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USABILITY OF MINIMALISM HEURISTICS IN HEAVY MACHINERY USER INSTRUCTIONS

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ABSTRACT

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Minimalism as an approach to creating user instructions has long been well known and prevalent in the field of software documentation. However, it has not been applied to hardware and specifically to heavy machinery until 2021 when Jenni Virtaluoto, Tytti Suojanen, and Suvi Isohella published their revised minimalism heuristics. The heuristics were designed to be used in evaluating both software and hardware documentation. Virtanen et al. tested the suitability of the heuristics in evaluating heavy machinery user instructions in 2020, and the results indicated that the heuristics were applicable for heavy machinery.

This study also evaluates the usability of the revised minimalism heuristics in evaluating heavy machinery user instructions from a fresh perspective that is independent from the original authors. This is done by evaluating excavator user instructions with heuristics and assessing their usability in a heavy machinery context, along with possible problems and possible improvements.

The theoretical framework of this study consists of minimalism, its origins, development, and central principles. It also examines the relationship between minimalism and heavy machinery.

The results show that while the heuristics are mostly applicable for evaluating heavy machinery user instructions, some of the heuristics are unsuitable or much better suited for evaluating software instructions. Based on the results, it could also be beneficial for the evaluator if there were separate heuristics for software and hardware products. Future research on this topic could include multiple professional participants evaluating various types of user instructions and involving real users in the process.

Keywords: minimalism, heavy machinery, heuristic evaluation, technical documentation

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Minimalismi on kauan ollut tunnettu ja laajalle levinnyt lähestymistapa tietokoneohjelmistojen dokumentaatiossa. Sitä ei kuitenkaan ole sovellettu laitteistoon eikä eritoten raskaaseen kalustoon ennen vuotta 2021, jolloin Jenni Virtaluoto, Tytti Suojanen ja Suvi Isohella julkaisivat uudistetut minimalismiheuristiikkansa. Heuristiikat on suunniteltu sopivaksi sekä ohjelmistojen että laitteistojen ohjeiden arviointiin. Virtanen ym. testasivat heuristiikkojensa käytettävyyttä raskaan kaluston ohjeiden arvioinnissa vuonna 2020, ja tulosten mukaan heuristiikat olivat sovellettavissa raskaan kaluston dokumentaatioon.

Tässä tutkimuksessa arvioidaan myös uudistettujen minimalismiheuristiikkojen käyttökelpoisuutta raskaan kaluston käyttöohjeiden arvioinnissa tuoreesta, alkuperäisistä tekijöistä riippumattomasta näkökulmasta. Tämä tehdään arvioimalla heuristiikoilla kaivinkoneen käyttöohjeita ja tarkastelemalla heuristiikkojen käytettävyyttä sekä mahdollisia ongelmia ja parannusmahdollisuuksia raskaan kaluston yhteydessä.

Tämän tutkimuksen tieteellinen viitekehys koostuu minimalismista, sen lähtökohdista, kehityksestä ja keskeisistä periaatteista. Lisäksi siinä tarkastellaan minimalismin ja raskaan kaluston välistä suhdetta.

Tulokset osoittavat, että vaikka heuristiikat enimmäkseen soveltuvat raskaan kaluston käyttöohjeiden arviointiin, jotkin heuristiikat ovat epäkäytännöllisiä tai soveltuvat paremmin ohjelmistojen ohjeiden arviointiin. Tulosten perusteella arvioija voisi myös hyötyä erillisistä heuristiikoista ohjelmistoille ja laitteistolle. Tulevissa tutkimuksissa voisi olla mukana useita ammattilaisia, jotka arvioivat erityyppisiä käyttöohjeita, ja todellisia käyttäjiä voisi ottaa mukaan prosessiin.

Avainsanat: minimalismi, raskas kalusto, heuristinen arviointi, tekninen dokumentaatio

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1 INTRODUCTION

The field of technical communication can roughly be divided into two parts: software and hardware. On one side of the coin, there are computer programs, applications, and websites, and on the other heavy machinery, home appliances, and tools. While these two product groups are profoundly different in their uses and purposes, they have their common ground: both need user instructions and competent people to create said instructions.

On the software side of things, the theory and practice of minimalism in user documentation has been widespread and much discussed for a long time. In fact, minimalism was born in the 1980's from the early years of the brand new and rapidly spreading personal computer and its word processing software that complete novices now had to master in many different professional fields as well as at home (van der Meij et al. 2009, 269). This posed a new kind of challenge for user instructions: the new pool of users was vast and had a more hands-on inclination to learning than the previous expert users (ibid., 266). At the same time, usability and science-based design influenced especially by educational research became established within document design which also had its effect on the development of the field (ibid., 267).

In the center of this turmoil was minimalism. Created by John M. Carroll, minimalism is an approach to creating user documentation that is user-centered and task-oriented (Dubinsky 1999, 35). Its foundation is in empirical studies on real learner behaviour, psychological theory of learning, and practical experience in designing user documentation (Carroll and van der Meij 1996, 72). The minimalist goal is to make the learning process as easy and quick as possible by minimizing the learning problems that the user instructions cause for the user (Carroll 1990, 7). The name minimalism comes from this idea of minimizing obstacles. Learning is made easier by adhering to a set of various principles that reflect the way new users naturally act; they learn by doing and reasoning, relying on their prior knowledge, and making errors (Carroll 1990b, 212). These principles include, for example, giving users real and meaningful tasks to work on right away, supporting users in learning by exploring, giving ample error information, and being concise (Virtaluoto et al. 2021, 22).

Software is very much the homestead and comfort zone of minimalism, and all of its aforementioned basic principles and tactics have been designed with a focus on computer programs. Mechanical engineering and heavy machinery, on the other hand, has rarely entered the field of minimalism conversation aside from a passing comment during the last three decades.

Jenni Virtaluoto, Tytti Suojanen, and Suvi Isohella finally brought hardware and minimalism together in a concrete manner in their user-centered model of a minimalist documentation process which takes into account that many modern-day technical communications professionals work with complicated business products and hardware instead of software products (2018, 187). They subsequently developed a set of heuristics which are based on the original 1995 minimalism heuristics created by John M. Carroll and Hans van der Meij. The heuristics can be used to evaluate existing documentation as well as be used during the documentation process itself, and they were created to be used with all kinds of user documentation, including hardware.

The subject of this thesis are these revised minimalism heuristics published in 2021, with a particular focus on the hardware aspect of the heuristics and how well they fit into a heavy machinery environment. The research question of this thesis goes as follows:

- Are the minimalism heuristics by Virtaluoto, Suojanen and Isohella suitable for evaluating heavy machinery user instructions?

To answer the question, I will conduct a heuristic evaluation on Liebherr hydraulic excavator user instructions using the heuristics. I will examine the applicability of each heuristic in evaluating the manual and by extension, heavy machinery manuals in general. I will report any problems in their use as well as any suggestions for improvements.

This thesis shares its research question with the 2020 workshop which Virtaluoto et al. organized to study the suitability of their own heuristics in a heavy machinery setting. The results of the workshop indicated that the heuristics were applicable and easy to use for heavy machinery user instructions (Virtaluoto et al. 2020, 244). However, the time allotted for the workshop and the heuristic evaluation itself was relatively short and gave the participants little time to focus on all heuristics (ibid., 245). As a result, one of the three categories received a disproportionate amount of attention due to its approachable and language-oriented content, while the other categories were given less consideration and had less findings. Although the workshop sparked interesting conversation about the role of the evaluator and the constraints of the real world on the documentation (ibid., 246–247), there were few comments on the heuristics themselves in a hardware setting. Virtaluoto et al. themselves also do not give much commentary on the hardware context in the results of the workshop or in their 2021 publication of the minimalism heuristics.

The results from the workshop are promising in terms of the heuristics' usability in the heavy machinery domain. Nevertheless, because this revised list of minimalism heuristics was developed as recently as 2021 and is intended to work as a multipurpose tool in many fields with different products, it would benefit from further testing and analysis which Virtaluoto et al. themselves call for (2021 32) It is also worthwhile to dive a little deeper into the heuristics and consider their use in a strictly hardware setting with the fresh set of eyes of an external observer. Examining each heuristic and their content and meaning separately in an independent study has the potential of unearthing room for improvement and offering the heuristics further credibility.

Additionally, heavy machinery manuals as a group of user documentation are very much in need of a usable evaluation tool. They are often very formalistic and traditional, have a lot of legacy material, and minimalizing them can definitely be a more daunting task than a body of software instructions. Virtaluoto et al. also suggest that the heuristics could potentially be used as a starting point in an organization to develop a minimalist style guide (2021, 32). For both updating existing manuals and creating new minimalist instruction, a clear and practical set of heuristics that is specifically geared towards heavy machinery would be immensely helpful. This thesis is a step closer to developing such a list.

The structure of this thesis goes as follows: chapter 2 contains the theoretical framework of this study which includes minimalism and minimalism heuristics. The chapter also examines the overlap between minimalism and heavy machinery. Chapter 3 explains the study method, which is heuristic evaluation, the study material, and how the study method is applied to answer the research question. Chapter 4 presents the analysis, and the conclusions of the study and ideas for further research are discussed in chapter 5.

2 MINIMALISM

2.1 Origins

Minimalism was born in the 1980's and 1990's when computers were becoming a part of everyday life, and learning to use software was a new kind of issue to tackle (Virtaluoto et al. 2021, 23–24). User documentation for computers went through some major growing pains: comprehensive, overly technical manuals and lengthy training courses that were originally designed for programmers and computer professionals did not suit the needs of regular office workers, and thus, free-of-charge and task-oriented user instructions were developed (Carroll 1990, 4). Whereas before expert-oriented instruction focused on comprehensively explaining all the possible program functions and inner workings of the computer, new task-oriented instruction gave the regular computer user the chance to learn through real-life exercises and learn the software in manageable, bite-sized pieces (ibid., 4–5).

According to John M. Carroll, the creator of minimalism, this new wave of instruction was shaped by the systems approach to instruction (ibid.) which was prevalent at the time in the 1990's. The starting point in the systems approach is "the hierarchical decomposition of learning objectives" (ibid., 7). A systems approach manual teaches the needed skills hierarchically in a prescribed order by making the reader first read instructions and then practice the most basic skills, later advancing to more complex tasks that build on the previously learned information (ibid., 81).

Minimalism as an approach to technical documentation was developed by Carroll in the early 1980's. Carroll introduced his minimalist model in his 1990 book *The Nurnberg Funnel: Designing Minimalist Instruction for Practical Computer Skill.* Carroll based his approach on "a series of design case studies in which manuals, interactive training environments, and other instructional tools were invented and evaluated" (ibid., 244).

Carroll's case studies observed how real-life learners interacted with instructions; what were their goals, their methods, and where they encountered problems (ibid., 3). He used real potential users, and the participants in the first study were, for example, secretaries and other office workers with no computer experience who learned to use a document processing software of a computer using only the accompanying instructional material (ibid., 18). Later, Carroll also conducted a similar study with a software that had a more advanced user interface and included an online tutorial in addition to the user manual (ibid., 49). The system was for more professional use, so the participants were professionals who already had some computer experience (ibid., 50).

In these studies, Carroll asked the participants to think aloud during their learning process, and the remarks were recorded or written down by Carroll and other researchers who tried to intervene as little as possible, only stepping in when errors led to participants potentially leaving the study (ibid., 18–19).

The studies revealed that the learning process was riddled with problems and frustration. Learners tended to stray from the path set by the training material and spontaneously try things on their own, driven by their own specific goals, interests, and the information they inferred from the software itself, even if it led to more errors (ibid., 5). Prior knowledge played a large role; the participants tried to make sense of the situation by thinking of their past experiences with other similar products (like the typewriter) which helped with some tasks but hindered others (ibid., 37–38). They skipped introductory and explanatory information in favor of getting to do something concrete (ibid., 27). They often became overwhelmed and confused as to what they were supposed to achieve with the exercises, which was shown by their exasperated remarks during the process (ibid., 25). Overall, all participants had serious difficulties in completing the given tasks (ibid., 22).

Carroll found that regardless of the system in question, there were five generally shared user problems (1990b, 210), and these five problems could be indicative of characteristics shared by most learners (ibid., 211–212). The user problems and their corresponding learning propensities are stated below:

User problem	Learning characteristic
Users “jump the gun” and use the system independently.	Users learn by doing.
Users get distracted by and explore functions that are “irrelevant” to their work.	Users learn by thinking, reasoning, and exploring.
Users have trouble systematically following instructions.	Users want to work towards meaningful goals when learning

Users' prior knowledge from seemingly similar situations interferes their reasoning of a new situation.	Users use their prior knowledge when they are making sense of a new experience or skill.
Users have trouble diagnosing and recovering from errors.	Users learn the limits of their own knowledge through error diagnosis and recovery.

Based on his results, Carroll concluded that even though the systems approach was an improvement from simply describing the product, the development did not hit the mark on the head. A systems manual with its hierarchical and controlled structure still facilitated the aforementioned user problems, in addition to creating very lengthy instructions (ibid., 211). It went against the learning strategies that the learners spontaneously lean towards and thus created obstacles for learning (Carroll 1987, 125).

Carroll found that the user problems and the learning characteristics they indicated revealed a need for a new type of instruction that supports exploration and gives the user space to take initiative in their own learning, even through user errors (1990b, 211). In his 1990 article *An Overview of minimalist instruction*, Carroll proposed five minimalist principles (ibid., 212-213):

1. Get the user started fast
2. Allow the users to explore and reason for themselves
3. Use real tasks in training
4. Exploit the user's prior knowledge
5. Support error recognition and recovery.

