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Research Article

Minimalism for the Win: User-Centered Design for Guidance in Industrial Maintenance

—Hanna Heinonen, Jenni Virtaluoto, Tiia Suomivuori, Kristian Forsman, Tuomas Kangas, and Sanni Siltanen

***Abstract*—Background:** *We conducted an exploratory study to test the delivery of technical instructions built on the principles of minimalism. The aim was to investigate how we could support target users' skill levels in a context-sensitive manner.* **Literature review:** *Related work examines minimalism, user needs and profiling, and industrial maintenance and technician experience.* **Research questions:** *1. How can the semantic structure of DITA XML be utilized in delivering technical information to users based on their skill levels? 2. How would a layered system of information support the principles of minimalism?* **Methodology:** *We created material and tested the concept in user studies with maintenance personnel in three countries. We collected feedback through participant observation, interviews, and questionnaires.* **Results and discussion:** *The minimalist approach of delivering information to maintenance technicians was well received and supported users with varying skill levels.* **Conclusion:** *The context-sensitive level of expertise concept empowers users to decide on the depth of technical information that they require to complete the task at hand. The semantic structure of DITA XML works well in the delivery of technical information to the users based on their skill levels. Many of the key principles of minimalism are applicable to hardware maintenance instructions.*

Index Terms*—Darwin Information Typing Architecture (DITA), industrial maintenance, minimalism, structured authoring, user-centered design.*

The ongoing Industry 4.0 revolution is changing the world of industrial maintenance. The focus is shifting from annual maintenance plans with predefined maintenance tasks to predictive and condition-based maintenance, in which computers help humans predict issues before they are visible to the human eye. In predictive maintenance, trends, patterns, and correlations are analyzed for anticipated failures to help with maintenance decision-making and to avoid equipment downtime and callouts [1]. In short, issues with equipment are identified and fixed before breakage.

With predictive maintenance, the work of maintenance technicians is also changing dramatically. Traditionally, when maintenance technicians work with certain equipment, they build up knowledge and learn the necessary tasks, rarely needing instructions to complete them. However, with predictive or condition-based maintenance, the tasks vary from day to day and from one piece of equipment to another, and even experienced maintenance technicians need guidance on which tasks to perform. Therefore, there is an increased need to provide instructions, even for experts [2]. Naturally, at the same time, novice technicians need more detailed instructions. Consequently, it is becoming increasingly important that the needs of technicians with different skill levels are supported efficiently and flexibly in the technical instructions that support their work.

In response to these challenges, we conducted an exploratory study in which maintenance technicians performed elevator maintenance with instructions built using an interactive design mechanism. This design was based on the feedback received earlier by the company that experts did not want to see too many details; too much detail hindered task completion, and the experts would rather operate without instructions than get lost in too many details. On the other hand, novice users needed those details, so they could not be removed altogether. Our aim was to investigate the

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Practitioner Takeaway

- The concept of context-sensitive level of expertise empowers users to decide on the depth of technical information that they require to complete a task.
- Filtering information using the DITA XML semantic structure works well to target information to different skill levels.
- Although minimalism has often been seen as an approach relevant only for software instructions, many of its key principles are also applicable to hardware maintenance instructions.

possibility of supporting different skill levels efficiently and in a context-sensitive manner with a delivery mechanism built on DITA semantic tagging. In this article, we introduce this mechanism and the concept of *context-sensitive level of expertise*, in which users are given the agency to decide on the depth of technical information required to complete the task at hand in a case-by-case manner.

The technical instructions used in this study were built using the principles of minimalism. They are action-oriented, user-centered, task-based, and concise [3]. Although minimalism has been a trend in technical communication for decades, relatively few reports provide advice on implementing it in practice [4].

In this study, we did not focus on the actual textual and visual content of the task topics, as this area has been studied earlier [2]. Instead, we expanded the principles of minimalism—usually applied in the content creation phase—to the delivery of maintenance instructions.

We propose that our delivery mechanism is inherently minimalist. Our approach "respects the integrity of the user's activity" [3]: according to the principles of minimalism, help should be available as needed but not interfere with the user's task completion. In addition, the proposed delivery mechanism allows users to act immediately and supports their actions despite their level of expertise. This is a priority in minimalism [3].

Since minimalism was created with novice software users in mind [5], it has been suggested that it might not be applicable to hardware settings or with complex enterprise products. Although our primary focus in this study is on the delivery instead of the creation of information, the documentation used in the tests was written with the principles of minimalism in mind and was aimed at expert users in hardware maintenance settings rather than novice users working with software.

LITERATURE REVIEW

Minimalism and User Needs Minimalism is a **user**-centered, **use**-centered, and **action-oriented** approach for creating technical documentation [6].

Minimalist instructions allow users to start working immediately on real-life tasks. The instructions encourage users to try things out on their own and provide ample error information for independent problem-solving. The focus is on providing users with the information they need when they need it and doing so as concisely as possible [3].

Although minimalism has been one of the major trends in technical communication since the 1990s [7], it has also been criticized. For example, it has been seen as applicable only to software documentation for novices [5]. One of its four principles, guided exploration, has also been seen as frustrating and inefficient for users [8]. In guided exploration, users are encouraged to explore the system independently instead of relying on detailed step-by-step instructions for completing tasks. This way, they are expected to learn the system in greater depth [6].

However, in many current contexts of use, the idea is not to get users to learn a new system but rather to allow them to accomplish the task at hand in the most efficient way. In such settings, omitting pieces of information in the instructions would be not only frustrating but also dangerous. However, the other principles of minimalism, such as providing user-centered and action-oriented information, are in line with the best practices of technical communication [4].

Modularity is also one of the cornerstones of minimalism, and present-day content management

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systems allow for modularity in a much more efficient way than the documentation tools of the 1990s did. Instead of merely reducing the amount of information—one of the misconceptions often associated with minimalism [9]—optimizing the information should be the focus [10]. The key is to present users with only the information they need at that specific moment and otherwise get in their way as little as possible.

The original minimalism heuristics proposed by van der Meij and Carroll [3] have recently been revised [4] to provide technical communication practitioners with a practical evaluation tool for assessing whether their content fulfills the principles of minimalism. The three main categories of the revised minimalism heuristics are as follows:

1. Core tasks and goal orientation
2. Accessibility
3. Error management

Along with troubleshooting instructions, the most typical error management information type in hardware manuals, the third category covers instructions that can help users prevent and recover from errors. It also deals with warnings and notes. Preventive maintenance instructions and checklists, typical of hardware, could also be classified as error prevention instructions. See Appendix A for a full list of the revised heuristics.

As mentioned above, minimalism originated in the context of software user instructions, but the revised heuristics are intended for hardware too. The applicability of the revised heuristics specifically to a hardware context was tested in a workshop with technical communication professionals, who evaluated the PDF of a traditional maintenance manual for industrial hardware [11]. In this limited test, the practitioners found the revised heuristics a useful tool for evaluating instructional content for heavy machinery end users. All workshop participants found several issues to be remedied during the relatively brief time allotted for the evaluation task, and participants also noted that the heuristics would work well as a checklist for content production.

Although the first and most important category of the revised minimalism heuristics concerned supporting the users in completing their core tasks, it was the second category—the accessibility of the instructions: the content, findability, understandability, and visuals—that workshop participants mainly focused on. Perhaps because they were communication experts, the workshop participants concentrated on the heuristics whose implementation and evaluation came most naturally to them.

