future accidents.

**USING THE LANGUAGE**

While other researchers have previously identified similar, individual aspects of the practice of firefighters (e.g. EVER-CHANGING PUZZLE and MONITORING in [35]) and other safety critical workplaces (e.g. TAKE GOOD CARE in [36]), our pattern language adds to these works by metaphorically zooming out [33, p. 283-284] to a wider configuration of firefighting frontline practice. We have discussed our findings with practitioners and researchers, presented selected patterns in their entirety [12] and reflected on the relation between the emerging understanding of frontline practice and the design of our navigation system.

As we detail in [11, 13], the pattern language approach for us has served four main purposes. First, as Erickson pointed out, pattern language serves as rationale in design processes for reflecting on practice changes. In our case, it allowed us to reflect on alternative proposals for navigation support and their fit with the existing practice. Second, as indicated by Crabtree et al., pattern language provides a description of the practice, as a resource for solving design problems and a means to access aspects of the practice that have not yet been supported by design. In our case, the knowledge for instance about MULTIMODAL ACTS helped to solve design problems. Third, beyond the aspects pointed out by previous research, our work shows that a pattern language emphasizes that an existing social configuration gains overall stability from a number of patterns. During the design, maintaining balance, at a new stage of evolution, becomes a central concern. Only supporting MONITORING with a new system, for instance, decreased the independence of the units. Fourth, a pattern language shifts the focus in dealing with aspects of human practice. Instead of primarily focusing on the shortcomings that need to be resolved or a specific task that needs to be supported by new technology, the pattern language approach considers the existing practice as a resource, it highlights the existence of a larger social configuration, in which the new technology will reside. The pattern BIG FAMILY for instance, might usually not become a requirement for a navigation system. The pattern language points to the importance of that aspect, nevertheless. In summary, pattern language adds a larger context to design processes that build on requirements elicitation and adds a structured framework to design processes that build on ethnographic fieldwork by building a more balanced view on practice.

Another promise of the pattern language approach is that it makes empirical data more accessible for outsiders. As our pattern language was constructed during our design project, we had not brought the pattern language to a context that extends beyond our own research project on navigation support. Doing so, however, could bring about understanding if and how this captured knowledge can be shared. Also, doing so might increase our understanding of using pattern language to reflect on the impact that novel ubiquitous computing systems might have on the existing practice.

We therefore conducted a study with technology designers, who had no previous background in the firefighting domain, to build understanding if and how the language allows to form a shared understanding of the practice and how it can be used as a tool for reflective dialogs on novel computing systems for frontline firefighters.

**Methods**

**Introductory Workshop**

In a workshop setting, software engineers, who had no previous experience with designing technology for frontline firefighters or other safety-critical environments, learned about the pattern language.

Nine engineers with backgrounds of computer science, business informatics, media informatics and geo informatics and different levels of experience ranging from fresh graduates to post doctoral researchers (all male, age 26 to 41) participated in the workshop. All participants had been developing software and were familiar with multiple programming languages. They also were familiar with software development for ubiquitous computing system as they just finished a project developing a middleware for sensor networks. Of the participants only one had had previous contact with firefighters through his social service with the medical emergency. No participant had previous knowledge about the specifics of the work on the frontline. Also, they were not familiar with the previous work conducted as part of this research. The participants, however, in their current BRIDGE project [6], were confronted with the task to design computing solutions for frontline emergency response workers and commanders in cross-border, cross-agency operations in large-scale incidents. Therefore, the participants were interested in learning about the work of firefighters on the frontline.

Posters of all patterns on the walls of the workshop room displayed the photo for the pattern and the summary description (Figure 2). Another poster showed a graphic of the overall pattern language (Figure 1). Each participant received a printed version of the pattern language. While participants entered the room and waited for the workshop to start, they could hear an audible representation of the work on the frontline from sounds of firefighters working with breathing apparatus captured at the frontline during the workshops in the training facilities.
After a short introduction and presentation, showing photos from the studies and briefly summarizing the method that was used to construct the language, a selection of patterns was assigned to each participant, resulting for every participant in an equal amount of text and a variety of not closely linked patterns. For one hour, in groups of two or three, participants read and discussed four or five of the patterns. In the following, they presented these patterns to the other participants. The posters and the pattern language overview helped to explain and connect the individual concepts. In total, the workshop lasted for three hours.