In addition to these five, Carroll listed four more principles in *The Nurnberg Funnel*; designing the materials to be read in any order, coordinating the instruction material and software (for example, with illustrations showing appropriate and error software states), using the learning situation itself to give the user ample opportunities for figure out the software, and iteratively developing training designs with real users and realistic domains while avoiding systematization (1990, 78–92).

Carroll designed three pieces of minimalist training material to test the validity of these principles. First of these were the modular Guided Exploration cards that each presented the user a single functional goal or task (for example, how to get started) with no reference to other cards, had incomplete information that had the user relying on prior and inferred information, and included checkpoint and error recovery information (Carroll 1990b, 213). The second design was the Minimal Manual that was significantly shorter than conventional manuals, had copious error recovery material and real tasks, engaged user's prior knowledge, encouraged exploration, and got the user started fast (ibid., 213–214). Finally, the Training Wheels interface was a software that made exploratory learning more plausible for novice users by simply blocking advanced actions that caused major obstructive errors (ibid., 214).

According to Carroll's experiments, Guided Exploration cards helped the learners perform better in a post-experiment test while also spending less time on the learning process (ibid., 213). Minimal Manual also made learning faster, and the test subjects using the Minimal manual finished more tasks more efficiently (Carroll 1990, 164–165). Van der Meij, Karreman, and Steehouser call this the "triple 33%" effect, which means that a minimal manual is "one third the size of a control manual, can be processed in about one third of the time, and yields about one third better learning outcomes" (2009, 269).

In *The Nurnberg Funnel,* Carroll introduces minimalism's benefits in straight comparison the failings of the system approach. He criticizes the systems approach on many shortcomings: being unnecessarily wordy (Carroll 1990, 8), too theory-based and general (ibid., 3), and downright ignoring error recovery information and the user's prior knowledge (ibid., 87–88). He also points out that the systems approach is not based on "any serious understanding of human learning" (ibid., 3).

Carroll, in turn, used the learning theories of John Dewey, Jean Piaget, and Jerome Bruner as the theoretical foundation of minimalism (Carroll and van der Meij 1996, 83–84). Dewey emphasized that instead of facts, learners should be taught skills (Carroll 1990, 2). According to Piager, using prior knowledge, having an achievable goal, and making errors makes learning a meaningful and rewarding experience (ibid., pp. 75, 86). Bruner additionally states that if the learner identifies with the task at hand and is allowed to be active in their own learning, they are more motivated and thus learning is enhanced (ibid., pp. 78, 81). All these viewpoints can be found in minimalism's principles.

2.2 Central principles

Minimalism can be a difficult concept to summarize and comprehend with a short explanation because of all the principles and tactics associated with it. Literature on minimalism is vast, and different authors tend to put emphasis on different facets of minimalism and have slightly different interpretations of the core tenets, sometimes even mistaking the approach to consists only of one or a few of its many principles. Carroll and van der Meij themselves comment that because minimalism has garnered interest from various disciplines, the resulting literature can be confusing (1998, 55).

To put it in a word, the essence of minimalism is the user. Janice Redish gives a wonderfully simple explanation of this: “Being user oriented means both writing for the user, not about the system, and understanding what users are like so that you can write for them” (1998, 219). Carroll’s goal was to bring the training material closer to how the users really act, what they want to achieve with the product, and minimize the learning problems caused by the training material itself (Carroll 1990, 7), thus giving minimalism its name. The basis of a minimalist approach is that most users do not want to, nor will learn by patiently reading, but instead wants to jump right into doing, explore, and try things for themselves. Since that is what users naturally do, the instructions should reflect this and support the user in their independent endeavours (Carroll 1990b, 210). User documentation should me designed to fit realistic user behaviour instead of trying to enforce a prescribed and unnatural way of learning.

While the user is the ultimate motivation and backbone of minimalism, Carroll and van der Meij raise task orientation as the central minimalist principle while the other principles either support it or result from it (1996, 72). Being task-oriented means focusing on what the user actually wants to do with the product and giving them the information they need in order to succeed when they need it (Brockmann 1998, 378). Training on real tasks is a the most obvious facet of task-oriented activity. The users should be given tasks that they would want to complete in real world, and skills needed for said task should be taught in the context of these tasks (van der Meij 1992, 8). According to Carroll and van der Meij, this increases motivation, success in real-life use situations, and helps the user to become independent in their learning (1996, 75).

Minimalism is often misinterpreted to mean only writing as little instruction as possible, but while “slashing the verbiage” (Redish 1998, 219) is another key element, the value of brevity in minimalism lies in its function to aid in task-oriented and self-initiated learning (Carroll and van der Meij 1996, 72). Beyond this, shortness in and of itself has no intrinsic value. While keeping the documentation concise and to the point is considered important, there are also principles in minimalism that go directly against brevity, which shows that short instructions are not the main gist of the approach (van der Meij 2003, 214). For example, offering the user copious amounts of detailed error information makes manuals longer, not shorter (ibid.). Reasons for this misconception could and probably does stem from the name (although, as stated earlier, the name indicates minimizing the learning obstacles set by the training material), or the commercial tendency to fixate on the appealing aspect of minimalism that can seemingly save time and money (Carroll and van der Meij 1996, 73).

Another central principle of minimalism is exploratory learning, also called guided exploration. In exploratory learning, the user can act on their own interests during the learning process and learn in the process of trying things out or themselves. This can be encouraged in user instructions by giving the user incomplete learning materials and open-ended activities (Carroll 1990, 83), using language and prompts that encourage exploration, and using student evaluation instead of expert evaluation (Carroll and van der Meij 1995, 246). Exploratory learning can be very motivating for the user and helps them in remembering the learned information better (Carroll 1990, 83). Carroll and van der Meij point out that "safe progress" should be considered when encouraging exploring, and that different projects call for varying amounts of supporting exploration (1995, 247) and analysis of the skill level and background knowledge of the user (1996, 75). The exploration should have clear boundaries so that the user can be steered to the correct direction in their exploration, and not left drifting and frustrated with little progress.

Exploratory learning is tied to the concept of "the paradox of sense-making", which Carroll addresses in *The Nurnberg Funnel.* It is the idea that "to learn, they [learners] must interact meaningfully with the system, but to interact with the system, they must first learn" (Carroll 1990, 77). The active, self-directed ways in which users learn best facilitate the user problems presented in chapter 2.1 in a systematic instruction environment (Carroll 1990b, 212). The paradox itself is not solvable, but minimalism compromises more towards letting the user's self-initiated and meaningful interaction lead the learning and adjusts the instruction strategy and material accordingly. This leads to supporting exploratory learning in the user instructions.

With exploratory learning and learning in general come mistakes. According to Carroll, the systems approach disregards error recovery and recognition, and assumes that a user following the instructions properly will not make serious mistakes (1990, 86). Minimalism, on the other hand, acknowledges that users make errors even despite intricate training materials, and spend a significant portion of their learning time trying to recover from said errors (van der Meij 2003, 227). The minimalist view is that, when possible, mistakes should be seen a learning opportunity. The error information must also be given where the mistakes are likely to happen, i.e. on the spot. Overall, thoroughly supporting the user in dealing with errors is one of minimalism's biggest contributions (van der Meij 2003, 217). Virtaluoto et al. also state that the unprecedented way minimalism approaches error information might be the most notable offering to user documentation (2021, 30).

This is not to say errors are encouraged: minimalist instruction strives to prevent as many mistakes as possible with effective and ample error information (warnings, for example), and especially such mistakes that have no pedagogical value and only annoy the user or endanger their progress (Carroll and van der Meij 1996, 77–79). No one goes into a learning wanting to make errors and then having to solve them. When mistakes still inevitably happen, the learner is given sufficient information to recognize the error, recover from it, and move on with their learning a bit wiser (ibid., 75–76).

User testing and task analysis is needed to develop effective minimalist instruction that caters to the user and is thus also in the center of the approach. The minimalist principles cannot be brought to action just on the basis of the written principles themselves, and to be user-oriented requires actually knowing the user. For instance, allowing exploratory learning requires information on what users can be expected to do, and where they make mistakes and need recovery information (Carroll and van der Meij 1996, 75). Working with real users also reveals the tasks that they are actually trying to complete, and which should be central to the manual (Carroll 1990b, 215). Furthermore, user testing keeps experienced developers in touch with novice problems and goals that they might have otherwise already forgotten (Carroll and van der Meij 1996, 74). Even more in present day, investigating user problems is paramount due to the speed in which technology and software advances, thus creating new and different problems that have to addressed either in design or in instruction (Carroll 1990, 49). Without user and task information implementing minimalism is shooting arrows in the dark.

2.3 Benefits and criticism

With minimalist instructions, the user is the one reaping the benefits. According to van der Meij's 1992 study, following minimalist principles helps learners complete tasks faster (15). They also become independent from the manual sooner and make fewer mistakes and spend less time recovering from mistakes (ibid.). Draper and Oatley claim that applying minimalism in practice does not require much more training than reading a few research papers (2000, 223). According to Karl Smart, providing minimalist documentation could potentially save money for the companies through cutting customer support costs when the users make less errors, and give the company a market advantage by providing user-friendly documentation (1998, 321). Alan Manning has also suggested that the minimalist approach could also be applied to other forms of professional communication (1998).

Despite the benefits, minimalism has been challenging to bring into practice. In the beginning, this was due to its lack of critical studies and specific guidelines on how to produce documentation (van der Meij 1992, 7), and nowadays, it tends to drown to the general ethos of usability and user-centeredness (Virtaluoto et al. 2021, 23). With or without minimalism, user-centeredness in documentation seems to be the norm, or at least the norm of intention if not practice. For people who have stepped into the field technical communication in the 2020's, the principle that user documentation should be user-centered seems obvious. However, Virtaluoto et al. noticed in the training program they arranged in 2017 and 2018 that even though the participating professionals were aware of the importance of keeping the users and their tasks in mind, this was not steadily reflected in the instructions they wrote (ibid.). There is thus still a need for practical tools that help technical writers produce user-centered documentation.

Truly committing to the idea of minimalism and gathering necessary user information to make a minimalist manual is costly and time-consuming (Virtaluoto et al. 2021, 23). Minimalist documentation takes longer to produce because the developers must take their time to identify the user's core tasks, prior knowledge and skills, needs, and points of error (Carroll and van der Meij 1996, 73–74). A manual writer can theorize what the user needs but finding out the stumbling blocks in a manual requires iterative testing and involving the users already in the making of the said manual (van der Meij 1992, 7). This development requires commitment and money that can be very hard to come by when it comes to documentation. Rummaging through documentation in hopes of minimalizing can certainly meet resistance, especially in the world of software where development is a constant and speedy process.

In addition to costing time and money, transitioning into minimalist documentation can be a daunting task in terms of challenging one's way of thinking and changing the way things have been done for decades upon decades. Carroll states that minimalism is difficult to implement in an organization because it "fundamentally conflicts with the standard practice of providing overly thorough training material and of remedying observed user problems with the addition of further training material" (1990b, 215). This was, of course, an opinion in a time when user documentation as a field was less user-centered and more systematic, but Virtaluoto et al. note that even today, masses of legacy documentation and traditional ways of producing documentation can make implementation difficult (2021, 23).

Alongside the difficulties in implementing minimalism, the core principles of the approach have also received their fair share of criticism. David Farkas and Thomas Williams criticize Carroll for developing minimalism in direct response to the systems approach, and they question whether the systems approach was even prevalent in documentation in the time of *The Nurnberg Funnel* (1990, 183). They also question whether exploratory learning is a good option for users who want to learn quickly to do something once and who find quick success more motivating than trial and error (ibid., 188–189). In general, the users in minimalism are seen exclusively as active learners who view learning positively which leaves out other types of users who want to quickly solve their problems and get their tasks done (Virtaluoto et al. 2018, 5).

Virtaluoto et al. state that because most of the research on minimalism is focused on novice users of software, applying the theory to machine instructions and instruction for expert users is difficult (ibid., 4). They also point out that exploratory learning, for example, is especially problematic in using large machines when there is safety be taken into consideration (ibid.) and that there are virtually no studies on the suitability of minimalism for hardware documentation (2020, 239).

Overall, the world is vastly different today than it was during the conception of minimalism. Nowadays, software itself is manufactured to be more intuitive and user-centered design is a hot topic. Carroll himself predicted that systems and applications themselves would eventually be designed to make for an easier learning process and the importance of user instruction would diminish (1990, 6). This had already happened to some extent, and the new forms of documentation (like virtual/augmented reality and video) offer new ways to be user-centered. Online forums also offer users the chance to bypass instruction, especially when trying to find solutions for error correction. All these factors call for a re-examination of the minimalist approach.

2.4 Minimalism heuristics

In this chapter, I will present the two existing minimalism heuristics: the original 1995 minimalism heuristics by Carroll and van der Meij and the revised 2021 minimalism heuristics by Jenni Virtaluoto, Tytti Suojanen, and Suvi Isohella.

2.4.1 Principles and heuristics for designing minimalist instruction

Carroll himself recognized the criticism that minimalism as an approach lacked specific guidelines and went on to develop the concept of minimalism further with Hans van der Meij. Van der Meij and Ard W. Lazonder conducted several studies with the objective of unearthing the concrete principles of the minimalist approach (2009, 270).