Even though it became clear in the workshop's wrap-up discussion that the participants had, in fact, kept the users and their goals in mind during the evaluation, the findings can also be seen as indicative of a wider issue regarding user-centeredness in technical communication, especially in the context of hardware: the subject matter experts and the authors of the instructions are not the users. To produce usable minimalist instructions that enable users to begin and complete their core tasks as quickly as possible, technical communicators need to know the users. Although it is possible to improve end-user instructions by ensuring that the content fulfills the accessibility criteria of the revised minimalism heuristics, the real challenge lies in optimizing the information for different types of users in their specific use situations.

Although this type of user-centeredness is at the heart of minimalism, the approach itself does not offer any concrete methods for producing user instructions for different types of users and contexts, for example. Instead, it assumes that all users are active learners.

The revised minimalism heuristics focus on the versatile needs of different types of users and are intended as a concrete tool to be used in the content production and evaluation phase. However, rather than pre-profiling users and delivering information based on that profile, the users themselves should be empowered to decide the level of information they require in each specific context [2]. This study explores this concept as a step forward in user-centeredness as well as action orientation.

User Profiling in Technical Communication

Technical communicators are familiar with user profiling based on expertise. For example, Hackos [12] categorized users into expert performers, competent performers, advanced beginners, and novices; Jayaprakash [13] classified them into experts, competent performers, and beginners; van Laan [14] talked about brand new beginners and experienced users; and van der Meij et al. [15] identified different types of needs for novice users and specialists. These profiles are then used as the starting point when creating instructions for users with different skill levels.

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DITA XML supports conditional profiling as well and offers the standard attribute *@audience* for filtering content for different audiences [16]. In many cases, this attribute is used to tailor outputs for experts and novices—i.e., to filter the same content to create different sets of instructions for each group of users. This DITA feature naturally supports the reuse of content in the authoring and publishing phase.

Although user profiling is a well-established concept in technical communication and mechanisms exist for its implementation, the traditional outcome has separate instructions for different user groups—for example, a quick guide for experts and a comprehensive user guide for novice users. In practice, the users are pre-profiled for their skills and are then delivered instructions based on that profiling instead of being able to decide on their information needs themselves while completing tasks.

Industrial Maintenance and Technician Experience During the last few decades, Industry 4.0 has transformed the way maintenance is actualized in the field and how services are implemented with remarkable developments in information technologies, cheaper sensors, and ever-increasing connectivity. Today's service businesses are driven by customer value, smart services, and sustainability [17], [18].

Sensor data are used to provide information on the behavior, use, and condition of the equipment. Data collected across time and across different pieces of equipment are analyzed with advanced data analytics methods. Artificial intelligence provides insights into the condition and maintenance needs of individual pieces of equipment [1]. With predictive and condition-based maintenance strategies, companies aim to avoid unscheduled maintenance visits, increase equipment up-time, reduce downtime and costs, and improve customer satisfaction.

Traditionally, preventive maintenance has used a time-based maintenance strategy in which specified maintenance tasks are carried out at certain time intervals. The interval can be adjusted, for example, to be shorter for high-utilization-rate equipment, but nonetheless, the activities performed during the maintenance visit are always predefined and static. On the contrary, condition-based, predictive maintenance strives to perform the necessary maintenance actions just before a predicted breakdown to prevent it. This condition-based maintenance strategy can achieve higher reliability with lower maintenance costs compared to a time-based maintenance strategy [19]. Furthermore, the aim is also to avoid over-maintenance and to perform only the necessary maintenance actions as there is a constant need for optimization and cost reduction.

At the same time, artificial intelligence solutions can predict the most probable root causes to aid in troubleshooting, and the system can offer context-relevant guidance and instructions for the technician. Previously, complex repairs were performed by experienced technicians, but with these new technologies, less experienced technicians are also able to work on such tasks.

From the maintenance technician's perspective, this means that the activities performed during each maintenance visit are different, and the tasks that the technician needs to perform vary from one piece of equipment to another. Technicians can no longer learn the task list by heart, and even an experienced technician needs to follow instructions, at least to understand which tasks to perform. In addition, some maintenance tasks may be performed very seldom with condition-based maintenance. Therefore, even experienced technicians might not remember everything and need to turn to the instructions to verify some details, such as parameter values. At the other end of the experience continuum, novice users still need very detailed instructions. This fact poses a new challenge for technical communication: How can you support the work of maintenance technicians, both experts and novices, when you can no longer rely on predefined talent profiles or standardized task lists?

Research Questions

Our research was motivated by the need to understand how the principles of minimalism can be implemented in practice. More precisely, we aim to answer the following research questions.

RQ1. How can the semantic structure of DITA XML be utilized in delivering technical information to users based on their skill levels?

RQ2. How would a layered system of information support the principles of minimalism?

As discussed above, minimalism has often been seen as applicable only to designing software documentation for novice users. Our primary focus in this study is on the delivery instead of the

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creation of information, but the documentation used in the tests was aimed at expert users in hardware maintenance settings rather than novice users working with software.

Research Methodology

We used the lean start-up method to develop and test the usability of the concept iteratively. The lean start-up method is based on a build-measure-learn feedback loop, where the phases of hypothesis, proof of concept, user evaluations, and adjustments are repeated as many times as needed [20]. The feedback loop allows for ideas and concepts to be tested flexibly with users with minimally viable products before going into full production mode with the product, therefore, testing the viability of the concept before any final business decisions are made.

We used both qualitative and quantitative methods in this study, including participant observation, interviews, and questionnaires. Our focus was on qualitative methods, as we wanted to gain insight into the opinions, thoughts, and feelings of maintenance personnel with different levels of experience working in the field [21]. We also obtained some quantitative results, but as our test groups were small, the results were only indicative. However, the participants in our user study were all people who performed the work described in the instructions, albeit with different levels of experience. Therefore, they represent people working in similar roles and, thus, their opinions carry considerable weight.

We tested the first iteration of the concept in Germany and Finland in late 2020, and a new, further developed and improved concept was tested in Poland during 2021–2022. For both iterations, user test participants performed tasks related to elevator maintenance using the instructions created for the purpose.

Iteration 1: Test Material Design and Test Setup for Germany and Finland

Test Material Design: We tested the first iteration of the concept in Germany and Finland with a prototype developed for Adobe XD. The content for the prototype was authored in Adobe XD. We analyzed the instructions for seven maintenance tasks and categorized each piece of information as either information for experts or information for novices. When users accessed the instructions for a task with a mobile phone, the expert-level information was shown as the default (see Fig. 1), and it progressed step by step. More detailed information was available for novice-level users for each applicable step with a *More information* button (see Fig. 2). Users who did not want to access the more detailed information could proceed without it.

This design was based on feedback received earlier by the company that instructions have too many details for the experts, but on the other hand, novice-level users need those details. Therefore, the aim was to support both user groups. With the test material design, we paid special attention to the clarity of instructions based on the principles of minimalism. We also wanted to create a clear sense of navigation within the task, related steps, and substeps. The test material was in English, and all test participants had a basic knowledge of English.

Participants: We tested the concept in Germany and Finland. For a summary of the participants, see Table I.

Test Setup: In Germany, the user tests were streamed over the Microsoft Teams platform with a USB camera. The tests were facilitated and observed remotely from Finland via Teams (see Fig. 3). An onsite assistant located in the same space as the user test participants was available in Germany for practical arrangements.