![Figure 2: Workshop Setting](image)

Follow-Up Interviews

With the announcement of the workshop, participants were informed about follow-up interviews that would take place in the days after the workshop to collect individual feedback. All workshop participants took part in one-on-one semi-structured interviews, within 7 to 10 days after the workshop. The one-on-one setup was chosen to allow all participants to provide in-depth feedback on their perspective.

In the first part of the interview, participants were asked to describe their understanding of the frontline practice. As participants returned printed materials after the workshop, they had to freely recall what they remembered from the workshop, without prior notice or preparation. Thereby, it was possible to understand their perception of the pattern language during the workshop. In the second part of the interview, interviewees were presented with an online version of the pattern language [10] that allows for an easy navigation between the patterns. Interviewees were asked to check if they were familiar with all the patterns by their names, and, if not, to check the details for the concepts that they did not remember clearly. In the third part of the interview, participants were confronted with four technology designs of novel computing solutions for frontline firefighters. Using the same design cases with all participants allowed us to compare their different statements. The cases also resemble design processes that are driven by a dominant technological vision. The four design proposals were selected from research projects for their variety in scale and nature.

Glove: For the first concept participants were told about the concept of an interactive firefighting glove using a photo from the work of Cannon and Rajan [7]. In the concept, each of the two firefighters in a unit wears the interactive glove. By making one of four gestures with their fingers, firefighters can send a message to their colleague. When a message has been received, the glove shows a light signal. Additionally, a sensor detects the distance between the gloves and indicates the distance on a four-bar LED display.³

Robot Swarm: For the second concept, participants read a quote from a paper by Naghsh and Roast [30] that describes how a swarm of robots surrounds a firefighting in a building and scans the area for potential dangers. The firefighter receives directional guidance from the swarm of a safe direction displayed using a set of LEDs attached to the helmet visor.

Head-Mounted Display: The third concept was presented using a video clip from a research project [16]. In it, researchers present a prototype of a navigation support system that, based on a set of sensors, provides the firefighter a head-mounted display in his mask with a floor plan on which the firefighter can see his current position. When sensors detect a danger in a certain room, such as a high temperature, the color of the room on the map changes to red.

Future Firefighter: The fourth concept was taken from a vision for a future emergency response scenario [32]. In the video, the authors describe their concept for the future firefighter. According to the vision, the firefighter is equipped with a body area network that combines a number of sensors and new means for communication. All information is displayed in the mask of the firefighter. The firefighter can read the outside temperature, switch to an infrared display mode, see avatars of the people he is talking to and gets information about victims in his field of view. The commander also can monitor the location of the firefighters on a tablet.

After the introduction of a concept, interviewees were asked to comment on the design by describing, on the one hand, the potential changes that they imagine for the frontline practice caused by system and, on the other, what technology designer of the system could learn from the practice. Participants were suggested to use the interactive version of the pattern language as a tool to support their arguments. Each interview lasted for about 45 minutes and was captured using an audio recorder. Later, all recordings were transcribed and translated from German to English. The data was then analyzed in an open coding process [24], looking for categories that describe the participants’ understanding of the pattern language and how they use it for commenting on the technology concepts.

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³ This type of interaction differs from the original work by Cannon and Rajan who suggested distance sensors as a means to sense the distance to the closest object.
Results

Introduction: Recalling Patterns
While sometimes not recalling them by name, participants could explain many of the patterns well. The following participant, for instance, started out with the overarching theme.

Fluid order, that I remember, of course, this overarching pattern: There is order but it also continuously and spontaneously adapted to the context.