The result of these endeavours was the minimalist design approach which presented four major principles that have their corresponding heuristics (Carroll and van der Meij 1995, 244). The heuristics brought clarity to the concept, and according to van der Meij, offered "precise guidance for understanding and applying minimalism" and "opportunities for experimental research on its distinct features" (2007, 295). The principles and heuristics are presented below:

Principle 1: Choose an action-oriented approach	Heuristic 1.1: Provide an immediate opportunity to act.
	Heuristic 1.2: Encourage and support exploration and innovation.
	Heuristic 1.3: Respect the integrity of the user's activity.
Principle 2: Anchor the tool in the task domain	Heuristic 2.1: Select or design instructional activities that are real tasks.
	Heuristic 2.2: The components of the instruction should reflect the task structure.
Principle 3: Support error recognition and recovery	Heuristic 3.1: Prevent mistakes whenever possible.
	Heuristic 3.2: Provide error-information when actions are error-prone or when correction is difficult.
	Heuristic 3.3: Provide error-information that supports detection, diagnosis, and recovery.
	Heuristic 3.4: Provide on-the-spot error-information.
Principle 4: Support reading to do, study and locate	Heuristic 4.1: Be brief; don't spell out everything
	Heuristic 4.2: Provide closure for chapters.

Heuristics under Principle 1 stem from the user's active role in learning and the aforementioned paradox of sense-making. Users learn by doing, but they need to learn in order to do. Therefore, the user should be allowed to get started right away (heuristic 1.1) and to explore, but they should also be guided in their exploration and not merely left to their own devices (heuristic 1.2) (Carroll and van der Meij 1995, 246). The user should be invited to explore activities that are meaningful and "sufficiently open-ended", but that are also clearly defined and direct the user to exploring that is productive (ibid.). As for the heuristic 1.3 *Respect the integrity of the user's activity*, this means that the user's goals and activities come first. Users can be coaxed to act a certain way and offered help, but ultimately, their goals should not be obstructed by those of the instruction designer (ibid., 247–248).

Principle 2 focuses on task-orientation: the user's objective is not the tool (product, software, etc.) itself, but the tasks that the user can complete with it. The user should therefore be given tasks that are realistic and relevant to the user (heuristic 2.1), however simple they may be (ibid., 249). These tasks must be appropriate for the user's experience level so that they can use their prior knowledge and skills (ibid.). Components of the instruction (in practice, the headings) should reflect the task structure (heuristic 2.2) so that they "convey deliberately and clearly the major procedural elements in the instructional tasks" (ibid., 250). Headings should not be so broad that the user does not understand what the specific task at hand is, but also not so example-specific that the user cannot connect them to the bigger picture (ibid.). Clear headings also make the needed information easier to find.

Principle 3 emphasizes effective support for error recognition and recovery. Users inevitably make mistakes and spend a great deal of time to correct them. Therefore, it is beneficial to prevent errors from ever happening (heuristic 3.1) by, for example, giving clear and effective instructions, providing hints and warnings, blocking error-prone actions, and re-designing the program or product itself to allow less error (ibid., 252). Error information should be given when a mistake is likely to happen, it is difficult to correct or to comprehend, and when the consequences without proper method of correction are severe (heuristic 3.2) (ibid., 252–253). The information should also be positioned "on the spot", meaning as close as possible to the error-prone action in the instructions (heuristic 3.4), for example, immediately before or after the relevant step (ibid., 254). Furthermore, heuristic 3.3 states that the error information itself should help the user recognize that they have made an error (detection), what kind of error they have made (diagnosis), and how to correct the error or go back to an error-free state (correction) (ibid., 253–254).

Principle 4 revolves around the way users read instructions. Some users read the whole manual (although not necessarily in order), some attempt the same but end up skipping and browsing, and some only touch the manual when their independent exploring comes to a halt due to a mistake or an impasse (ibid., 255–256). The user instructions should cater to all kinds of readers. Brevity is a universal tactic that benefits all (heuristic 4.1): cutting unessential information (or at least moving it after task information), omitting information that the user can figure out for themselves, and writing shorter chapters keeps the user motivated, saves time, and makes the instructions more easily approachable (ibid., 256). Chapters should also have closure (heuristic 4.2) so that they are as independent of each other as possible, which benefits browsing readers (ibid., 257). This could mean, for example, instructing the user to save their work after completing a task and return to the start screen from where they started. Chapter independency (or modularity) can also be promoted by having the user work on independent products and/or skills in each chapter so that there is no need to consult other chapters aside from the one at hand (ibid.).

While many of the heuristics are applicable for hardware instructions, the list is clearly very much meant for designing software documentation. Overall, Carroll and van der Meij make no mention of hardware, and all examples, illustrations, and tools offered in the article revolve around software applications. They do however state that the purpose of the heuristics is to be used as a baseline in developing minimalist instruction for different environments and audiences, and not as a prescriptive set of rules (ibid., 244). Janice Redish also suggested as early as in 1998 that the heuristics need some alteration so that they would work with a wider selection of users and products (243).

2.4.2 Revised minimalism heuristics

Minimalist heuristics were taken a step further in 2021, when Jenni Virtaluoto, Tytti Suojanen, and Suvi Isohella created the revised minimalism heuristics. Contrary to the 1995 list of principles and heuristics, the new heuristics were refined to work as an evaluation tool (Virtaluoto et al. 2021, 27) rather than tool for designing documentation from the beginning.

The heuristics were a continuation to the minimalist documentation process introduced in 2018. Virtaluoto et al. combined the principles of minimalism, usability methods, and the best practices of technical communication field with the real-life documentation process, resulting in a documentation process model where every phase is centered around the user and the responsibilities of the technical communicator are made clear (2018, 188). The revised minimalism heuristics were designed to be used in the middle of this documentation process and when collecting feedback after publication (Virtaluoto et al. 2021, 26).

In their minimalism heuristics, they similarly took "the main ideas from minimalism heuristics and combined them with the best practices of technical communication" (2021, 23). Said best practices stem from a wide selection of technical communication literature and from the writers' own background experience in the field and its research. As a result, their heuristics are more detailed, comprehensive, and practical than in Carroll and van der Meij's list. In their article *Minimalism*

Heuristics Revisited: Developing a Practical Review Tool, Virtaluoto et al. give an extensive account on how the minimalism heuristics and best practices of the field are intertwined (2021, 28–30).

The list has 18 heuristics divided under three main categories and eleven sub-categories (Virtaluoto et al. 2021, 27–28). The abbreviations in the parentheses refer to the original heuristic by Carroll and van der Meij that are the basis of the revised heuristic. The heuristics go as follows:

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?

One of the key differences between the revised minimalism heuristics and the original list from Carroll and van der Meij is that Virtaluoto et al. have left out the idea of exploratory learning. They state that guided exploration is not a good fit for heavy machinery and hardware (2021, 29). They also state that because people in 2020's are generally much more tech-savvy than their counterparts in the 1990s, being coaxed into learning with exploration can feel "patronizing" (ibid.). Modern day people are indeed more familiar with the basic layouts and commands in many different software environments and can, therefore, probably process direct instructions much more effectively than their counterparts some decades earlier.

A completely new addition to the heuristic list are the visuals. Carroll and van der Meij's heuristics do encourage the writer to use visuals to connect the instruction to the system state, but they do not elaborate further on how the visuals should be used, and visuals are not outright mentioned in any of the heuristics. Virtaluoto et al., however, give several concrete factors to look for when evaluating instructions' visual usability. This heuristic stems more from the domain of the field's best practices than minimalist theory.

Unlike Carroll and van der Meij's list, the revised minimalism heuristics addresses motivation directly in heuristic 1.3 *Does the documentation explain why the task is done, in addition to how?* Motivation in user instructions includes textual elements in the instructions that motivate the user to read the instructions and perform the procedure at hand accordingly (Loorbach 2013, 6). Explaining why the task is needed is an effective form of motivation, especially in cases where the task is obscure enough to leave the user guessing.

The list also covers error management more extensively than the original heuristics. One of the heuristics even names safety standards, legislation, and the Machinery Directive as something to be considered. This was added especially for heavy machinery user instructions since following safety standards is vital in machine manuals (Virtaluoto et al. 2021, 32). Troubleshooting chapters are also essential for error recovery in manuals, and Virtaluoto et al. have dedicated a new heuristic (4.7) for this purpose.

While the original 1995 heuristics were designed for only software, Virtaluoto et al. created the revised heuristics to be a flexible tool that can be modified and adapted to suit all kinds of products, situations, and companies across the fields of both software and hardware (2021, 32). Virtaluoto et al. have tested the usability of their minimalism heuristics for reviewing heavy industry machinery end-user instructions in a minimalism workshop they arranged in the spring of 2020 (2020, 242). Because minimalism literature does not offer any guidelines on conducting a heuristic evaluation, Virtaluoto et al. drew the process mainly from usability research (2021, 30)

The workshop had five participants which included four technical communication professionals and a researcher, all of which had experience with heavy machinery user instructions (2020, 242). After an opening presentation about minimalism and the evaluation process, the participants performed individual heuristic evaluations using the heuristics and an evaluation form, and afterwards filled in a questionnaire about using the heuristics and took part in a wrap-up discussion (ibid., 242–243).

The findings of the workshop indicated that the heuristics were suitable in evaluating heavy industry machinery end-user instructions (ibid., 244). The participants found many usability problems in a relatively short time using the heuristics and found using them easy (ibid., 248). Virtaluoto et al. concluded that technical communication experience is required to use the heuristics effectively and that the participants benefitted from an introduction to minimalism and the heuristics (ibid.).

The workshop included interesting conversation about the constraints the real world poses for documentation and how the background knowledge of the product or the documentation process may steer the evaluator to disregard some heuristics (ibid., 246). Schedules and budgets are often tight, gathering user information is difficult, and having a double role as both the producer and evaluator of the instructions may cause the evaluator to hesitate in reporting problems when they know the reasoning behind them (ibid., 246–247).

However, the workshop was relatively short, and the time allotted to evaluating the material with the heuristics was only two hours. This resulted in favoring certain more easily approachable heuristics while giving others less attention, and the participants themselves felt like the time constraint made them neglect some categories and that they would have benefitted from having more time (ibid., 245). The heuristics in category 1 (core tasks and goal-orientation) were largely ignored in favor of mainly utilizing the heuristics in category 2 (Accessibility) which to the language professional participants were easier to apply due to their concrete nature (ibid., 248). These limitations of the workshop give a good reason to study the heuristics further in evaluating heavy machinery manuals.

2.5 Minimalism and heavy machinery

Minimalism was born and developed in the world of software, and as of yet, minimalism and heavy machinery have not been discussed much in a shared context. Until the last few years, hardware in general has hardly even been mentioned in minimalist publications, and the sparse mentions have only been passing comments on how minimalism or some of its principles are not suited for certain users or products. There certainly has not been much thorough examination of the relationship between minimalism and heavy machinery.

That being said, combining minimalism and hardware seems to be on the rise as a point of interest. Virtaluoto, Suojanen and Isohella brought hardware into the discussion in a more concrete manner in 2020. They state in their article *Applying Minimalism in the Real World: Results From a Workshop* that the usefulness of minimalism has not been examined in the context of heavy industry machinery manuals (Virtaluoto et al. 2020, 239). They created the revised minimalism heuristics that were designed to work with hardware instructions as well as software. They tested the heuristics in a workshop with technical communications professionals who used it to evaluate heavy industry machinery end-user instructions (ibid.). The heuristics and the workshop are addressed further in the previous chapter 2.4.2.

After the publication of the revised heuristics, Hanna Heinonen, Jenni Virtaluoto, Tiia Suomivuori, Kristian Forsman, Tuomas Kangas, and Sanni Siltanen have studied applying minimalist principles in the delivery of hardware maintenance instructions to the maintenance technicians (2022). They used a touchscreen mobile phone to deliver elevator maintenance instructions to the technicians who could choose the amount of detail in the instructions based on their own skill level; novice, standard user, or an expert (Heinonen et al. 2022, 489). The instructions first opened as a simple checklist, which was deemed useful by expert user with a lot of experience and familiarity with the maintenance tasks (ibid., 495), whereas a standard or a novice technician had the option of getting additional information by opening links to more detailed instructions (ibid., 492).

According to Heinonen et al., the key principle at work with this approach is the idea of giving the user all needed information but not forcing it on them, as well as the idea giving them the opportunity to get started immediately (ibid., 486). The minimalism heuristics by Carroll and van der Meij address these principles, as do the revised heuristics by Virtaluoto et al. Heinonen et al. state that because the technician (i.e. the user) can choose the level of information presented to them and can get started fast with the instructions (especially the experts), their approach to the delivery of the instructions is thus "inherently minimalist" (2022, 486). Their results revealed that the users' opinions on the layered and skill-level based system of information were positive (ibid., 494). They thus concluded that many minimalist principles, such as being action-oriented and user-centered, giving the user more agency in the instruction process, and helping them get started fast are suitable for hardware maintenance instructions (ibid., 497).

While Heinonen et al. deem allowing the user to get to work immediately to be suitable for the maintenance instructions, I would argue that it is not recommendable for heavy machinery user manuals but is instead an unsafe approach. This is dependent on the context, the form of documentation and the user in question. In the study by Heinonen et al., the instructions being tested were instructions for standard elevator maintenance procedures, and not user manuals of large and potentially dangerous machines. The maintenance situation itself was probably relatively low risk. To perform a task safely with heavy machinery, the user must be given preliminary information on, for example, required tools and safety precautions. Running headfirst into action is ill-advised, even with an expert user.