In Finland, the user tests were also streamed over the Microsoft Teams platform with a USB camera. The tests were facilitated onsite by a facilitator and observed remotely from other locations in Finland.

All user test sessions followed a predefined test flow. Before the tests, we explained the purpose and scope to the participants. Each participant signed a research consent form and gave us permission to record videos and take photographs during the user tests. The facilitator emphasized that we were not testing the participants or their skills but rather the concept and user-interface prototype that had been developed.

The participants then proceeded to perform elevator maintenance tasks based on the tasks and instructions offered by the application prototype. The application prototype was used with a mobile phone with touch-screen functionality. Each participant completed four randomized tasks during testing. We asked the participants to think aloud and describe what they were doing and how they felt about the instructions and the application prototype user interface. If the German

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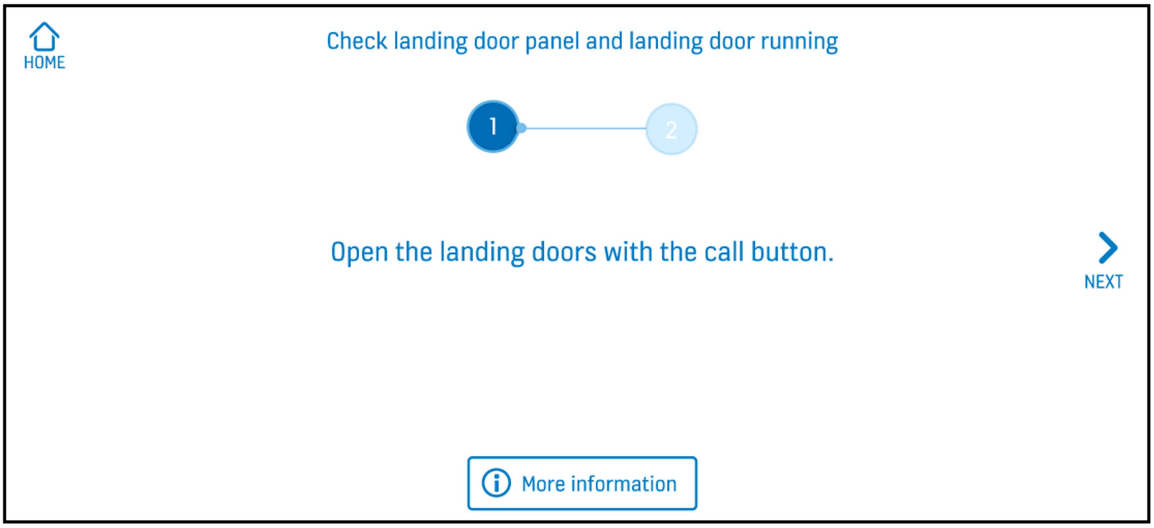

Fig. 1. Expert-level information shown for a task.

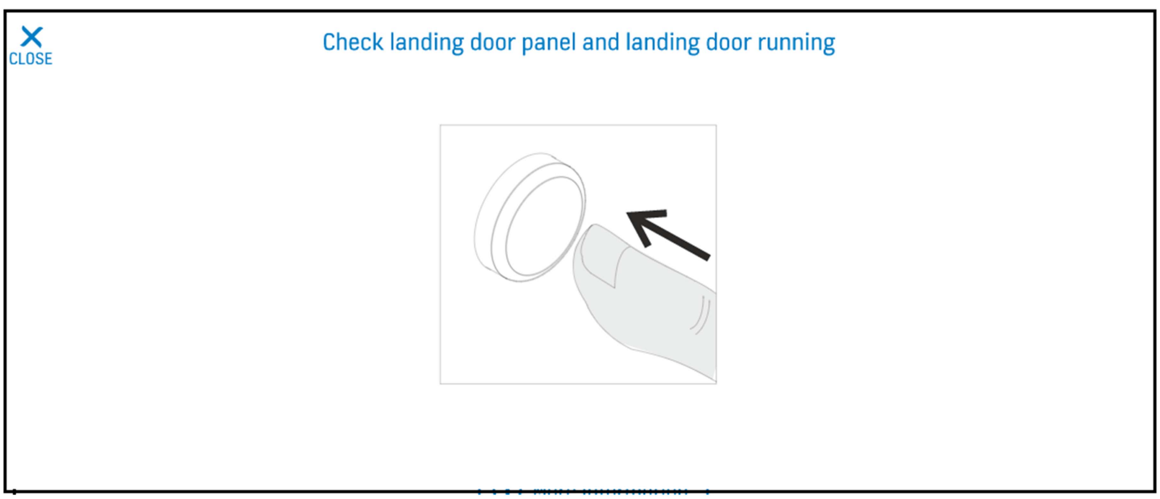

Fig. 2. Novice-level information accessed with the *More information* button.

TABLE I
SUMMARY OF USER TEST PARTICIPANTS IN GERMANY AND FINLAND

User Test Location	Number of Participants	Less Than 2 Years of Maintenance Experience	2-7 Years of Maintenance Experience	8 or More Years of Maintenance Experience
Germany	7	1	4	2
Finland	2	2	-	-

participants had trouble explaining themselves in English, they could speak in German, and the onsite assistant then served as an interpreter for the facilitator and observers.

After all maintenance tasks were completed, the participants completed a questionnaire evaluating the concept and its usefulness with seven-point Likert-scale questions (see Appendix B). Finally, a

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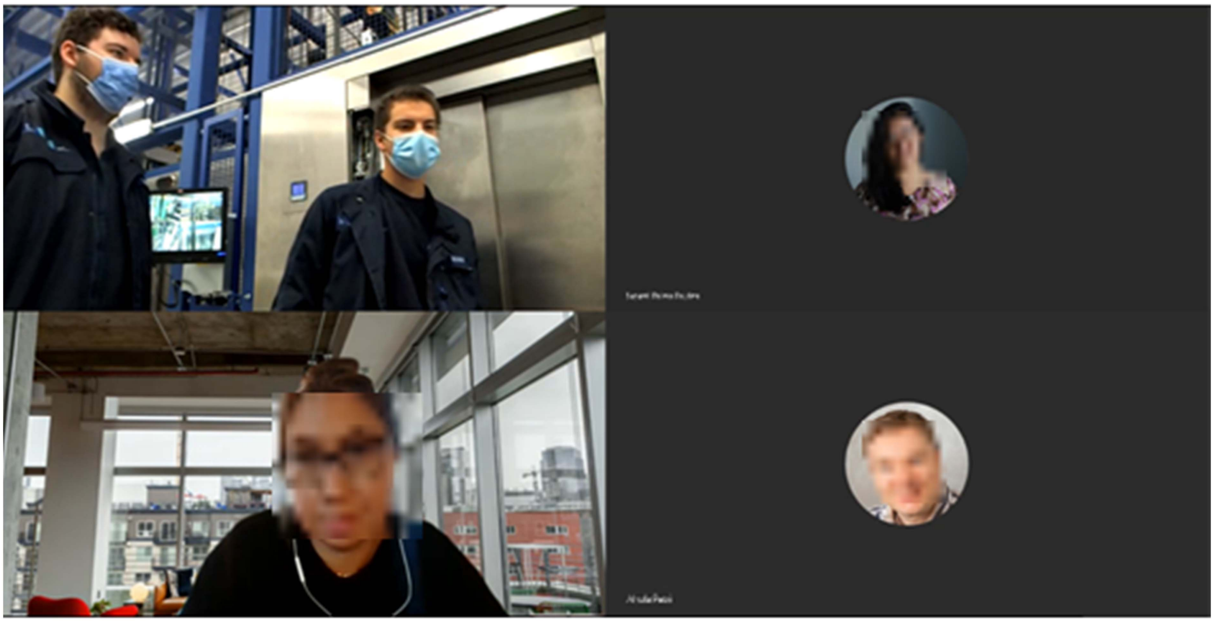