Other participants did not remember all the patterns by name but recalled the concepts. In some cases, participants did not recall the English names of the patterns but used words in German that translate to the pattern names in English. The following participant, for instance, only used the English words for BACKUP TEAM and EVER-CHANGING PUZZLE, but described INDEPENDENT UNITS, LEARN BY MISTAKE and TAKE GOOD CARE using German words.

I don’t know the name now, that the firefighters form independent groups of two to three people and they then also, once they’re inside, have to make independent decisions. That there always has to be a back-up team that is there for any emergencies and is available. That they learn from mistakes and they are well documented [...] There is also the ever-changing puzzle that information is always partly known and that the picture builds up slowly or some parts can change because the situation changes, too. That one has to be careful and to care for ones own safety and the safety of the others, that all is uncertain and one can never know what will happen. [...] Also part of the safety is that one has to know the way back.

As the quote above also shows, participants had mostly clear ideas of the patterns and were able to describe them. Only in the discussion later some minor misunderstandings came to the fore, regarding the detailed contents of the patterns. With the help of the pattern overview, however, all participants could recall the majority of the concepts immediately, and, after briefly scanning the overviews, could use all patterns as a means to support their comments on the design concepts.

Identifying Miss-Matches and Missing Features
When comparing the proposed designs and the practice described in the patterns, participants identified mismatches. Both the proposed systems with the robot swarm and the head-mounted display pictured the firefighter as a person working alone and did not include information about the interaction with other firefighters such as mentioned in independent units or rigid structure. Interviewees commented:

First I ask, why is it all about one firefighter because usually they are together with others and this sounds almost like as if one would like to replace the teams with robots and one says that when the robots are there it is enough if one is alone and this I doubt a lot.

Actually there was nothing ... that is all about the individual firefighters ... there was nothing about a whole unit that works together or a command post that can intervene but it was an individual means of support.

For the system with the head-mounted display, interviewees also saw the need to integrate updated information in the system to support EVER-CHANGING PUZZLE. While the video did not explicitly talk about whether or not the displayed map can change, participants identified this as an important aspect. One interviewee referred more generally to the problem, he said: “The problem is how current is this information, how static? [...] If the building burns the structure can change.” Others specifically mentioned the pattern and provided an in-depth critique:

I see a problem with the ever-changing puzzle, how recent is my information? There [on the map] it still says ‘the room is safe’ and I go in and there is a big conflagration and the backdraft. How well can I rely on that information or how do I add new information? [...] What’s about the ever-changing puzzle? That would be my exclamation mark.
Here’s danger lurking for an IT system.

Discussing Overall Concepts
Apart from missing features in the proposed systems, participants discussed how the systems match the frontline practice overall, by asking how they can be used by firefighters. For the interactive glove, for example, some participants questioned the core concept of distance sensing in relation to MULTIMODAL ACTS and thought about the value of touch that firefighters currently use to stay aware of each other. One interviewee commented:

I ask myself: It is always the case that two stay together, that’s how I understood it. [...] Actually, this converts the distance felt by touch to a visual input. But if you touch your partner you can not only know the distance but also learn for instance that there is a step in case your partner is lower than you.

For the system with the swarm of robots, interviewees used a number of different patterns to check the concept. They discussed, for instance, the pattern INDEPENDENT UNITS:

I don’t like “the swarm of robots determine a direction that the firefighter has to follow.” [Quote from the description of the concept] If that means that the robots decide and you just have to follow that would not work. That is a sign of independence. [...] I am not sure if the independent units would be so independent if the robots say everything.

Mentioning the pattern EVER-CHANGING PUZZLE and aspects of the patterns SHARED ESTIMATES and TAKE GOOD CARE, another interviewee asked, in a similar manner, for more transparency in the data communication:

I think that the information has to be precise, or, how should I say that, it should not be like that, it is, I believe, difficult if these robots somehow capture a lot and then conclude something and then they say ‘attention here is a
dangerous obstacle’. Because you are somehow skeptical. How does the robot know that? So in principle from this puzzle and from this information that I have, I want to make my own guess how the situation is, I believe, because I have the experience and not the robots. It has to be like that: that the robots if they measure, feel, somehow, that this one-to-one goes into this puzzle.