Giving the user the power to decide how much instruction they get is also impractical for heavy machinery manuals. In the study by Heinonen et al., this approach was indeed successful, but the maintenance instructions were in a digital, mobile, and interactive form. When it comes to a lengthy machine manual, however, there is not really a similar usable mechanism in place because the physical instructions (or at most a PDF file) do not have the same flexibility when it comes to presenting information. To give alternative instructions for different users to choose from would be to create alternative manual versions, which adds to the already large body of documentation. Hypothetically, if there were heavy machinery manuals implemented in the same mobile fashion as the maintenance instructions in the study, letting the users gauge their own skill level and need for documentation is also tricky question from a legal point of view. What would the machine manufacturer's level of responsibility be if the user decides to skip on the offered extra instruction and causes an accident as a result?

When one goes back to the original minimalist principles and their 1995 heuristics, there are other principles, as well, that are not suitable for heavy machinery. Guided exploration which was heavily emphasized in early minimalist literature is hazardous with industrial machinery; the danger in accidentally misusing a heavy machine is usually more severe than clicking the wrong button in software. The user of a machine is supposed to succeed on the first try and making multiple attempts can be costly in time, money, or safety. That is not to say that making mistakes with software is desirable, either, but the consequences can be very different.

Virtaluoto et al. omitted the idea of guided exploration from their heuristics and state that "complicated business products may not be suitable for the type of guided exploration minimalism encourages" (2021, 24). As described in chapter 2.3, guided exploration has somewhat lost its appeal in the modern-day context anyway, because people usually have good technological skills and are more often interested in efficiently completing their tasks instead of freely exploring a system (Heinonen et al. 2022, 486). This might be a more recent development in software, but a user of heavy machinery has probably always been more interested in getting to work with their machine than exploring its capabilities.

Trusting the user's skills and intelligence is also in the forefront of minimalism. Van der Meij writes that "the minimal manual exploits the user's prior knowledge as much as possible" (van der Meij 1992, 7). The writer of the instructions must do their best to estimate what information and skills the users already possess. This is to write instructions that are the right amount of "incomplete" to encourage exploratory learning and to make for less reading (Carroll and van der Meij 1996, 73).

However, any type of assuming is risky business with heavy machinery. The key tactic in writing heavy machinery manuals, at least from a legal point of view, is often to assume that the user does not know things, and as van der Meij says, "legal issues such as liability claims may force the minimalists to become more maximal" (ibid., 15). One of the functions of heavy machine user instructions, alongside serving the user, is to protect the manufacturer from legal repercussions. The users might be the primary audience, but lawyers are also a very prominent target group. When a user suffers an injury and sues, missing or confusing information in the manual is a solid argument in court (Ross 2015). Writing for these two groups creates quite a conflict: the very information that the user deems unnecessary and impatiently skips over might be the cornerstone of the company's defence if the user gets injured. The cliché comment that "no one reads manuals" might be true even with industrial machine manuals, but at least the assumption that the user does read them is a protective factor for the company.

While there are some misfits, many of the principles and heuristics can very well be applied to machine manuals. Adhering to real life task structure in instructions benefits the user regardless of whether they're sitting behind a desk or installing wear parts to an industrial machine. Making the information findable by giving it intuitive headings is especially important when the user is utilizing a manual that is several hundred pages long. Writing concise instructions and modular content with independent topics also serves a busy heavy machinery user well when they open the manual just to read one chapter that is relevant to their urgent situation.

The most notable aspects that fits heavy machinery manuals is effective and ample error information. Preventing mistakes, giving on-the-spot error information with error-prone actions, and supporting error diagnosis and recovery are even more important with heavy machinery than in software where mistakes pose a less physical threat to the users' safety. Preventing accident and damage is also important from a financial perspective because repairing and replacing industrial machinery is extremely costly.

I will go into further detail on the applicability of the minimalist heuristics in my analysis in chapter 4.

3 METHOD AND DATA

In this chapter, I will firstly present the method – heuristic evaluation – used in this thesis. Secondly, I will describe the research material, which parts I have selected for the evaluation, and my reasoning behind the selection. Finally, I will explain how the method will be applied to the research material, and how results will be used to answer the research question of this thesis.

3.1 Heuristic evaluation

Heuristic evaluation (or expert evaluation) is an evaluation method that originally stems from usability research and was first described by Jakob Nielsen and Rolf Molich in 1990 (Virtaluoto et al. 2021, 30). The goal of a heuristic evaluation is to find usability problems in a product or a user interface (Korvenranta 2005, 113). The evaluator uses a list of heuristics which are guidelines or principles that the product should adhere to (Suojanen et al. 2015, 78). A style guide can also function as a set of heuristics.

The evaluator determines where the product does not comply with the used heuristics, lists the problems and the heuristics they break, and gives them a severity rating (ibid., 80). The rating can help in deciding which problems take priority when there is not much time for development (Korvenranta 2005, 115). Possible solutions to the problems can also be included in the evaluation (ibid., 116).

If there are multiple evaluators, a discussion where participants go through the findings often concludes the evaluation (ibid., 115). Ideally, the heuristic evaluation should be conducted by 3-5 people as a higher number of evaluators does not generally produce a significantly better result (Nielsen 1990, 255). Having evaluators with different professional roles, such as a subject matter expert and a language professional, ensures that the widest possible range of usability problems is found (Virtaluoto et al. 2021, 32).

According to Nielsen, a heuristic evaluation has many advantages: it does not require a great amount of resources or planning, its intuitive and motivating, and it can be utilized early in the development process as well as in evaluating a finished product (1990, 255). It is also a very versatile method of evaluation. Heuristics can be easily modified for different types of products or for different user groups (Suojanen et al. 2015, 80), and it can be combined with other procedures (Virtaluoto et al. 2021, 31).

The lack of end users' involvement, however, is a prominent shortcoming of a heuristic evaluation. Leaving the users out of the process always poses the risk of overlooking certain flaws in the document that are perhaps only relevant for the actual user. The evaluator can be given a typical usage scenario to help them relate to the users (Nielsen 1994), although creating said realistic scenario would require testing real life users. Subjectivity also plays a marked role in the evaluation. When the evaluation is based on the evaluators' personal view on what is problematic in a product, there can be a mismatch in the separate findings and some problems might be left uncovered. This risk can be mitigated be using a clear set of heuristics that leaves as little room as possible for interpretation (Paz et al. 2013, 120).

While the list of usability heuristics by Nielsen is by far the most known list, due to the very malleable nature of the method, there are numerous other heuristic lists developed for different products. Some examples of these relating to textual usability are Laura Rautava's heuristics evaluating user documentation of mobile applications (2018), Vesa Purho's heuristics for translating user instructions (2000), and usability heuristics for evaluating translations in general by Tytti Suojanen and Tiina Tuominen (2015). Minimalism heuristics by John M. Carroll and Hans van der Meij, and revised minimalism heuristics by Jenni Virtaluoto, Tytti Suojanen, and Suvi Isohella were discussed in further detail in chapters 2.4.1 and 2.4.2.

3.2 Research material

The Liebherr R 934 C-Litronic hydraulic excavator manual was downloaded from https://www.pdfmanual4trucks.com/liebherr/. The manual was published in 2006 and is 296 pages long with comprehensive chapters on safety, operation, malfunctions, and maintenance. Excavators are very commonly used machines in construction, mining, and many other industries.

In the scope of this thesis, I will mainly concentrate on chapters 3.3 *Operation*, 3.4 *Working with the machine*, and 4 *Malfunctions*. I will also review other parts of the manual or the manual as a whole when a heuristic specifically calls for it. For example, heuristic 2.3 includes a question about the table of contents, and heuristic 3.2 mentions the Machinery Directive whose requirements are spread throughout the manual.

Chapters 3.3 and 3.4 have the most amount of straightforward task information which gives me the opportunity to utilize the minimalism heuristics concerning tasks. The chapters also generally include the most amount of diverse task, concept, safety, and error information which makes them a suitable evaluation subject to primarily focus on. Chapter *3.3 Operation* has instructions on how to start, stop, tow, and drive the machine, along with chapters on adjusting the settings and speed of the machine. The tasks are more general in nature and prepare the machine for excavation work. Chapter *3.4 Working with the machine* has more specific instructions on how to excavate with the machine, how to move different machine parts with the controls, and how to operate optional extra devices and controls. Both chapters start with relevant general safety instructions regarding the tasks instructed in the chapters.

I will also concentrate on chapter 4 *Malfunctions* which consists of troubleshooting information. Troubleshooting has its own heuristic (heuristic 3.7) in the minimalism heuristic list so focusing on this chapter in my evaluation is required in order to assess the whole list. The chapter opens with general information and instructions on handling faults and errors and includes error code charts (error codes are displayed in the machine's control system) and common faults and errors and their remedies.

3.3 Research method

The research question of this thesis is:

- Are the minimalism heuristics by Virtaluoto, Suojanen and Isohella suitable for evaluating heavy machinery user instructions?

To answer this question, I will analyze the operating instructions of Liebherr R 934 C-Litronic hydraulic excavator by performing a heuristic analysis where I will use the minimalism heuristics created by Jenni Virtaluoto, Tytti Suojanen, and Suvi Isohella. I will look for usability problems in the manual with the help of each individual heuristic. In chapter 4, the found usability problems will be described and grouped under the three categories present in the heuristic list core tasks and goal-orientation, accessibility, and error management. The categories will be furthered divided into the subordinate heuristics which will be discussed individually.

In addition to presenting the found usability problems, I will discuss the applicability of the minimalism heuristics in evaluating a heavy machinery user manual. I will consider the reasons why they might be suitable, as well as possible factors hindering their use, and any confusion in their wording or meaning. Any arisen ideas to develop the heuristics to further fit hardware manuals will also be discussed. Additionally, while I will not test the heuristics with software instructions nor concentrate on finding usability problems from a software perspective, I will discuss any problems and suggestions for improvement that arise during my evaluation that are not specific for hardware use but have to do with the general content and usability of the heuristics.

As stated in chapter 3.1, the conductor of a heuristic evaluation usually gives the found usability problems severity ratings that help in prioritizing which problems absolutely need solving and which problems are mainly cosmetic. It is also possible to provide recommendations for improvement or fixing the problems. The aim of this thesis, however, is not to fix the manual or its usability problems, but to simply determine whether the minimalist heuristics are suitable for heavy machinery manuals. I will, therefore, rather focus on the amount and range of usability problems that the heuristics yield.

The ideal number of evaluators is 3–5 people, and a single person is not able to spot all problems in a product, as was also mentioned in chapter 3.1. In the scope of this thesis, however, I will be the sole evaluator. Since my goal is to assess heuristics and not to find every single problem within the document, I believe the efforts of one person are enough to answer the research question. In addition, I will have significantly more time to focus on my evaluation than the two hours spent by the participants in the 2020 workshop.

It is also worth noting that I myself am not a subject matter expert in hydraulic excavators. Virtaluoto et al. state that "the heuristics related to the core tasks of the user require a thorough knowledge of the user and the functionality of the product" (2021, 32). Because I have never used an excavator myself nor been involved in making a manual for its use, I expect that my findings in category 1 (core tasks and goal-orientation) will be fewer than those of a subject matter expert or a real user. I do, however, have experience in creating and updating user instructions for other types of heavy machinery that are used in a similar and same environment as an excavator. I am thus familiar with the common problems that the users of such machines face.

4 ANALYSIS

In this chapter, I will present the usability problems found in the analysis material. The findings are firstly grouped under the three main categories that form the minimalism heuristic list, and secondly under the heuristics present in those three categories. Each individual heuristic is addressed separately, and all related usability problems in the material are gathered under the relevant heuristic. Under each heuristic, I will discuss the suitability of the heuristic in evaluating a heavy machinery manual and problems and possible improvements both hardware-specific and general. In chapter 4.4, I will provide a summary of the found issues and suggested improvements. I will also consider the usability of the minimalism heuristic list as a whole.

4.1 Category 1: Core tasks and goal-orientation

4.1.1 Core tasks

1.1 Does the documentation concentrate on the user's core tasks? (OH2.1)

Whether a piece of heavy machinery documentation concentrates on core tasks is a tricky question to answer. Core tasks are real-life activities performed with the product that interest and motivate the user (Carroll and van der Meij 1995, 248). With a software product, the meaning of the heuristic is clear: the way to concentrate on core tasks would be to give the user tasks that make sense to them and are meaningful achievements (ibid., 249), as opposed to giving making them targeted but unmotivating exercises to learn the different functions of the program. Necessary skills will be taught in the process of working towards a concrete and compelling purpose. This begs the question of what are the core tasks of an excavator user or other heavy machinery, and how can a heavy machinery manual realistically concentrate on core tasks?

If the idea in software is to frame the learning process with the core task to motivate the user, with heavy machinery that is no possible due to the sheer quantity of information and tasks needed for the core task. For an example, the ultimate core task of an excavator user is, to put it in very simple terms, to dig and transport soil material. Having a comprehensive chapter "*Digging with the machine*" is, however, will not work because the chapter would essentially have to include all required preceding tasks and descriptions, and there are quite a few. The chapter would have to cover half of the manual.

To get to work with the machine is a long journey of safety measures, setting up, and familiarizing oneself with the machine and its controls.

Even if we leave out all the preparatory tasks and safety measures, instructing the highest core tasks (i.e., the thing actually done with the machine) in the manual is difficult because the core task is frequently made out of many smaller tasks, especially with a large machine and a complicated process. A machine also can have multiple uses for the user, but the basic machine functions needed for them are the same. An excavator, for example, can be also used for lifting loads and demolition. Although it goes against minimalist principles, it often makes more sense to explain the functions clearly so that the user can apply them as needed in the task.