Fig. 3. Teams view of user testing in Germany.

```
<task>
<title>Check entrance and corridor</title>
<taskbody>
 <steps>
   <step>
    <cmd>Check the condition of the lights in the entrance and corridor.
      <image href="lights.svg" placement="break"/>
    </cmd>
      <info>On floor level, the entrance light must be efficient enough for a user
            to see ahead and enter the car, even if the car light has failed.</info>
   </step>
 </steps>
</taskbody>
</task>
```

Fig. 4. Example content delivered to expert (highlighted with orange), standard user (highlighted with blue), and novice (highlighted with yellow).

semistructured interview took place, with the German onsite assistant serving as an interpreter when needed.

Iteration 2: Test Material Design and Test Setup for Poland

Test Material Design: For Iteration 2, we developed the concept further based on the feedback received from Iteration 1. The content for instructions was authored in DITA XML format and stored in the company's content management system. A total of 82 tasks were created in English, of which 59 were unique and the rest reused according to DITA principles.

We used a predefined set of DITA XML elements in authoring and used specific elements to target information for three skill levels: experts, standard users, and novices. The third level was added based on the feedback received for Iteration 1. For an example of semantic tagging of a file, see Fig. 4.

The content was exported from the content management system to a dynamic delivery service. Mobile devices were then able to fetch the content from the dynamic delivery (see Fig. 5).

For this iteration, we developed a mobile-phone application to show the instructions and guide the

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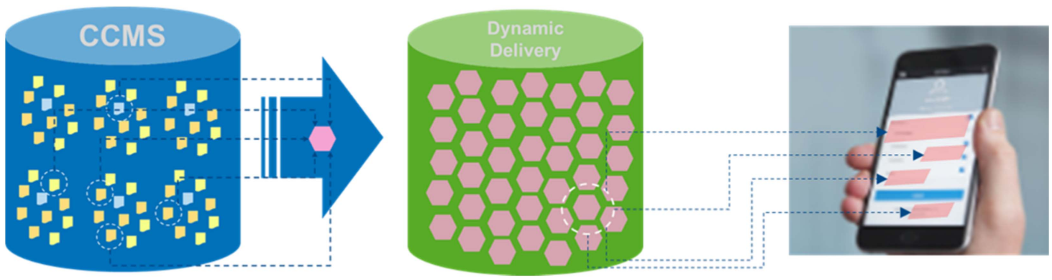

Fig. 5. Delivery of the DITA XML content from the component content management system (CCMS) via dynamic delivery service to a mobile device.

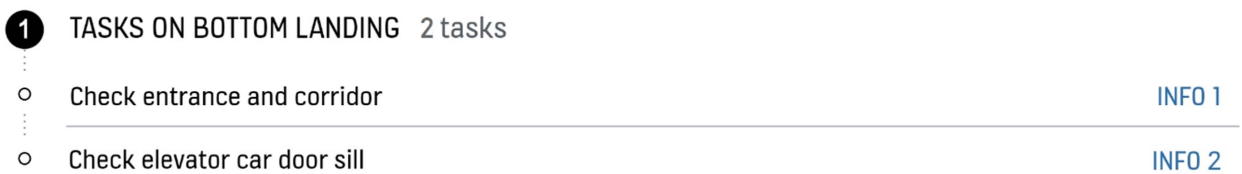

Fig. 6. Task list for expert users.

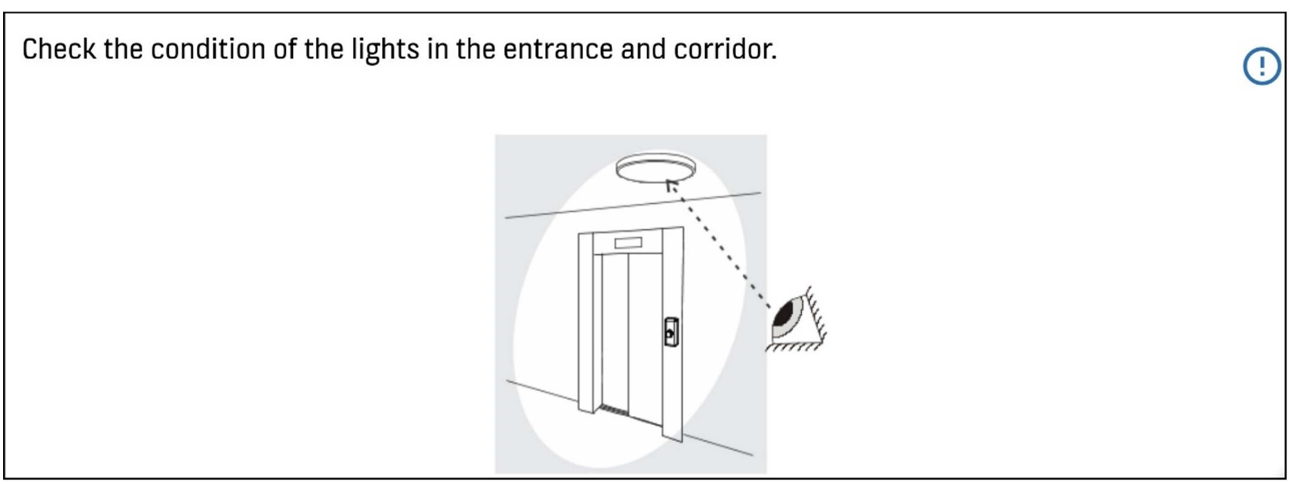

Fig. 7. Standard task instructions.

work. In the user interface, the task list and the related instructions were dynamically built with the DITA XML content so that only relevant tasks and instructions were displayed for each maintenance visit. For expert users, a checklist of tasks was created from the DITA XML titles (see Fig. 6). Users familiar with the task could proceed with just the checklist, without opening more detailed instructions. However, if the user needed instructions for any task, they were available. The standard-level instructions would then be displayed when the user opened the link (see Fig. 7). From standard-level instructions, novice users could access further details (see Fig. 8) whenever needed.

Our design allowed the users to decide how much information they needed for each task. If they were familiar with a task, they could proceed without instructions. However, if they needed instructions, two levels were available to them, and they could select information as needed.

For testing in Poland, the DITA XML content was localized into Polish. The users were able to use the application in their preferred language, either in English or Polish. From the delivery point of view, both languages worked in the same way.

Participants: We tested the concept in Poland. For a summary of the participants, see Table II.