The future firefighting scenario, presenting an overall, seemingly perfectly integrated system, made participants use different strategies for applying the pattern language as a means to talk about the overall system concept. Immediately after the video finished, an interviewee commented: “This is a lot of information, this is like a computer game.” When asked to inspect the system more closely, he used the patterns as a checklist to evaluate the system and could solidify his critique.

OK, the ever-changing puzzle is OK, monitoring is OK, but all those multimodal acts, here there is so much information in the visual channel. That’s overwhelming. OK, the way back if they have a pretty big display, OK, that will be better and infrared cameras in smoke situations … ever-changing puzzle OK, everybody can have all the information. But, I don’t know which pattern this was that the people feel in control, I don’t think that was a pattern … Maybe these independent units? Exactly!

Another participant described that the system will endanger existing patterns. He also envisions a new pattern that will be required to handle the new system.

As I see it, based on all this data they give instructions. […] That is maybe a new pattern ‘remote instruction’ but things like skills such as mash-up or handy multi tools are lost.

While discussing the concept of HANDY MULTI TOOLS an interviewee discussed the nature of the system design and how it compares to existing tools for firefighters. In his remarks, he described the relation between tools and tasks in the way that databases are designed and identifies a new relation between tasks and tools for the new system.

I think they [the firefighters] do not want to rely on technology but better use it as tools, for specific tasks, there are also multi-tools that support many tasks. There is not a one-to-one relationship, this tool for that task, but one tool supports many tasks. And here it is even so, […] a one-to-many relation reversed from what is currently being done, namely that I have a small tool and that is for multiple tasks, here I have a tool, namely the suit and it is responsible for everything. I think this is not good.

Whether or not one might agree to the statements made, the above quotes on the systems by the participants are broad, as they touch many aspects of the systems, and rich, as they are very specific on certain aspects. Thereby, the quotes above are examples on how to start a reflective discussion on the overall concepts of the proposed systems in relation to frontline practice.

Adding Features and Changing Concepts

In different cases, participants called for improvements or changes to the proposed designs. For the interactive glove, for instance, a participant suggested an alarm to be triggered if the sensed distance between members of the independent unit becomes too large.

One idea, for example, if the glove recognizes if the other person is too far away that it signals that […] What I spoke about was that with independent units that they should take care for each other, that it [the systems] tells them ‘you have forgotten your partner somewhere.’

For the head-mounted display, the pattern THE WAY BACK made interviewees suggest a feature that would include that return path on the map. An interviewee described this by making a case in which he actively tried to use a pattern as a means to search for a missing feature and also as a direct means to provide the design solution.

It would be good, if one could say, from this pattern, this and that has not been included and one could include it in this and that way. I try if I can find something. What was again “the way back”? […] I read the pattern for 10 sec Yes, this has not yet been included … at least I have not seen it in the video. So if this really has not been included, one could say that it is important that the way back is always clear and this could be either integrated through visual clues, you could integrated that into the heads-up display, or using the rope. But I think the rope already exists, I would assume now that it did not get replaced by the system.

The approach in this case is to retain the existing practice and ensure that the patterns become reflected in the design. The proposed solution represents a linear transfer of an aspect from the pattern to the design of the computing system.

Another interviewee, for the systems with the swarm robot, invented a new way of using the system and suggested a new procedure for firefighters using the system. In the proposal, instead of receiving directions from the robots, the firefighter can control and send the robots as a new means for take good care.

My procedure would be: I do know the place and if I do not know something I send my scouts. By that way I fulfill ‘take good care’ […] I do not need to feel with my leg [the surrounding, as described in the pattern] but I know [from the robots] that the floor is strong enough.