In addition to the topmost core tasks that might be impractical or impossible to include in the manual, there are other, slightly more low-level tasks that the users still want to complete with the machine that take precedence in their minds over other activities. In general, the user is probably much more interested in, for example, driving a machine from point A to point B than checking the coolant level. In the context of a heavy machinery manual, the realistic core tasks would then be the main tasks and machine functions that are needed in order for the user to get working towards their goal.

How about the ways in which a heavy machinery manual can *concentrate* on these core tasks? As is usual and required of hardware user instructions, the tasks and parts of a manual are organized by logical subject matters and in a succession that reflects how the machine would be operated in real life and what information is needed beforehand for safe use. The structure of a heavy machine manual is generally rather fixed: the order usually goes from the machine description and technical and safety information to operating the machine, while maintenance and troubleshooting information usually concludes the manual. The central tasks thus have their rational place in a manual and prioritizing them by presenting them first before any other information would be highly irregular and unrealistic, and probably hazardous and confusing for the user, too. They can and should, however, be presented as soon as possible in the manual, and not left behind tasks that are less central to the user.

Even this, however, should be done within sensible subject matters. In the excavator manual, for example, description and instructions of the driver's cabin and its components come before driving the machine. While driving the machine is inarguably more central for the user, it makes no sense to put driving instructions before using the windshield wiper. Driving the machine should still come as soon as possible within its own main chapter (3.3 *Operation*).

If positioning is mostly out of the question, how about concentrating on the central tasks by giving them more attention in the instructions? Even if certain tasks are more central from the user's point of view, those tasks usually have prerequisite tasks. The user of an excavator, for an example, cannot jump straight to driving the machine, but there must first be instructions on how to start the engine and how to jump start the engine in case of failure, how to read the control panel display, and so on. The user must be instructed in these activities with just as much detail and care as the more appealing central tasks. It is thus not plausible to give the central tasks more consideration regarding their content, length, or form, either.

Overall, "concentrating on core tasks" is better suited for software where there are often multiple different activities that the user could possibly engage themselves with and get lost in, and where there is a risk that the instructed hypothetical tasks might not make sense to the user. In a heavy machinery setting, it is not likely that the user would question the purpose of the instructed task, or that the manual would give instructions on a task that is not relevant at least in some situation. As stated earlier, the means to concentrate on core tasks are rather negligible as well.

Considering all these points, the first heuristic at least in its current form is not applicable for heavy machinery instructions in the same way it is for software. A better suited heuristic would thus be: "*Does the documentation include the user's core tasks and are they presented as soon as is possible and sensible?"*. This heuristic is also worded in a more practical way so that it gives the evaluator two concrete points to focus on.

The core tasks are included in the excavator manual in chapters 3.3 *Operation* and 3.4 *Working with the machine*. These specific core tasks are chapters 3.4.4 *Operating the swing gear*, 3.4.6 *Joystick functions when setting up the machine*, and 3.3.7 *Driving.* The first two chapters deal with moving the machine parts that enable digging or transporting material, and the last chapter deals with driving the machine around. Location-wise, the instructions are positioned as early as is possible and sensible: chapters 3.4.4 and 3.4.6 are located close to the beginning of chapter 3.4 *Working with the machine* after safety instructions and amidst a few other relevant chapters. Chapter 3.3.7 is also positioned sensibly after safety information and starting the engine under chapter 3.3. *Operation*, although is could be argued that driving should come before chapter 3.3.6 *Emergency operations.*

1.2 Does the documentation reflect the real-life structure of each task? (OH2.2)

Heuristics 1.2 seems to have a slightly different meaning from the original heuristic. Carroll and van der Meij mostly address headings under their corresponding heuristic 2.2 *Components of the*

instruction should reflect the task structure (1995, 250). They state that the headings should be "crafted to convey deliberately and clearly the major procedural elements in the instructional tasks" (ibid.), meaning that the tasks should be in the same order they are executed in real life, and they should have intuitive headings. A realistic structure and clear headings help the user find information and comprehend the big picture of the skill they are learning or product they are using.

The revised minimalism heuristic, on the other hand, appears to delve a little deeper from the macro-level manual structure and headings. It asks whether individual task instructions are written as the task would be executed in real life, while logical document structure and intuitive headings are addressed in other heuristics. This heuristic is an important one, especially with heavy machinery when making a mistake because of straying from the real-life succession of a task can, as explained in chapter 2.5, be hazardous and lead to consequences that cannot be undone with a press of a button. Heuristic 1.2 is, therefore, as equally important in a hardware environment as in software, if not more.

Properly evaluating the tasks in the manual would require a subject matter expert since I do not have first-hand knowledge on how the instructed tasks would be executed in real life, but the steps in the tasks seem to follow a logical order. Procedures that I am more familiar with, like jump starting the engine and towing, also have credible content. The manual presents step results especially well with a small L-shaped arrow, which prompts the user to check for all signs that the step was executed successfully.

1.3 Does the documentation explain why the task is done, in addition to how? (OH2.2, Extended)

Heuristic 1.3 leans a bit more towards software in the sense that heavy machinery users may have more concrete goals in mind when they open the user instructions, and the motivation behind most tasks is somewhat obvious. They likely experience less confusion overall as to why they are executing a task and might need less motivation.

Nevertheless, it still important to make the user aware of the importance of some actions that they may question, especially when the task concerns safety. A task such as driving a machine may have many obscure-sounding prerequisite actions that the user may be tempted to ignore in their haste to get the machine moving. In these situations, providing explanation ensures that the user will at least understand why skipping tasks is a bad idea. Heuristic 1.3 is, therefore, useful and essential for heavy machinery manuals.

The documentation has some explanations on why tasks should be done, for example, such direct phares as "*to obtain optimal comfort*" and "*to avoid damaging LIEBHERR diesel engines*". Some tasks begin with a few sentences of descriptive information to explain the task's goal or what event could lead the user to complete the task. These instances are not very common and only occur with tasks whose purpose is not intuitive to the user, such as preheating the coolant oil. Tasks that have a clear goal, like driving and starting the engine, have no explanations.

Most of the motivation is found in the warnings, notes, and safety instructions. This makes sense given the fact that the safety information has many singular instructions whose purpose is not immediately clear. The user cannot be expected to know, for example, why the engine power must be reduced when the machine is 3 000 meters higher than the sea level, or why all panelling locks have must be unlocked when operating the machine.

There are some chapters where the motivation is not written but rather shown in a figure. In section *Operating the stanchion cylinder* (under 3.4.6 *Joystick functions when setting up the machine*), the heading of the task is obscure and gives the user no clue as to what operating the cylinder accomplishes. The section has a figure, however, that shows the arm of the excavator moving along with the joystick that controls the cylinder.

4.1.2 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)

While the concept of exploratory learning was completely omitted from the revised heuristics because Virtaluoto et al. deemed it incompatible with hardware and present-day software users (2021, 29), getting to work immediately is still included in heuristic 1.4. This is presumably because it is a valid approach with software, and the heuristics were created for both software and hardware products. However, as stated earlier in chapter 2.5, getting to work immediately with a heavy machine is not safe given the possible hazards that it might pose. The first question in the heuristic 1.4 is thus much more suitable for a software environment where getting to work immediately promotes learning instead of inviting accidents.

The second question of the heuristic, on the other hand, is suitable for heavy machinery manuals as well. Unnecessary information before task steps can be a problem, especially if the task topic opens with large chunk of concept information that should preferably be in its own topic. Beginnings of task topics are often also used as dumping grounds for all kinds of notes and additional information that does not have a predetermined placement anywhere else.

For heavy machinery, the first question of the heuristic should be ignored so that only the question left is: *If the documentation contains general information, prefaces, or introductory information before the steps, is the information concise and necessary?*

Most of the information preceding steps in the Liebherr manual is related to safety, which is to be expected in a heavy machinery manual. All information is necessary for the user to execute the task safely and successfully, except for the explanations that offer the user motivation for the task. However, as mentioned previously with heuristic 1.3, motivation does have its place with tasks whose purpose is not self-evident.

Some safety precautions are repeated multiple times, for instance, both in the general safety section starting the chapter and in a separate warning preceding a task or a step. In these cases, the mention in the general safety could be omitted, seeing as the it was still thought necessary to add it where the task in question occurs.

4.1.3 Immediate assistance

1.5 Is the documentation available when needed? (OH1.3)

Having the documentation available to the user when needed is important in both software and hardware. The forms of documentation do differ: nowadays, having physical instructions for software products is very uncommon, but heavy machines still usually have thick physical manuals delivered with them, alongside a digital copy. Regardless of the form the instructions take, heuristic 1.5 is indisputably relevant for all kinds of product.

I have no way of knowing whether the Liebherr excavator manual is available for the machine's users on the spot, but the manual does state that the instructions belong with the machine and should be kept inside the machine's cabin. It is, therefore, reasonable to assume that the manual, at least in its physical form, is delivered to the user alongside the machine.

Upon the arrival of the machine, it is quite improbable that the user learns how to use an excavator solely with the help of a manual. There is most likely real-life training from a more experienced user or a representative of the machine manufacturer or vendor. In a moment of need, the almost 300-page manual is not exactly the most usable piece of instruction, but it does give the user access to (presumably) all information that they could possibly require. The length of the manual makes it especially important that it is skimmable, and that the user can find the needed information quickly.

1.6 Does the user get targeted instructions at the relevant touch points on the user journey? (OH1.3, Extended)

The meaning of this heuristic is initially a bit confusing due to its wording. Virtaluoto et al. explain that the principle behind this (along with heuristics 1.4 and 1.5) is goal-orientation which is the paramount quality in user documentation (2021, 28). To find further clarity, I examined the Finnish translation of the heuristic. The translation seems to have a slightly different form. The Finnish phrasing is "*Saako käyttäjä täsmäohjeistusta, joka sopii suoraan käsillä olevaan tilanteeseen*?" which has no mention of a "user journey", but instead asks whether the user is given targeted instructions that can be directly applied to the "situation at hand".

A user journey consists of a person trying to accomplish a goal with a product (Gibbons 2018). As for the "relevant touch points", Virtaluoto et al. state that in the planning phase of a document, "the focus must be on what users do at each touch point on their journey with the product-to-be-documented and what they need at those specific points" (2021, 25). They also emphasize "the user's needs for accessible information" (ibid., 32). Given that this heuristic is grouped under *Immediate assistance*, one could conclude, then, that a relevant touch point means a time in the user journey (perhaps a problem or a point of confusion) when the user needs instructions on how to interact with the product in order to work towards their goal. The Finnish translation also supports this understanding.

The concrete meaning of this heuristic, at least in terms of software, can also be searched from Carroll and van der Meij's original minimalism heuristic 1.3 ("*Respect the integrity of the user's activity"*) since heuristic 1.6 is its extended version. This means that the user's goals come first, and the product and its tools and information should be designed in a way that does not obstruct those goals (Carroll and van der Meij 1996, 82). Help must be readily offered but it should not be imposed on the user (Carroll and van der Meij 1992, 247). Carroll and van det Meij present passive help tools as a way to aid this objective, such as extra bits of information that appear next to a term when the cursor sweeps over it (ibid.). The concept of these help tools fits the heuristic's Finnish version and its call for "targeted instructions". The tool is, however, not applicable for heavy machinery manuals which are cohesive documents with a certain order, and which usually have a physical form which must include all the same information as a digital copy of the same manual (clickable info boxes are not thus possible). Furthermore, there is not much information in a hardware manual that is optional in nature, and where it could be left up to the user whether they observe the information or not.

Heinonen et al. applied this heuristic in their study where they gave the technicians performing hardware maintenance tasks the option of deciding the level of detail in the instructions according to their own skill level (2022). This study was discussed further in chapter 2.5.

The participants of the 2020 minimalism heuristics workshop noted that the revised heuristics 1.6 and 2.3 are similar and deal with related issues (2020, 245). Giving targeted instructions when the user needs them and the findability of said instructions are, indeed, intertwined concepts when it comes to heavy machinery. I would go a bit further and say that immediate assistance for heavy machinery users *is* information that is easy to find, since a physical machine manual does not have the same tools as software in its disposal.

This heuristic is thus more applicable for software documentation, and Virtaluoto et al. agree (ibid.). Since findability is already covered in the two heuristics under said category, heuristic 1.6 is not needed nor useful when evaluating heavy machinery instructions.

4.2 Category 2: Accessibility

4.2.1 Content

2.1 Is the documentation as concise as possible in its overall selection of contents? (OH4.1)

A certain portion of the information in a heavy machinery manual is often irrelevant to the user in the sense that they will never need it, or they simply skip reading it. The requirements for the manual set by machine safety, laws, and standards still dictate that the instructions must cover many things that the user might find useless. Furthermore, the information or tasks that most users might not ever need can always be crucial to one user in a particular situation. The tactic with heavy machinery is typically to include everything in the manual that could plausibly be relevant. The keywords in heuristic 1.2 in terms of hardware are thus “as concise *as possible*”.

That is not to say that a machine manual cannot have unnecessary content. When machine features are updated, added, or removed, it is always possible that some tasks or chapters made obsolete by the update are left in the manual by mistake. This can happen especially when the technical writer in charge of the documentation is new to the machine or not yet familiar with the structure of its manual and which parts of it the update affects. There can also be unnecessary repetition or even sections that are just plain pointless for all users. Because of these possibilities, heuristic 2.1 is applicable for heavy machinery manuals, as well.