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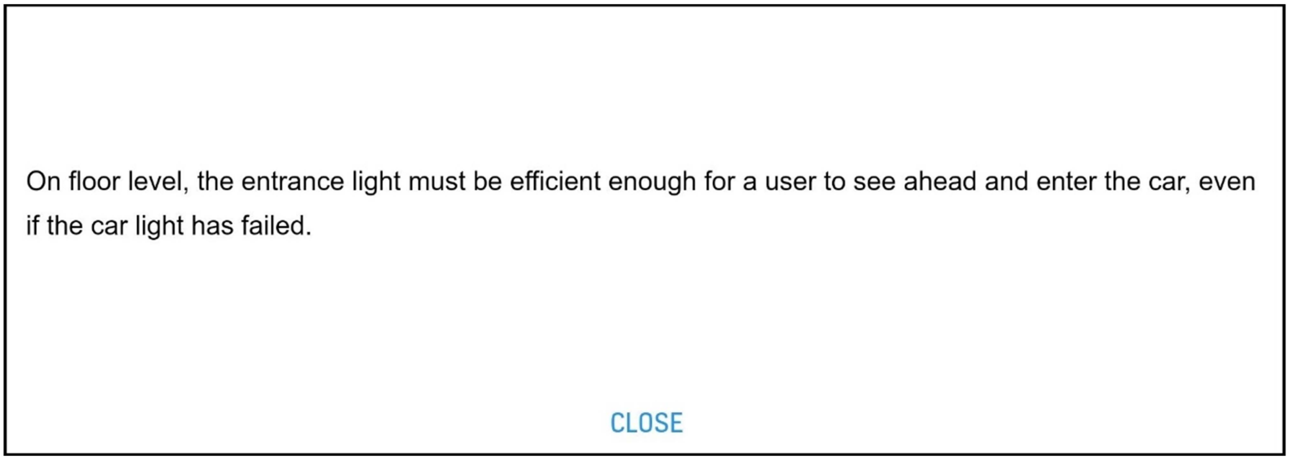

Fig. 8. More information available for novice users.

TABLE II
SUMMARY OF USER TEST PARTICIPANTS IN POLAND

User Test Location	Number of Participants	Less Than 2 Years of Maintenance Experience	2-7 Years of Maintenance Experience	8 or More Years of Maintenance Experience
Poland	13	-	4	9

Pilot Project Setup: We tested this iteration of the application and related instructions in a pilot project, a small-scale implementation used to prove the viability of the idea. The testing was integrated with the daily work of 13 Polish maintenance technicians, and it involved the maintenance of 610 pieces of equipment during a six-month period. Therefore, it was not an actual test setup but the application was used by the company's maintenance technicians as a part of their daily tasks. The selection of participants for the pilot project was made by the business line.

Due to the COVID-19 pandemic and related travel restrictions, we could not use participant observation or interviews in Iteration 2. After the pilot project was completed, the maintenance technicians filled in a questionnaire evaluating the concept and its usefulness with 7-point Likert-scale questions and open feedback (see Appendix B). We created the questionnaire in English, translated it to Polish, and made it available in both languages to the respondents. We requested research consent from each technician involved in the testing.

Data Storage and Ethical Review All the collected data were stored in Microsoft SharePoint according to company policies and principles outlined in the consent forms. As local regulations did not require an ethical review for a study such as this, it was exempt from Institutional Review Board reviews.

RESULTS

The general attitudes toward the phone application and the instructions displayed on them were positive for both iterations. The participants were engaged in the testing and eager to share their feedback on the concept. The questionnaire response rate was 100%, further proving the engagement of the test participants. A summary of the data-collection methods for each of the iterations is presented in Table III.

Iteration 1 For Iteration 1, we collected feedback on the usefulness of the information on the screen. There were questions on both the readability of text and images and the clarity of the images (see Fig. 9). As the mobile-phone screen is rather small, the purpose of these questions was to discover whether the user interface and information design for the tasks were successful, and the users could easily read and utilize the information displayed on

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TABLE III
SUMMARY OF DATA-COLLECTION METHODS

Iteration	Quantitative	Qualitative		
	Questionnaire (7-point Likert Scale)	Questionnaire (Open Feedback)	Participant Observation	Interview
Iteration 1	x	x	x	x
Iteration 2	x	x		

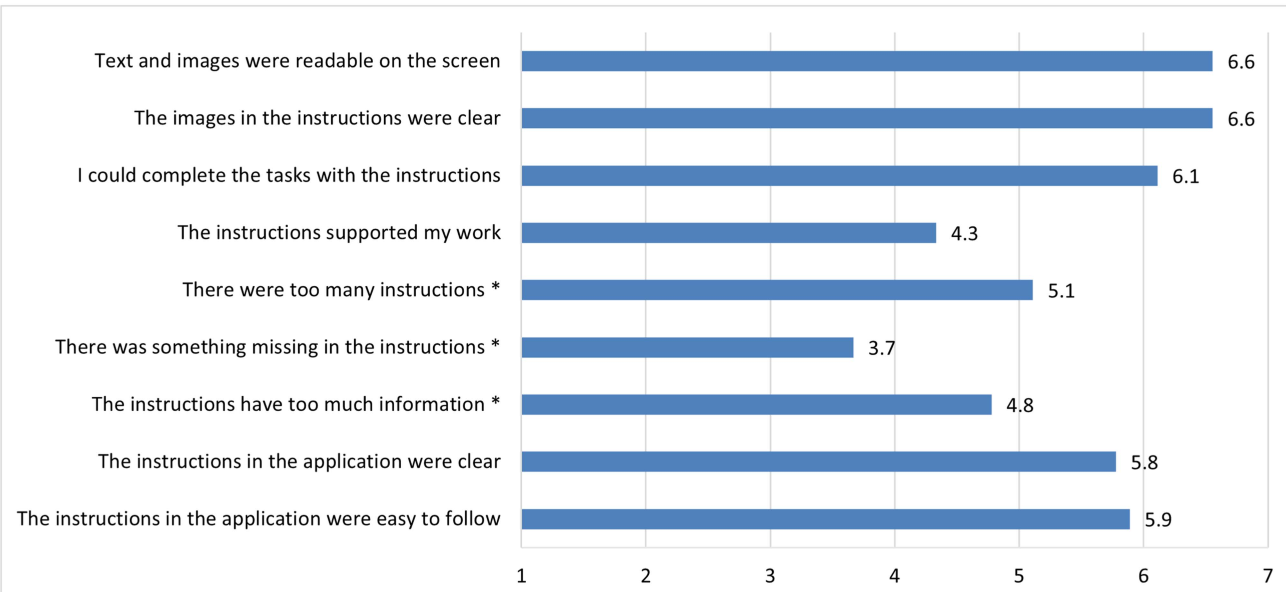

Fig. 9. Feedback for Iteration 1. The larger the score, the better the result (1 = totally disagree, 7 = totally agree). Scores marked with $*$ are reversed as the original question was negatively phrased.

the screen. The users were very satisfied with both the readability and clarity of the task instructions.

We also collected feedback on how the delivery of the instructions supported the work of the participants. In interviews, the more experienced participants commented on the need for an additional layer of instructions that would display only the title of the tasks (expert view). They noted that for an expert familiar with the tasks, it sometimes takes longer to read the instructions than it does to complete the task. They recommended a simple task name as a checklist for the experts who have no need for the actual task instructions. This can also be seen in the ratings of “there were too many instructions” and “there was something missing in the instructions” (see Fig. 9), as the two layers of information did not fully support the work of all expertise levels. Overall, however, the participants felt that the instructions were clear and easy to follow.