For the future firefighter scenario, another interviewee, while not directly making a change proposal for the design, used shared estimates to point to an aspect that is missing in the overall system and, when considered in the future, could again empower the on-site firefighters.

For example those shared estimates […]—I actually like these shared estimates—they are maybe missed out, they are neglected. You do not ask the firefighter on-site ‘how do
you assess the situation? ’ but instead you rely on this collected data and fuse the data […] and make decisions.

The above examples of a glove system that does not replace touch but becomes active in emergency cases, a head-mounted display that displays the firefighter’s path, a robot swarm that is controlled by a firefighter and a smart system that also allows for input from the person on-site, show how pattern language can be to change system designs so that they are inspired by the existing practice.

**Divergent Views**

While the quotes so far might give the impression that participants shared similar views on the systems, this was indeed not always the case. Sometimes, individual participants held contrary positions concerning if and how the proposed system influence firefighting practice. Putting these statements next to each other shows the contrast. For the robots, one participant argued:

*They [the robots] […] give a bit of additional information. That is all that they do. About rigid structure, they are at the end of the food chain. Of course they do not belong to the family. Independent units … Well, they have a guy that they belong to. […] If the robots do not stand in the way, I have no idea what kind of influence they should have.*

For the same system, other participants had different views on potential changes. “*I am not sure if the independent units would be so independent if the robots say everything,*” was one statement. Others noted: “*[The system] maybe contradicts this take good care because I go without thinking because the robots say everything is safe,*” and questioned the information provided by the robots “*Can a robot capture the same multimodal acts as a human? I would doubt that.*” Also, participants discussed the relation to BIG FAMILY in greater detail and used it as a means to talk about the trust one can develop in a robot.

In another case, a participant talked about the future firefighter scenario that provides a firefighters the visor display with all information. He said:

*I think there are of course things that do not change. Rigid structure, big family, it [the system] has no influence on that. It only provides him information. It does not give instructions. […] Then I have procedures, they do what they always do and get additional information […] Fulfilled as well. Monitoring very clearly fulfilled. Ever-changing-puzzle even, too. […] This take good care, technology has nothing to do with that, he acts, the firefighter of the future, he would need to do the same, what he always does. Feeling, sensors and feeling and being careful, he always does that. […] If this visor helmet stops working, they can work as before.*

The other interviewees had divergent view on the system. The following example is from a participant who had a very different perception of the system, for him the system would entirely change firefighting practice.

*What would be changed a lot would be those multimodal acts if I only take a look and get all kinds of information, temperature, there’s a living person […] in the end it’s only about moving yourself to the place, to do something and going back out. Everything else is handled by technology. […] Finally, everything would change absolutely everything or almost everything with monitoring, the way back and take good care and everything that deals with technology and not with emotions like big family. One can send and idiot inside. Maybe one also does not need the big family anymore as all critical situations are prevented.*

Interestingly, the positions of individual participants varied. An interviewee, for instance, did not envision the robots to influence the frontline practice at all but foresaw a number of practice changes for the future firefighting scenario.

**The Role of the Pattern EXERCISE**

In different cases, participants referred to the pattern EXERCISE when they foresaw that a system poses a large change for the existing practice. For the head-mounted display, for example, an interviewee stated that “*this would require a lot of exercise*” and for the future firefighting scenario another said:

*That would completely change the way of working as a firefighter. […] And if one introduces something this extremely novel, that would have to be exercised for a long, long time so that one gets routine with this new technology.*

It remains, however, an open question whether or not training could solve the problem of using the new systems. Arguing with EXERCISE one could easily get the impression that any system can be introduced as its issues can be solved with EXERCISE. The question that these statements do not address is what comprises an adequate amount of training for the introduction of the system. Currently, the pattern EXERCISE in firefighting frontline practice does not necessarily provide a means to support radical change.