As with heuristic 1.2, accurately evaluating the content selection of the excavator manual would require a person closely acquainted with the use of the machine. Nevertheless, from my point of view as someone with some experience with other heavy machine manuals, there seems to be nothing in the manual contents that could not be useful at least in some situation to some kind of user.

4.2.2 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)

Having a logical structure in both the contents of the document and in individual topics helps the user immensely in finding information, and as discussed under heuristic 1.6, it provides the user immediate assistance. The user can use their intuition and their preconceived idea of a manual's structure when looking for a relevant section for their needs. This works especially well with heavy machinery manuals because the basic structure is often very uniform regardless of the type of machine. Additionally, when the section structures are consistent and logical, skimming becomes much easier. This heuristic is thus relevant and applicable for heavy machinery manuals.

In its current form, heuristic 2.2 directs the evaluator's attention first to the overall structure and contents, most likely through the table of contents. The second question asks the evaluator whether the structures of the chapters (or sections) are consistent, but unlike in the first question, not if the sections' internal structure is logical. At least for myself, considering this was a natural continuation for the questions, but this could also be explicitly stated in the heuristic to avoid it slipping the evaluator's attention. The questions could perhaps be combined, for example: *Is the overall structure of the documentation logical and consistent, as well as the structures of all topics/sections?*

As for the overall structure of the excavator manual and the layout of the chapters, there is some room for improvement. In chapter 3.3 *Operation*, after instructions on how to start the engine, the manual has a section called *Starting aids.* The section has subchapters on, for example, jump staring the engine and emergency measures for some parts of the machine. These could be moved to the troubleshooting section where they could be found in case of an occurring problem, instead of putting them in the middle of the operation chapter where the user must skip several sections if nothing goes wrong, and they want to continue working with the machine. Additionally, chapter 4.3 *Fuses and relays* is the last section of chapter 4 *Malfunctions* even though it has only descriptive information and does not contain any troubleshooting information, unlike the other two chapters 4.1 *Error code charts* and 4.2. *Faults and remedies.* Aside from these few cases, the manual is structured logically and in a consistent manner.

The internal structures of the sections are also overall quite consistent when it comes to the order of different elements, but the use of symbols varies a lot. The safety listings in the beginning of chapters include steps that are marked with a line, but everywhere else steps are mostly marked with an arrowhead, and sometimes with a small white square. The arrowheads, lines, and boxes are still used for other purposes as well, such as giving notes and sometimes even in warnings. This makes differentiating steps and other forms of information difficult at times, and the manual would generally benefit from using the symbols much more consistently.

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?

In addition to logical and consistent structure, findability is also made of smaller concrete ways of finding information that heuristic 2.3 addresses. The table of contents and indexes are the first things the user turns to when trying to find a specific piece of information from a long manual. According to Virtaluoto et al., the headings “should reflect the task structure and help users find the information they need” (2021, 29). The phrase “clear and intuitive” thus refers to the fact that the user must be able to skim the manual using the headings and that the tasks should effectively communicate to the user what is the purpose of the task. To the same end, the keywords in an index must be descriptive as well. The benefit of an electronic manual is that finding information is easier, but it requires a search functionality that is easy to use, such as, for example, clickable headings in the table of contents and bookmarks. The contents of this heuristic are thus equally as important for heavy machinery as for software manuals.

The Liebherr manual has a clear and well-structured table of contents with bolded first-level chapters and indented sub-chapters. It does not include an index, which as a feature is increasingly rare in user instructions, but nonetheless, would have been useful since its helps greatly in locating all sections pertaining to a certain topic or concept.

For the most part, the headings in the manual describe the contents of the chapters well, and most of the task headings in the manual are in gerund form, like for example "*Starting the diesel engine*" and "*Connecting the batteries*". However, this is not consistent, and a great number of headings also have verbal nouns in them, such as "*Emergency control speed adjustment*", or just a noun, such as "*Emergency operation*". The differences are confusing because gerund forms give a clear description of what the task at hand is, but other headings are easily confused with the conceptual sections that are sprinkled amid the tasks and have similar headings. As a result, the findability in the manual suffers quite a lot.

The heuristic does not mention specifically which verb form should be used in the headings. Van der Meij mentions gerunds (like "*Starting the engine*") and infinitives (like "*To start the engine*") as good choices (2004, 6), and going into such detail would be possible, but also quite prescriptive and not very realistic. Companies often have their own style guides for such linguistic details.

As for searching the document, the user can use the text search functionality to find what they need in the manual when they open it in a PDF reader program. However, the table of contents is not clickable, and the PDF has no bookmarks. This is especially impractical because with a nearly 300-page manual, those two elements are crucial for finding information. Repeatedly scrolling all the way down the desired chapter takes a lot of time from the user.

Heuristic 2.3 does not mention the need for numbered headings. The headings in the manual are generally numbered, but only down to the third level. This sometimes makes it hard to grasp the hierarchy between the sections on lower levels. For example, chapter 3.3.3 *Starting/stopping the machine* already has a third-level heading, but there are three heading levels below it. These are differentiated only with a slightly smaller font. In this case, this could be due to a technological limitation: some technical documentation software does not allow for headings below a certain level to be numbered. Nevertheless, having numbered headings is overall important, and even though they are usually a given in any linear piece of technical documentation, adding it to the third bullet point of the heuristic would ensure that this is taken into consideration.

Furthermore, heuristic 2.3 specifies many things as factors of findability, but it does not mention references. The precision of the internal references within the excavator manual varies quite a bit. They range from direct references to chapters ("*see chapter 'Battery care'*") to somewhat vague instructions, like "*Start the engine as described earlier*" or "*in accordance with the regulations given in the operating instructions*". It would be more beneficial to the user to replace these more general references with references to specific chapter headings so that the user does not have waste time finding the correct instructions. At the very least, using a consistent method for referencing would be better for the user than miscellaneous expressions. Adding a bullet point with "*precise and consistent referencing*" to the heuristic would help the evaluator to pay attention to the references.

4.2.3 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?

Having easily understandable information is important for all kinds of user instructions, especially when the users of a product have varying amounts of experience. Documentation that is easy to understand helps the user avoid mistakes, which again is crucial when dealing with heavy machinery. Heuristic 2.3 is very user friendly for the evaluator: whether the documentation is "*easy to understand*" is quite a broad question, but the specifying bullet points help the evaluator to get started on different concrete aspects of understandability. The heuristic is thus suitable for evaluating heavy machinery manuals.

The tasks instructed in chapters 3.3 *Operation* and 3.4 *Working with the machine* are not very long to begin with, but when necessary, longer tasks have been divided in smaller sections. For example, the task of starting the diesel engine includes sections on switching on the electrical system, deactivating the anti-theft device, and starting the engine. These tasks could have simply been put under just “*Starting the engine*” but giving them their own sub-chapters helps the user get a better grasp of the stages of the task and helps with findability, too.

Steps are written in clear and understandable language, and the sentences in the manual are overall short and structurally very understandable. The steps are also mainly in imperative form with only a few exceptions. Virtaluoto et al. mention that information presented with the active and imperative voice is an attribute of a good document, as well as positive language where the user in encouraged to do something instead of forbidding them or blaming them for making a mistake (2021, 29–30). However, they do not ask for these attributes directly in the heuristic.

“*Verb forms relevant to the information type*”, however, is mentioned in the fourth bullet point. A technical writer with some training and/or experience should easily know what this means, but someone less familiar with manual writing might not. Mentioning the use of active and imperative voice and positive language in further detail in the heuristic could, therefore, save time for some evaluators. Although, it is worth noting that refraining from using the negative voice in warnings and cautions just for the sake of sounding more encouraging is not wise in a heavy machinery manual because it is important to be as clear as possible with potentially hazardous tasks. Positive voice is, nevertheless, a good tool elsewhere in the manual.

The steps also predominantly include one action per step, or at most, two very closely related actions. The heuristic makes no mention of the commonly used “one-action-per-step” rule, but since having two actions is often also justifiable, the second bullet point’s mention of a “*clear*” step is enough.

The terminology in the manual is appropriate and seems standard for the user group. There is some opportunity for more simplified language, however, with some verbs and phrases. For example, words like “*halt abruptly*” and “*display on the screen*” could be replaced with “*stop suddenly*” and “*show on the screen*” to make them easier for understand for users whose first language is not English, for example. In addition, there also a small number of grammatical mistakes and incorrect punctuation, and at least one instance where a word is written in German instead of English. The heuristic does not explicitly ask whether the language is grammatically correct, but since finding all typing errors would require reading the whole document with a very keen eye and thus spending a lot of time that could be spent focusing on more major problems, omitting such a specific question is preferable.

As an additional observation, the steps in the manual are not numbered, but are instead usually indicated with a right-pointing arrowhead. Numbering steps in manuals is helpful because it separates the task actions from all other information, makes the procession of task clearer, and helps with referencing and findability. "*See step 2*" is a clearer reference than "*see the second step*", and step 2 is easier to find from a numbered list. Heuristic 2.4 does not directly address the need to have numbered steps, but instead asks whether the documentation contains "*clear, action-oriented steps*". Adding "*numbered*" to this list would be beneficial. This could arguably also fall under the heuristic category findability for the reasons stated above, but since heuristic 2.4 already directly mentions steps and numbering also helps with understanding the task, it could be addressed within this heuristic.

4.2.4 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?

The visual elements of a user document were not addressed directly in the original heuristics by Carroll and van der Meij. Virtaluoto et al., on the other hand, give a detailed heuristic dedicated just for them. One could argue that visuals and their usability are even more important with heavy machinery manuals than software instructions. A computer program largely consists of words on a screen, but when the product is a large machine and using it happens in the physical world, describing tasks gets difficult with just words. Heuristic 2.5 is, therefore, very useful for evaluating heavy machinery user instructions.

The excavator manual uses figures in appropriate places to show parts, positions, displays and locations, for example. All figures are relevant and serve a clear purpose to illustrate the components of a task. The user is usually not left guessing what any button, switch, or part looks like, and when the location of a part is not described in the text, it is shown in a figure with enough context to locate the part.

The figures are clear and scalable line art with consistent style. Almost all callouts are clearly marked into the figures with lines indicating machine buttons and parts, with a few exceptions. Sometimes the callouts visible in the figure are not present in the text. The majority of the figures are numbered and have clear descriptions that tie them to the instructions, and the figures and the text are well connected to the text with the callouts.

Smaller figures (mostly of machine buttons and screen symbols) that are positioned next to the text or relevant step do not have descriptions, callouts, or anything to tie them to the text other than placement. In some cases, this could be useful, especially if it is not obvious what the figure is referring to. The figure could also be placed under the relevant step to make the connection more obvious (although placing the figures to the side does make the manual shorter).

One potential modification to the last question in the bullet point list would be "*Are the images and text in the documentation clearly connected using callouts* ***and positioning****, for example?*". Callouts are an effective tool, but placing the visual as close to the relevant step or procedure is also important in order to avoid confusion. In most cases, the figures in the manual are positioned appropriately right before or next to the relevant step, although there are some exceptions where the visual is a bit further away.

4.3 Category 3: Error management

4.3.1 Preventing errors

3.1 Have errors been prevented? (OH3.1)

The wording of heuristic 3.1 is a bit vague for a heuristic evaluation when it comes to what the evaluator should actually look for in the document. Carroll and van der Meij's original heuristic encourages the document designer to "prevent mistakes whenever possible" (1995, 252). They introduce many concrete tools for prevention: using simple language and understandable terminology, using user testing to redesign the instructions, blocking errors, using hints, and improving the program itself to prevent errors (ibid.). Some of these ways are unapplicable for hardware manuals. Hints, for example, are too soft a tool for potentially dangerous machines. If an action can lead to a mistake, a warning or caution is in place. User testing and blocking errors is needed for hardware as well, but this is usually done with and within the product in product development, and not so much with the user manual.

The ways to prevent errors (or mistakes and accidents) in heavy machinery user instructions include writing accurate and comprehensive task instructions that are easy to follow and generally giving the user all necessary information to use the machine safely and correctly. Generally, the main way to prevent accidents is always to engineer the machine to be as safe as possible, while all residual risks are addressed in the manual with warnings, cautions, and notes in appropriate, mistake-prone places.

All aforementioned ways of realistically preventing errors in a heavy machinery manual are already covered by other heuristics in the list (except for using warnings and notes where they are needed, but this is discussed further under heuristic 3.3). Heuristic 2.4 calls for clear language and understandable terminology. Other heuristics in category 3 cover the use and positioning of warnings and notes, as well as troubleshooting. In a way, most of the heuristics help with preventing errors in some capacity, and heuristic 3.1 is not really needed after applying them because there are no additional ways of error preventing left in machine manuals after their content has been taken into consideration. If the instructions being evaluated were for software, previously mentioned actions like blocking errors and hints would still be leftover tactics, but as stated before, they are not suitable for hardware manuals. Heuristic 3.1 is, therefore, not needed nor applicable for heavy machinery user instructions.

4.3.2 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)

Heuristic 3.2 is an important question because legal requirements and standards are paramount in the heavy machinery industry, as Virtaluoto, Suojanen, and Isohella themselves state (2021, 32). It is, however, quite a laborious task for an evaluator to do research on all applicable legislation and standards. This depends, of course, largely on the evaluator’s existing competencies, knowledge of the product and the requirements of the manual. Someone with substantial experience with safety legislation and the product, for example a machine safety specialist, might already have a clear impression of what the manual must entail. For a regular technical writer who might have not been involved in the initial making of the manual at all, the heuristic is a daunting box to check.