Iteration 2 For Iteration 2, we introduced the additional layer recommended by the test participants in Iteration 1, and the participants were able to complete tasks with the checklist only. This time, the focus of feedback collection was on the layers of information and their usefulness for the participants and their task completion. The concept of three layers of information (expert, standard, and novice) was rated positively (see Fig. 10), but open feedback suggested that task titles must be well designed to work as a checklist. In open feedback, some of the novice participants commented that they liked the idea but sometimes had difficulty understanding the task based solely on the titles given, requiring them to open the standard instructions to understand the task.

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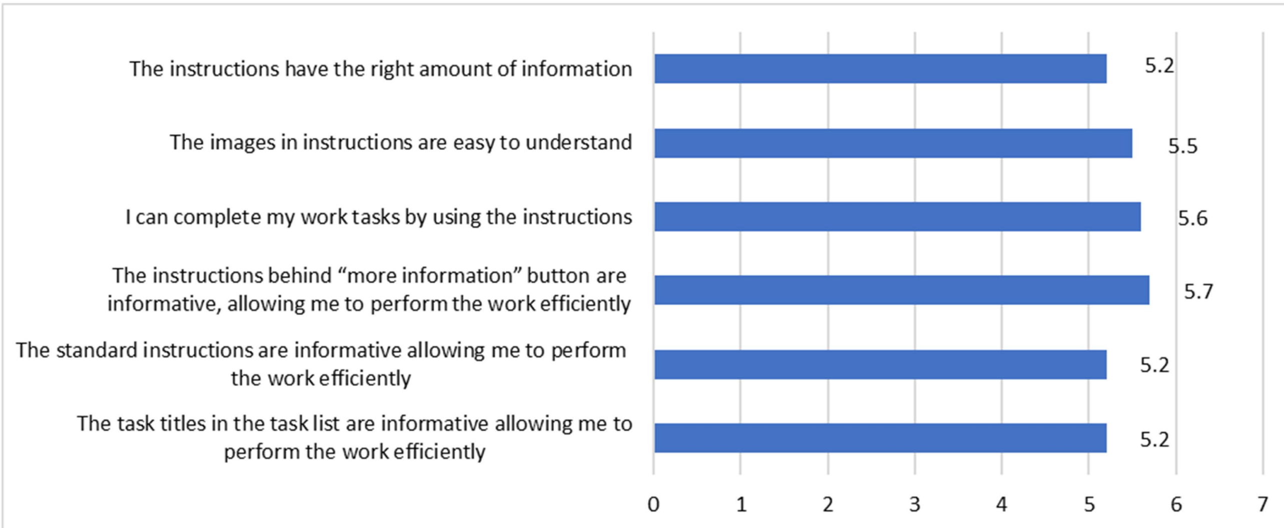

Fig. 10. Feedback for Iteration 2. The larger the score, the better the result (1 = totally disagree, 7 = totally agree).

Clear deviation can be seen in the answers, with most participants rating the concept very positively and one participant much lower. However, in the open feedback, the participants were very positive about the concept, noting that it offers them easy access to the instructions while they are maintaining equipment and effectively facilitates the needs of different users and expertise levels.

We left the clarity of the task instructions out of scope for feedback collection for the second iteration as it followed the same principles as earlier. As some modifications were made to the way images were handled, that question was included. The results indicated that images were still clear and useful for the participants.

To summarize, test participants rated both iterations positively, and adding another layer requested by Iteration 1 participants improved the concept and user satisfaction, as evidenced by ratings for Iteration 2.

Discussion

The context-sensitive level of expertise concept that we tested in this study strengthens user independence and agency, which is one of the priorities of minimalism. In the past, with separate instructions for novice and expert users, it had not been possible for users to decide on the required level of information on the spot. Traditionally, users have been classified based on their perceived skill levels, and instructions have then been targeted to these groups. This classification was done at the beginning of the documentation process, often with no access to users or user data. In this type of process, it is difficult to be truly user-centered.

Furthermore, as we are moving toward Industry 5.0 and striving to create individually personalized experiences [22], we must also start to contextualize expertise. To be able to support the users in their task completion, we should not be guessing how much information they need but empowering them to decide on their own information needs contextually on a case-by-case and task-by-task basis.

The revised minimalism heuristics suggest that immediate assistance should be available when users need it and that they should be able to get to work immediately. The context-sensitive level of expertise concept that we implemented in this study empowers the users to decide on the necessary level of information and allows them to proceed when they are comfortable doing so.

As with any new technology, there is a learning curve during the rollout of this type of new concept as the users get used to the new type of delivery. However, as the feedback from our test participants and pilot users was very encouraging and positive, it is safe to say that the design of our concept was successful.

As discussed above, minimalism has been a trend in technical communication for decades, but there are relatively few reports on implementing it in practice [4]. Because the minimalist approach was

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created with novice software users in mind, it has also been suggested that it might not be applicable to hardware settings or complex enterprise products. More recent work on minimalism also seems to focus on software [23]. Based on the results of our study, however, the principles of minimalism—such as providing users with action-oriented and user-centered information—are not setting-specific and can also be applied to hardware maintenance documentation.

The world of industrial maintenance is changing with remote monitoring and condition-based maintenance programs. Traditionally, many maintenance programs have had standardized tasks. For instance, a preventive maintenance program includes a set of checks to be performed, and by working within that program, the maintenance technicians have learned to perform the checks without the need to use any instructions. However, in the condition-based maintenance programs that are becoming more common, the tasks vary from day to day and equipment to equipment, and even the more experienced maintenance technicians need guidance on what tasks to complete. Therefore, there is a need to deliver instructions that support the work of all the maintenance technicians, from experts to novices.

Furthermore, when moving from a static preventive maintenance task list to condition-based maintenance programs, decisions are made by an artificial-intelligence system. Wanner et al. [24] describe how the unified theory of acceptance and use of technology model [25] can be modified to measure the acceptance of artificial-intelligence maintenance decision support systems. A central factor in technology acceptance is users' trust in the system and the transparency of decision-making.

It is good to remember that many human factors affect how users accept and evaluate new technologies or applications. First, users belong to different categories of the technology acceptance lifecycle [26]. Second, several factors influence how users perceive technology and how easily they adopt it. For example, the voluntary nature of use and social acceptance also play a role [27], [28].

A part of the deviation in the overall rating of our concept by test participants may have been affected by their various positions along the technology acceptance curve. One participant gave extremely low ratings for most questions in the questionnaire compared to all the other participants, and that fact raises a question about this participant's position on the technology acceptance curve.

In our study, some of the novice participants gave feedback on the usefulness of the task titles and reported that the tasks could not be completed with the titles only. Even though the titles must be carefully designed and authored so that they work as a checklist for experts, they cannot include all the information that the standard or novice instructions do, and users must learn to turn to the more detailed levels of instructions when needed.

From the authoring and delivery point of view, the concept we tested in this study works well. DITA XML is a markup language, and content authored with it can be processed to extract specific information for particular use cases [29]. When the content is designed and authored carefully, and the semantic tagging is used properly, it is possible to deliver specific information to specific parts of the user interface with application design and careful coordination with user interface designers. However, if needed, the same content can still be used to create other outputs, such as a complete PDF file of the instructions. Well-designed and authored content, therefore, enables a truly omnichannel delivery of instructions. As the structure of the DITA XML content remains the same in the translation process, this solution is also language-independent. Naturally, proprietary XML content models can also be used, but we recommend the industry-standard content model, DITA.

Van der Meij et al. point out that since 2000, research has become increasingly focused on supporting the experiences of users and fostering motivation [15]. However, very little has been done to apply this principle in practice in technical communication, even though calls for more practice-oriented and accessible academic research have been made [30]. The results of our study are, therefore, also relevant to the field of technical communication in general.