**Posing Questions**

Participants discussed the proposed systems in relation to changes that they may cause for the patterns. More then speculating about the changes, participants sometimes expressed that they are unsure about the impact. An interviewee commented on the map displayed on a head-mounted display as a potential change for the relation between commanders and subordinates and expressed that he is “not sure. I guess that would change the relation between firefighters and commander.” Another interviewee commented the same system and its impact for the pattern TAKE GOOD CARE. He left open the potential impact and called for further research: It “could be positively and negatively affected […] one would have to study that.” In this way, pattern language serves as a tool for identifying questions to be answered by further research.
Conclusion: Overall Feedback

Following the discussion on the proposed concepts, participants were asked to summarize their experience with the pattern language for discussing the proposals.

In their statements, the value of pattern language as a means to talk about the novel systems became apparent: “This is a manageable number of patterns that give this frame to talk about it,” a participant stated and continued “For me this is now, so to speak, the basis and my picture of the firefighting domain.” Another interviewee added: “I find them to be well-defined, I would not say for anything that it is no individual pattern for me.” Patterns reminded the participants on aspects that might otherwise get forgotten:

‘Multimodal acts’, I would for instance not have thought about that. This idea I would not have had [...] This really helped to think it through. Also the ‘exercise’ would not have come to my mind.

Taking the pattern language beyond the workshop, another participant envisioned the language used as a shared glossary in his project work with partner from different organizations.

Everybody has a certain idea and they talk about it but they cannot hurl a word at each other. [...] If I now ask somebody: ‘Did you ever think how your technology supports multimodal acts?’ Then he knows exactly, OK, it’s about this more sensible perception of information with the senses and thinks that how that fits into his technology.

As these quotes and the previous examples show, during the discussion the pattern language becomes an important means of communication for commenting on technological proposals for frontline firefighters.

DISCUSSION

We have started this paper by pointing to the need of including the social dimension in the design of computing systems and by pointing to the difficulty of connection contextual analysis and design and by pointing to the discussion of producing shareable research results.

In our example, we have used pattern language as a tool to make developers familiar with a practice that had been unknown to them and confronted them with new technological proposals. Our participants’ comments, especially when taken together, brought to the front a great variety of issues, implications for design. Participants made extensive use of the patterns as words to describe practice concepts despite the limited time to study them. Only in a few cases, usually when the mismatch between the described practice and the design was very visible, a direct link between contextual analysis and design could be seen. In most cases, there was not a direct or unique link between the practice description and the implications. The interviews showed that the participants, supported by pattern language, considered a variety of different implications for different practices that a single system might have. Consequently, a pattern language approach does not provide a process between ethnography and design that can be easily followed or where the next step is defined by the previous, based on a logic set of rules. Instead, a specific value of pattern language is the support of an open dialog on implications for design. In this dialog, a system might support a number of patterns but still could be in conflict with a single aspect that cannot be easily ignored.

Instead of deriving design solutions from individual aspects or answering the question if a certain pattern should be changed or emphasized, pattern language allows confronting a new system with an entire practice; it allows to “to metaphorically zoom out to a wider view” [33, p. 283-284], it sparks “reflective thought and conceptual analysis” [25, p. 59], and poses questions about ‘what it means for a system to be ‘good’ in a particular context” [26]. This dialog, in practice, does not need to be limited to a closed circle of developers, as in our study; it could be opened-up to the people affected by the changes, too.

CONCLUSION

In this paper, we have presented results from a study focused on making knowledge from field studies available for a discussion about implications for design. In our case, the pattern language approach has shown to be a meaningful tool to reflect the impact of four new systems for frontline firefighters. Pattern language is only a limited tool for directly deriving design solutions. Instead, it supports communication and thus an open dialog on implications for design. Alexander’s and Erickson’s proposal of using pattern languages to support design has shown to be a handy framework for this. While our study does not constitute a controlled experiment, we, nevertheless, hope that the presentation and discussion of the approach allows other researchers to build on, further develop and testify our findings. While we are not sure if the openness of the approach and variety of the comments by the developers allows us to claim that a pattern language is a means of ‘bridging the gap’ between contextual analysis and design [28], at least it helps to prepare the jump.

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