Heuristic 3.2 is, therefore, mostly suitable for a person who already has been involved in safety matters and knows what to look for. Virtaluoto et al. emphasize that to apply the heuristics effectively, there should be multiple different professional roles in the evaluation table (ibid.). This heuristic suggests that the heuristic evaluation should include someone with safety expertise. Another alternative would be to provide the evaluators with a summary of all applicable safety standards and legislation that they could use in their evaluation. However, evaluators' competencies aside, this is still an essential heuristic that needs to be included simply for legal reasons.

Since I have no way of knowing all the standards and legislation that applied to this manual at the time of publication, I will in the scope of this thesis concentrate on the Machinery Directive which is directly mentioned in the heuristic and at least in theory should have been taken into consideration. The Machine Directive applicable in the time of the Liebherr excavator manual's publication was the 1998 directive, as the new 2006 directive did not become applicable until 2009 ("Mechanical Engineering: Machinery", section EU machinery legislation).

The Machinery Directive has its own chapter for user instructions requirements (chapter 1.7.4 *Instructions*). The excavator manual has all the required information on the machine's markings, intended use (as well as inappropriate ways of use), workstations, adjustment, use, handling, attaching and dismounting equipment parts, maintenance and servicing, and characterizations and use of optional tools. The manual has no training instructions, but the directive states that they should be included "*where necessary*" (20), so the absence of these instructions may very well be justifiable. Necessary drawings and diagrams also seem to be included in the instructions. The manual does not, however, state the airborne noise emissions caused by the machine as is required (ibid.), but instead only shows the position of the machine plate that indicates the sound/power level of the machine. This is a clear deviation from the Machinery Directive.

3.3 Are all the warnings and notes necessary? (OH4.1)

Having unnecessary warnings and notes is possible with all kinds of instructions. The writer of a heavy machine manual especially might use excessive warnings wherever there is the slightest risk of a mistake to make sure there is as little liability as possible on the machine manufacturer in case of an accident. Notes can also be clumsily stuffed full of information that the writer was not sure whether to include, or where to place. Heuristic 3.3 is thus applicable for heavy machinery manuals.

Almost all warnings and notes in chapters 3.3 *Operation* and 3.4 *Working with the machine* of the manual seem necessary and have useful information on possible hazards and things to take into consideration. There is one warning which elaborately explains the use of a safety belt (basically a seat belt) and which could in theory be omitted based on trust in the user's common sense. On the other hand, expecting common sense from the users can easily go wrong, and them ignoring the seat belt can be reasonably expected, so the warning is probably still necessary.

To address the content of the heuristics in a more general sense, while this and other heuristics in this category deal with relevant factors in warnings and error information, there is no specific heuristic on whether warnings and cautions are used where they are needed. Missing warnings, especially when the involved risk for the user is significant, are a major problem in a heavy machinery manual. The excavator manual has instances where bits of information should preferably be written as a warning or a note due to the content, but instead, are lost among task and concept information. Such a heuristic would also be especially useful if there is a safety professional involved in the evaluation who would have even better insight into the matter than a regular technical writer.

Additionally, there are some instances in the excavator manual where the information in a note is more appropriate for a warning. It is stated in the manual in chapter *2.1 Symbols in the operating instructions* that the notes contain helpful user tips and operating and maintenance procedures to ensure the longevity of the machine. The warnings and cautions, on the other hand, relate to possible death, injuries, or damage to the machine. There are still, for example, both notes and cautions for actions that could possibly damage the engine. It would thus be beneficial to have a heuristic that takes the content in the warnings and notes into consideration.

For these reasons, I would propose a few additional heuristics to the existing listing under the category *Warnings and notes*:

1. *Have warnings been used where necessary?*
2. *Is the information in the warnings and notes appropriate for the information type?*

3.4 Are the warnings and notes located next to the relevant procedure? (OH3.4)

Having the warnings and notes close to the relevant procedures is important in heavy machinery user manuals to avoid mistakes and accidents. When they are positioned next to the accident-prone step, they are more likely to catch the user’s attention before said accident can happen, or they can help in recognizing the mistake if it does happen, as well as in understanding its cause (Carroll and van der Meij 1995, 254). This means that the user might not need to turn to the troubleshooting section at all for help. Seeing a warning or note regarding a possible mistake can also give the user a sense of security that they have executed a step correctly and reduce anxiety (Virtaluoto et al. 2021, 30). Heuristic 3.4 is, therefore, well suited for evaluating heavy machinery user instructions.

The warnings and notes in the excavator manual in chapters 3.3 and 3.4 are located next to relevant procedures, usually preceding the step it concerns. Sometimes warning and notes are placed after the step, and in these cases, the information is less pressing and does not warn of a possible physical danger to the user. If the warnings and notes are more general or prerequisite for all following steps and/or procedures, they are appropriately placed in the beginning of chapters.

4.3.3 Error recognition

3.5 Does the documentation offer error information: recognition, diagnosis, solution? (OH3.3)

The principle of the user needing information for error recognition, diagnosis, and solution carries over to the revised minimalism heuristics from Carroll and van der Meij's original heuristics. They introduce the idea of internal and external triggers when recognizing a mistake (1995, 253). Internal triggers are based on the user's feelings of something having gone wrong despite the lack of a concrete indicator, and external triggers happen when something in the program prompts suspicions of a mistake (ibid.).

With heavy machinery, recognizing the error or the malfunction (meaning detecting that an error has happened) is most often due to external triggers and is fairly straightforward: the machine does not get the job done, the control system display shows an error code, or a machine part is broken. The trigger might be internal, as well, but it is unlikely that the user of a heavy machine will start diagnosing errors where there is no actual indication of a problem. Diagnosis is usually simultaneous as the nature of the error is usually evident right away once the user notices it.

The main tool for offering error recognition, diagnosis, and solution information in heavy machinery manuals are troubleshooting sections, for which the heuristics already have a separate heuristic (heuristic 3.7). In addition, however, user instructions have error information sprinkled in with other chapters, especially if the problem is common, easily fixed, and the solution can be explained briefly. This information can be presented in notes, or as a part of a step, for example. For this reason, having a separate heuristic for error information scattered around the manual is useful for heavy machinery manuals as well as software instructions.

The excavator manual has instances of error information outside chapter 4 *Malfunctions.* In chapter *Switching on the electrical* system, for instance, there is a note: "*If no automatic check of the keypad and monitoring screen is carried out when the ignition key is in the contact position, check that the main battery switch is set to 'on'*". Unlike in the troubleshooting chapter, these bits of error information often leave out the cause of the problem, but nevertheless, help in diagnosing and solving it. There are also the special cases of chapters 3.3.5 *Jump start procedure* and 3.3.6 *Emergency operations* which are corrective tasks that only need to be performed when a problem occurs. They are still placed outside the troubleshooting chapter probably due to the length of the needed instructions and because they are most likely needed when performing the preceding tasks.

Although most of the error information is appropriate, some instances are rather unhelpful, telling the user, for example, to "*find the problem and correct it"* without referring them to the troubleshooting chapter. There are also other mentions of fixing a problem or an error without any specification as to how this should be done.

3.6 Is the error information located close to the relevant procedure? (OH3.4)

This heuristic is rather similar to heuristic 3.4 which asks whether the warnings and notes are located next to the relevant procedure. They are not, however, identical since error information and warnings and notes are different concepts with technically separate functions. Having the error information close to the relevant step or task helps the user when an error occurs. They are not left wasting time wondering what happened and what to do next, and they are less insecure about their following actions when they know what went wrong. Just as with warnings, having the error information close to the procedure might also prevent the mistake from ever happening if it catches the user's eye. Additionally, proximal positioning of the error information often means that the error information itself needs to explain the error context and specifics in less detail (Carroll and van der Meij 1995, 254). The surrounding text provides this context well enough. For these reasons, heuristic 3.6 is useful for both software and heavy machinery instructions.

The error information in the excavator manual (which was discussed under the previous heuristic) is located close to the relevant procedure. The smaller bits of error information in notes and tasks are positioned next to the task or step in question. Chapters 3.3.4 *Starting aids* and 3.3.5 *Jump start procedure* are located after the chapters on starting and switching off the engine. It could be argued that the chapters should follow right after starting the engine since they would be needed right away in case engine start fails, but putting them after starting and switching off disrupts the user less if there is no problem with the engine and is only a marginally worse option. The chapter 3.3.6 *Emergency operations,* on the other hand, compiles together a few different emergency operations which are separated from the relevant tasks. Emergency speed control, for example, is far away from the speed control main chapter.

4.3.4 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?

A comprehensive troubleshooting section is essential for a heavy machinery user manual because without it, trying to find remedies for problems in a manual that is several hundred pages long would be an endlessly frustrating and time-consuming task. Heuristic 3.7 that calls for a troubleshooting section is thus a vital component of the heuristic list.

The manual has a troubleshooting chapter, although it is named *Malfunctions,* which as a title is slightly unconventional and might cause some confusion for the user. The chapter is clearly marked in the table of contents.

Considering that I have no experience in using an excavator and who has not been taken part in the creation of this manual, I cannot determine with any certainty whether the problems depicted in the troubleshooting section are indeed the ones most often faced or reported by users. However, as I stated earlier, I do have experience with troubleshooting chapters of other heavy machinery user instructions, and I am somewhat familiar with common issues included in those manuals.

Chapter 4.1 *Error code charts* explains the causes behind the error codes shown in the machine control system and their remedies, which is definitely useful information for the user. Chapter 4.2 *Faults and remedies* lists faults or errors that the users themselves might notice without any written error information from the control system. The listed faults seem very common for a construction machine: the engine will not start or overheats, unusual noises, the machine will not move, hydraulic oil level is too low, and so on. None of the faults seem trivial or unnecessary.

4.4 Summary and the overall applicability of the heuristics

Most of the problematic heuristics are in category 1 *Core tasks and goal-orientation* which seems to be the most software-centric category. The very first heuristic that calls for concentrating on core tasks is suitable for a software context, where building the instruction material and learning around core tasks is doable and recommendable. This is not the case with heavy machinery where the ways of concentrating on core tasks are very limited, and the ultimate core tasks of the user are often difficult to instruct. The heuristic has to be modified to fit heavy machinery context.

Another unsuitable heuristic is 1.6 which addresses the need to give the user targeted instruction when needed, and which Virtaluoto et al. themselves deemed possibly more applicable for software (2020, 245). Like in the first heuristic, the ways of giving immediate assistance to the user are limited in a physical or digital machine manual that is several hundred pages long. This can be best provided by making the information findable which is already covered elsewhere in the heuristic list.

Heuristic 1.4 is not completely unapplicable, but the first half of the heuristic which calls for the user start working on real-life tasks immediately is not suitable. Getting started immediately is a core principle in minimalism and recommendable for software, but in hardware it can lead to serious accidents and mistakes that are not easy to fix and can damage the machine permanently. The second question about the necessity of the precursory information does apply, however. Rest of the heuristics in the first category (real-life structures of tasks, providing motivation, and documentation availability) are also suitable for heavy machinery.

Heuristics in second category 2 *Accessibility* are all straightforwardly suitable for heavy machinery manuals and hardware in general. This is unsurprising given results of the 2020 workshop organized by Virtaluoto et al. Most of the findings of the workshop stemmed from this category, and it is easy to see why: the heuristics address linguistic, structural, and visual aspects that are universally useful in all kinds of instructions, including heavy machinery. They are also factors that are, in large part, possible and easy to evaluate just with common sense without any extensive knowledge of the product being documented. I suggested a few general additions earlier in my analysis that could be included into the heuristics (such as adding a bullet point about references in heuristic 2.3), but the heuristics are also perfectly applicable in their current form.

Category 3 *Error management* has heuristics that are mostly applicable for heavy machinery manuals. They cover universally important aspects of error information, such as location and warnings. The category also has heuristics on troubleshooting, safety standards and legislation which are vital components of hardware manuals and especially heavy machinery instructions. The first heuristic of the category (3.1) which calls for preventing errors is the most taxing for the evaluator because of its obscure wording that does not really give anything concrete to focus on. The concrete ways of preventing errors are already covered by other heuristics or are only applicable in a software environment, and the heuristic is thus not suited for heavy machinery user instructions. Given that warnings, notes, and error information in general play an important role in heavy machinery manuals, I also suggested a few new heuristics earlier in my assessment: have warnings been used where necessary, and is the information in the warnings and notes appropriate for the information type?

As for the entirety of the heuristic list, one of its biggest strengths is that it makes the evaluator review both the little textual details (for example, the visual connectors and the verb forms) but also the manual structure and content choices. In a heuristic evaluation, it can be easy have a one-track mind and use one's all energy in the most glaring offences, and thus accidentally ignore viewing the manual as a whole. The concrete questions in the list help the evaluator focus on all relevant aspects of the assessment, resulting in more found usability problems and a more comprehensive evaluation. A detailed list of heuristics that has a practical touch is especially helpful to someone who has little experience in heuristic evaluation.

The order of the heuristics is also logical for the evaluator. The second category, accessibility, especially goes sensibly from regarding the entire selection of contents to smaller components, such as linguistic elements like headings and visuals. This gives a clear workflow for the evaluator. Additionally, giving error management its own distinct category with varied heuristics is all the more important in a heavy machinery context because of the importance of safety. Positioning it last in the list is also well-founded since much of the content in the preceding heuristics, such as clear language and findability, plays into effective error management and has already been accounted for when the evaluator gets to the last category.