Limitations and Suggestions for Further Research We tested our concept in two iterations in three countries. For Iteration 1, we used standard usability testing where participants used the instructions to perform tasks while thinking aloud and gave subjective feedback on a

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questionnaire and in a semistructured interview (see Appendix B for Iteration 1 questionnaire). For Iteration 2, the concept was not tested in an actual test setup, but the application and related instructions were used by real maintenance technicians in the field. Due to the COVID-19 pandemic and related travel restrictions, we could not use participant observation or interviews as a data-collection method, so we collected feedback with a questionnaire only (see Appendix B for Iteration 2 questionnaire). However, as the use of the application was integrated into the daily work of the company's maintenance technicians for 6 months, the feedback received holds great significance.

As Iteration 2 was not an actual test setup, the selection of participants was made by the business line. The sample did not include any novices with fewer than two years of maintenance experience. Therefore, this fact can be considered a limitation of this study as Iterations 1 and 2 cannot be directly compared. However, as the concept of standard and novice instructions remained the same as in Iteration 1, and the concept was positively rated by participants in Iteration 1, we can say that the concept supports maintenance technicians with different levels of expertise in their work.

In future research, the same study could be conducted with a larger number of participants from several different countries who represent all expertise levels. Such a study could examine how people choose the layers of information that they use and how the layers correspond to their information needs and experience with maintaining equipment. Technology acceptance and users' willingness to use new technologies should be considered in future research.

Industrial maintenance is characteristically a high-risk environment that is governed by safety regulations. Maintenance technicians typically wear personal protective equipment such as helmets and cut-resistant gloves, and using the touch screen of a smartphone, often with dirty gloves, is cumbersome. Therefore, there is also an increasing interest in using smart glasses to deliver technical instructions to the field. As DITA scales well to different devices and uses cases [31], it is also a solution that supports possible new delivery channels for technical instructions. Consequently, even though we tested our concept with a mobile phone in this study, the scalability of DITA means that the same information can be used on other small-screen devices such as smart glasses, wearable displays, and smartwatches. This would offer an interesting area for further research.

Conclusion

We designed our exploratory study to test the delivery—as opposed to the creation—of technical instructions built on the principles of minimalism. Our research questions were as follows.

> **RQ1.** How can the semantic structure of DITA XML be utilized in delivering technical information to users based on their skill levels?

> **RQ2.** How would a layered system of information support the principles of minimalism?

We explored how the semantic structure of DITA XML can be utilized in delivering technical information to users based on their skill levels. Since all of the available DITA XML elements in task topics are known, applications can be built on these principles, and the content is then delivered to different parts of the application. Our study shows that well-formed and well-tagged content works very efficiently for this purpose, and the solution is also language-independent because the structure of the topics remains the same in the translation process. Therefore, filtering information with different DITA XML elements is an excellent and flexible way to target information at different skill levels.

Minimalism is usually discussed in the context of designing and creating instructions for users. In this study, instead of focusing on minimalism in the content creation phase, we applied the principles of minimalism in the delivery phase. As discussed above, the literature on minimalism calls for designing instructions that allow the user to start working immediately with real-life tasks. The aim of minimalist instructions is to get in the way as little as possible and to empower users to decide on the depth of the technical information that they require to complete the task at hand. This is what the context-sensitive level of expertise concept seeks to accomplish.

We also discovered that although minimalism has often been seen as an approach relevant only to software instructions for novice users, many of its key principles—such as action orientation and user-centeredness—are applicable to hardware maintenance instructions too.

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TABLE IV
MINIMALISM HEURISTICS [4]

1 CORE TASKS AND GOAL-ORIENTATION	
Core tasks	1.1 Does the documentation concentrate on the user's core tasks? (OH2.1)
	1.2 Does the documentation reflect the real-life structure of each task? (OH2.2)
	1.3 Does the documentation explain why the task is done, in addition to how? (OH2.2, Extended)
Getting to work immediately	1.4 Can the users start working on real-life tasks immediately? If the documentation contains general information, prefaces, or introductory information before the steps, is the information concise and necessary? (OH1.1; OH4.1 Extended)
Immediate assistance	1.5 Is the documentation available when needed? (OH1.3)
	1.6 Does the user get targeted instructions at the relevant touch points on the user journey? (OH1.3, Extended)
2 ACCESSIBILITY	
Content	2.1 Is the documentation as concise as possible in its overall selection of contents? (OH4.1)
Findability	2.2 Is the overall structure of the documentation logical and consistent? Are all topics/sections structured in the same way? (OH4.2, Extended)
	2.3 Do the users find what they are looking for? Does the documentation contain: (OH3.1, Extended) • A clear and precise table of contents • A clear and intuitive index • Clear, intuitive headings and keywords • An accessible and intuitive search functionality for online or electronic documentation?
Understandability	2.4 Is the information in the documentation easy to understand? Does the documentation contain: (OH3.1, Extended) • Long tasks broken into shorter sequences • Clear, action-oriented steps • Short, simple sentences • Verb forms relevant to the information type • Terminology that is appropriate to the user group • Clear, simple language?
Visuals	2.5 Is the documentation visual? • Have graphics, images, videos, etc., been used where appropriate? • Are the visuals relevant? • Are the visuals used consistently? • Are the visuals clear and readable both online and in print? • Are the visuals clearly labelled (titles, figure numbers, etc.)? • Are the images and text in the documentation clearly connected using callouts, for example?
3 ERROR MANAGEMENT	
Preventing errors	3.1 Have errors been prevented? (OH3.1)
Warnings and notes	3.2 Have all the applicable safety standards and legislation (e.g. the Machinery Directive) been taken into consideration in the documentation? (OH3.1, Extended)
	3.3 Are all the warnings and notes necessary? (OH4.1)
	3.4 Are the warnings and notes located next to the relevant procedure? (OH3.4)
Error recognition	3.5 Does the documentation offer error information: recognition, diagnosis, solution? (OH3.3)
	3.6 Is the error information located close to the relevant procedure? (OH3.4)
Troubleshooting	3.7 Does the documentation contain a troubleshooting section? (OH3.1, Extended) • Is the troubleshooting section clearly visible in the table of contents? • Does the troubleshooting section contain the problems most often faced and/or reported by the users of the product?

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Appendix A
Heuristics

Table IV lists the heuristics used in this study.

Appendix B
Questionnaires

Iteration 1

1. How many years of experience in the field of elevator maintenance or similar do you have? [free-form field]
2. The instructions in the application were easy to follow [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
3. The instructions in the application were clear [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
4. The instructions have too much information [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
5. There was something missing in the instructions [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
6. There were too many instructions [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
7. The instructions supported my work [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
8. I could complete the tasks with the instructions [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
9. The images in the instructions were clear [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
10. Text and images were readable on the screen [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]

Iteration 2

1. How many years of experience do you have in the field of elevator maintenance? [free-form field]
2. The task titles in the task list are informative, allowing me to perform the work efficiently [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
3. The standard instructions are informative, allowing me to perform the work efficiently [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
4. The instructions behind the “more information” button are informative, allowing me to perform the work efficiently [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
5. I can complete my work tasks using the instructions [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
6. The images in the instructions are easy to understand [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
7. The instructions have the right amount of information [Likert scale 1–7, 1 = totally disagree, 7 = totally agree]
8. Please provide any additional comments on the instructions and how informative they are [free-form field]
9. Any other feedback you would like to give? [free-form field]

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References

[1] T. Zonta, C. A. da Costa, R. da Rosa Righi, M. J. de Lima, E. S. da Trindade, and G. P. Li, “Predictive maintenance in the Industry 4.0: A systematic literature review,” *Comput. Ind. Eng.*, vol. 150, Dec. 2020, Art. no. 106889, doi: 10.1016/j.cie.2020.106889.
[2] H. Heinonen, S. Siltanen, and P. Ahola, “Information design for small screens: Toward smart glass use in guidance for industrial maintenance,” *IEEE Trans. Prof. Commun.*, vol. 64, no. 4, pp. 407–426, Dec. 2021, doi: 10.1109/TPC.2021.3110616.
[3] H. van der Meij and J. M. Carroll, “Principles and heuristics for designing minimalist instruction,” *Tech. Commun.*, vol. 42, no. 2, pp. 243–261, 1995.
[4] J. Virtaluoto, T. Suojanen, and S. Isohella, “Minimalism heuristics revisited: Developing a practical review tool,” *Tech. Commun.*, vol. 68, no. 1, pp. 20–36, 2021.
[5] S. W. Draper and K. Oatley, “Action centred manuals or minimalist instruction? Alternative theories for carroll’s minimal manuals,” in *Computers and Writing*. Dordrecht, The Netherlands: Springer, 1992, pp. 222–243. doi: 10.1007/978-94-011-2854-4_15.
[6] J. M. Carroll, *The Nurnberg Funnel: Designing Minimalist Instruction for Practical Computer Skill*. Cambridge, MA, USA: MIT Press, 1990.
[7] C. R. Lanier, “Toward understanding important workplace issues for technical communicators,” *Tech. Commun.*, vol. 65, no. 1, pp. 66–84, Feb. 2018.

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[8] T. R. Williams and D. K. Farkas, "Minimalism reconsidered: Should we design documentation for exploratory learning?," *ACM SIGCHI Bull.,* vol. 24, no. 2, pp. 41–50, 1992, doi: 10.1145/142386.142393.
[9] J. M. Carroll and H. van der Meij, "Ten misconceptions about minimalism," *IEEE Trans. Prof. Commun.*, vol. 39, no. 2, pp. 72–86, Jun. 1996, doi: 10.1109/47.503271.
[10] H. van der Meij, "Minimalism revisited," *Document Design*, vol. 4, no. 3, pp. 212–233, 2003, doi: 10.1075/dd.4.3.03mei.
[11] T. Suomivuori, J. Virtaluoto, and T. Suojanen, "Applying minimalism in the real world: Results from a workshop," *VAKKI Publ.*, vol. 12, pp. 225–238, 2020.
[12] J. T. Hackos, *Content Management for Dynamic Web Delivery*. Hoboken, NJ, USA: Wiley, 2002.
[13] S. Jayaprakash, *Technical Writing*. Mumbai, India: Himalaya, 2008.
[14] K. van Laan and J. T. Hackos, *The Insider's Guide to Technical Writing*. Laguna Hills, CA, USA: XML Press, 2012.
[15] H. van der Meij, J. Karreman, and M. Steehouder, "Three decades of research and professional practice on printed software tutorials for novices," *Tech. Commun.*, vol. 56, no. 3, pp. 265–292, 2009.
[16] OASIS Open, "DITA version 1.3 specification," OASIS Open, Burlington, MA, USA. Accessed: Mar. 27, 2022. [Online]. Available: http://docs.oasis-open.org/dita/dita/v1.3/csprd01/part1-base/dita-v1.3-csprd01-part1-base.html
[17] M. Grijalvo Martín, A. P. Álvarez, J. Ordieres-Meré, J. Villalba-Díez, and G. Morales-Alonso, "New business models from prescriptive maintenance strategies aligned with sustainable development goals," *Sustainability*, vol. 13, no. 1, 2021, Art. no. 216, doi: 10.3390/su13010216.
[18] J. M. V. Cedeno, J. Papinniemi, L. Hannola, and I. Donoghue, "Developing smart services by internet of things in manufacturing business," *LogForum*, vol. 14, no. 1, 2018, Art. no. 6, doi: 10.17270/J.LOG.2018.268.
[19] G. Zou, K. Banisoleiman, A. González, and M. H. Faber, "Probabilistic investigations into the value of information: A comparison of condition-based and time-based maintenance strategies," *Ocean Eng.,* vol. 188, 2019, Art. no. 106181, doi: 10.1016/j.oceaneng.2019.106181.
[20] E. Ries, *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*, 1st ed. New York, NY, USA: Crown Bus., 2011.
[21] S. Döringer, "'The problem-centred expert interview'. Combining qualitative interviewing approaches for investigating implicit expert knowledge," *Int. J. Soc. Res. Methodol.*, vol. 24, no. 3, pp. 265–278, 2021, doi: 10.1080/13645579.2020.1766777.
[22] P. K. R. Maddikunta et al., "Industry 5.0: A survey on enabling technologies and potential applications," *J. Ind. Inf. Integr.*, vol. 26, 2022, Art. no. 100257, doi: 10.1016/j.jii.2021.100257.
[23] H. van der Meij and M.-L. Flacke, "A review on error-inclusive approaches to software documentation and training," *Tech. Commun.*, vol. 67, no. 1, pp. 83–95, Feb. 2020.
[24] J. Wanner, L. Pop, K. Fuchs, K. Heinrich, L.-V. Herm, and C. Janiesch, "Adoption barriers of AI: A context-specific acceptance model for industrial maintenance," in *Proc. 29th Eur. Conf. Inf. Syst.*, 2021. [Online]. Available: https://dblp.org/db/conf/ecis/ecis2021.htm
[25] V. Venkatesh, J. Thong, and X. Xu, "Unified theory of acceptance and use of technology: A synthesis and the road ahead," *J. Assoc. Inf. Syst.*, vol. 17, no. 5, May 2016, Art. no. 1, doi: 10.17705/1jais.00428.
[26] G. M. Beal and J. M. Bohlen, "The diffusion process. Agricultural extension service," Iowa State Univ., Ames, IA, USA, Special Rep. 8, 1957.
[27] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS Quart.*, vol. 13, no. 3, pp. 319–340, 1989, doi: 10.2307/249008.
[28] V. Venkatesh and F. Davis, "A theoretical extension of the technology acceptance model: Four longitudinal field studies," *Manage. Sci.*, vol. 46, pp. 186–204, Feb. 2000, doi: 10.1287/mnsc.46.2.186.11926.
[29] M. Priestley, G. Hargis, and S. Carpenter, "DITA: An XML-based technical documentation authoring and publishing architecture," *Tech. Commun.*, vol. 48, no. 3, pp. 352–367, 2001.
[30] R. Andersen and J. Hackos, "Increasing the value and accessibility of academic research: Perspectives from industry," in *Proc. 36th ACM Int. Conf. Design Commun.*, Aug. 2018, Art. no. 5, doi: 10.1145/3233756.3233959.
[31] S. Siltanen and H. Heinonen, "Scalable and responsive information for industrial maintenance work: Developing XR support on smart glasses for maintenance technicians," in *Proc. 23rd Int. Conf. Acad. Mindtrek*, Jan. 2020, pp. 100–109, doi: 10.1145/3377290.3377296.

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