5 CONLUSIONS

The aim of this thesis was to evaluate whether the minimalism heuristics by Virtaluoto et al. are suitable for evaluating heavy machinery user instructions. This was done by conducting a heuristic evaluation on a hydraulic excavator manual using the heuristics in question. Each heuristic was examined from the point of view of a heavy machinery manual, and suitability, problems, and possible improvements were discussed.

Based on the results of my assessment, my answer to the research question is that the heuristics are mostly suitable for evaluating a heavy machinery manual. I was able to apply nearly every heuristic to the research material in my evaluation, and most of them could be applied straight away without any confusion about suitability. This is because the majority of the heuristics addressed factors of user instructions that are relevant in all kinds of user documentation, and the things addressed by some heuristics, like safety standards and findability, can even be deemed especially important for heavy machinery manuals.

Overall, I was able to find a significant number of problems in the excavator manual with the heuristics, and the nature of the problems varied from small details to bigger structural problems. For the most part, they gave me very concrete things to look for in the documentation and they were easy to apply to the study material. The succession of the heuristics was intuitive for the user and their division into three distinct categories was also logical.

Out of the total of 28 separate heuristics, there are two heuristics that are not applicable for heavy machinery, and two that need modification in order to be suitable. This is due to the profound differences between software and hardware instructions, and a single heuristic in these cases cannot work for both groups of user documentation. In addition to being mostly only applicable for software, some of the problematic heuristics also are worded rather vaguely or broadly, which might cause confusion for the evaluator. This is especially noticeable when compared to the other heuristics that are easy to understand and direct the evaluator's attention to very concrete things in the manual.

In their current form, there is no clear distinction in the list which heuristics are more fitting for software and which for hardware, even though it is clear from this study that all heuristics are not applicable for both. As discussed in chapter 2.4.2, Virtaluoto, Suojanen, and Isohella created the heuristics to be used freely and to be modified to fit different products and purposes (2021, 32). When the idea is to pick and choose the heuristics that are useful to one's own particular situation, it does make sense that the listing is extensive and contains diverse heuristics that take both worlds into account as broadly as possible.

However, given that all products and user instructions that technical communicators work with can be roughly divided into two distinct categories – software and hardware –, I propose that having a distinct set of heuristics for each field would be an improvement. The fundamental differences of these fields and the different approaches needed their documentation warrant it.

Furthermore, it is not always guaranteed that the evaluators using the heuristics have sufficient knowledge and practical experience to instantly dismiss some heuristics as only relevant for software. As mentioned earlier, the meaning and application of some heuristics is a bit fuzzy, and they required some reflection even from myself, even though I have spent a long time delving into minimalism and the heuristics. Technical writers come from many different backgrounds: some from technical communications or language study programs, but some also from a more technical and practical education. At the very least, having a singular set of heuristics causes some unnecessary thinking effort when evaluating something other than software, and this could be avoided by making two versions. There will probably be some need to further modify the list for it to fit the specific hardware product in question, but having field-specific heuristics makes for an easier adapting process.

This study is only the second of its kind that tests the revised minimalism heuristics in evaluating a heavy machinery manual, and the first with an author other than the creators of the heuristics. It certainly has its limitations: I was the sole participant in the heuristic evaluation, which is not optimal, and while I have some experience from the technical documentation field and in heavy machinery user instructions, I lack long-standing professional experience and specific knowledge on the machine whose manual was being evaluated.

Nevertheless, the results of this study indicate that while the revised minimalism heuristics are largely suitable for evaluating heavy machinery, there are certain problems that make them less than ideal. To further verify these problems and to discover new ones that escaped my attention, a similar research project with a greater number of professional participants that have field experience would be in order. Virtaluoto et al. also suggest a study where a manual would be tested by real users before and after using the minimalism heuristics to improve the manual (2021, 32). Involving real users would certainly shed light on whether applying the heuristics in manual development makes the manual better the point of view of an actual user, as well.

In addition to performing a heuristic evaluation, it would certainly be interesting to give the participants of future studies plenty of time to reflect on the heuristics' context of use in a heavy machinery manual and their ease of use in more detail, as was done in this thesis. While the original 2020 workshop had some interesting conversation on many factors in the evaluation, the allotted time did not seem to allow deeper consideration.

Additionally, heavy machinery is just one side of the broader field of hardware. In order to determine whether the heuristics can be applied to a broad selection of different products, as Virtaluoto et al. intended, the list will have to be tested with all kinds of various user instructions. While this study indicates that the list is partly geared towards software products, it would also have to be tested with software manuals to discover any problems specific to that domain.

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SUOMENKIELINEN LYHENNELMÄ

Minimalismiheuristiikkojen käytettävyys raskaan kaluston käyttöohjeissa

1 Johdanto

Teknisen viestinnän alana voidaan karkeasti jakaa ohjelmistojen ja laitteistojen dokumentointiin. Ohjelmistoalalla minimalismi on ollut käyttöohjeissa laajalle levinnyt ja paljon keskustelua herättänyt lähestymistapa aina synnystään 1980-luvulta asti. Tällöin tietokoneista ja ohjelmistoista tuli laitteita, joiden käyttöä noviisikäyttäjien piti oppia monissa ammateissa sekä kotona (van der Meij ym. 2009, 269). Asiakasdokumentaatiolle syntyi uusia haasteita: uusi käyttäjäkunta oli valtava ja noviisien oppimistavat olivat käytännönläheisempiä kuin asiantuntijaoppijat, joille ohjelmisto-ohjeita aikaisemmin kirjoitettiin (mp.).

John M. Carrolin kehittämä ratkaisu tähän pulmaan oli minimalismi, joka on käyttäjä- ja käyttölähtöinen lähestymistapa tuottaa asiakasdokumentaatiota (Dubinsky 1999, 35). Minimalismissa tavoitteena on minimoida opetusmateriaalin aiheuttamat oppimisongelmat noudattamalla periaatteita, jotka myötäilevät oppijoiden luontaisia oppimistaipumuksia (Carroll 1990). Näitä periaatteita ovat mm. oikeiden ja merkityksellisten tehtävien antaminen käyttäjille, kokeilevan oppimisen mahdollistaminen, monipuolinen vianmääritystieto ja ohjeistuksen ytimekkyys (Virtaluoto ym. 2021, 22).

Vaikka minimalismi syntyi ohjelmistodokumentaation parissa ja sillä on siellä vankka jalansija, minimalismista ja raskaasta teollisuudesta ei sen sijaan ole juurikaan keskusteltu samassa yhteydessä ennen vuotta 2021. Tällöin Jenni Virtaluoto, Tytti Suojanen ja Suvi Isohella kehittivät uudistetut minimalismiheuristiikat käytettäväksi sekä ohjelmistojen että laitteistojen asiakasdokumentaation arvioinnissa. Virtaluoto ym. testasivat heuristiikkojaan raskaan kaluston ohjeen arvioinnissa työpajassa jo vuonna 2020, ja myös tämän pro gradu -tutkielman tavoitteena on arvioida, sopivatko nämä uudistetut minimalismiheuristiikat raskaan kaluston käyttöohjeiden arvioimiseen. Tätä tutkitaan suorittamalla heuristinen arviointi kaivinkoneen käyttöohjeille minimalismiheuristiikoilla ja tarkastelemalla niiden käytettävyyttä arvioinnissa, sekä esittelemällä löydetyt ongelmakohdat heuristiikoissa ja mahdolliset parannusehdotukset.

Koska heuristiikat ovat hyvin uudet ja Virtaluoto ym. kehittivät ne toimimaan monipuolisena arviointityökaluna ja mahdollisesti myös minimalistisen tyylioppaan pohjana, on niiden testaaminen riippumattomien tutkijoiden toimesta tärkeää. Vuoden 2020 työpajassa oli myös aikarajoitteita ja moni heuristiikka jäi arvioinnissa vähälle huomiolle, minkä vuoksi jotkin ongelmakohdat saattoivat jäädä pimentoon. Lisäksi Virtaluoto ym. eivät ole vielä käsitelleet yksittäisen heuristiikkojen soveltuvuutta raskaan kaluston ohjeisiin.

2 Minimalismi

Minimalismin kehitti John M. Carroll 1980- ja 1990-luvuilla, jolloin tietokoneet yleistyivät ja ohjelmistojen opettelusta tuli arkipäivää (Virtaluoto et al. 2021, 23–24). Uudet oppijat olivat noviiseja asiantuntijoiden sijaan, ja vuosituhannen lopulla vallitseva systemaattisen lähestymistapa dokumentaatioon tarjosi heille hierarkkista ohjeistusta, jossa ensin luettiin ohjeet ja sitten opeteltiin käytännön harjoituksilla rakentaen aina aikaisemmin opitun päälle (Carroll 1990, 81).

Carroll tutki oikeita oppijoita, kuten sihteerejä, oikeissa käyttötilanteissa ja huomasi, että tehtävien suorittaminen ohjeistuksen mukaan oli heille vaikeaa (mts., 3; 22). Oppijat toimivat omin päin, nojasivat taustatietoihinsa, tutkiskelivat ohjelmaa ja tekivät paljon virheitä, joita heidän oli vaikea selvittää (Carroll 1990b, 210). Carroll näki näiden ongelmien tarkoittavan, että oppijoilla oli oppimisen suhteen yhteisiä ominaisuuksia: he oppivat tekemällä, tutkimalla ja miettimällä, he haluavat oppia merkityksellisten tehtävien parissa ja hyödyntävät taustatietojaan uuden oppimisessa, ja he oppivat virheiden ja niiden korjaamisen kautta (mts., 211–212). Systemaattinen lähestymistapa ei Carrollin mukaan sopinut yhteen näiden ominaisuuksien kanssa, ja tarve oli uudentyyppiselle ohjeistukselle, joka antoi oppijalle enemmän valtaa oppimisessaan ja nojasi oppijoiden luontaisiin käyttäytymismalleihin (mts., 211).

Teoksessaan *The Nurnberg Funnel* Carroll luettelee minimalismin periaatteet, joiden mukaan käyttäjän pitää päästä alkuun nopeasti, heidän pitää antaa kokeilla asioita itse, heille pitää tarjota oikeita tehtäviä harjoituksiksi, heidän taustatietojaan täytyy hyödyntää, ja virheiden tunnistusta ja niiden selvittämistä täytyy tukea (mts., 212–213). Muita periaatteita olivat myös oppimateriaalin suunnitteleminen niin, että sitä voi lukea missä järjestyksessä tahansa, opetusmateriaalin ja ohjelmiston koordinoiminen, oppimistilanteen hyödyntäminen, ja materiaalin kehittäminen iteratiivisesti oikeiden käyttäjien avulla (Carroll 1990, 78–92). Carroll perusti periaatteensa osaksi John Deweyn, Jean Piagetin ja Jerome Brunerin oppimisteorioihin (Carroll ja van der Meij 1996, 83–84).

Hän testasi periaatteiden toimivuutta kolmella erityyppisellä minimalistisella oppimismateriaalilla, ja tulosten mukaan ne auttoivat käyttäjiä suoriutumaan paremmin ja käyttämään vähemmän aikaa oppimisprosessiin (Carroll 1990b, 213), sekä oppimaan nopeammin ja tehokkaammin (Carroll 1990, 164–165). Van der Meijin vuoden 1992 tutkimuksen mukaan minimalistinen oppimismateriaali myös vähentää käyttäjien tekemiä virheitä, ja he käyttävät vähemmän aikaa niiden korjaamiseen (15).

Minimalismin käsitetään usein virheellisesti tarkoittavan vain sitä, että kirjoitetaan mahdollisimman lyhyitä ja vaillinaisia ohjeita. Todellisuudessa minimalismin keskiössä on käyttäjä ja tämän tarpeet, ja ohjeistuksen pitäisi heijastaa sitä, miten käyttäjät luonnostaan toimivat (Carroll 1990b, 210). Carroll ja van der Meij nostavat käyttölähtöisyyden minimalismin tärkeimmäksi periaatteeksi, ja muut periaatteet joko tukevat sitä tai ovat sen seurausta (1996, 72). Käyttäjälähtöisyys tarkoittaa sitä, että ohjeistuksessa keskitytään siihen, mitä käyttäjä oikeasti haluaa tehdä ja annetaan tälle siihen tarvittava tieto silloin kun se on tarpeen (Brockmann 1998, 378).

Oikeiden tehtävien antaminen käyttäjälle on selvästi käyttölähtöisin periaate, ja käyttäjien tarvitsemien taitojen oppiminen pitäisi sisällyttää tehtäviin, jotka he oikeasti haluavat suorittaa (van der Meij 1992, 8). Kokeilevassa oppimisessa käyttäjä pääsee oppimaan itsenäisen tutkimisen ja päättelyn avulla, joka lisää motivaatiota ja parantaa opitun muistamista (Carroll 1990, 83). Carroll ja van der Meij kuitenkin painottavat, että kokeilevan oppimisenkin täytyy tapahtua hallituissa raameissa, ja se ei saa vaarantaa käyttäjänä edistymistä tehtävässään (1995, 75).

Vaikka ohjeiden lyhyys mielletään usein minimalismin tärkeimpänä arvona, sillä ei ole itseisarvoa ja sekin on olennaista vain silloin, kun se palvelee käyttäjää ja auttaa häntä itse käytössä (Carroll and van der Meij 1996, 72). Jotkut minimalismin periaatteista, kuten monipuolisen virhetiedon antaminen, jopa sotii ohjeiden lyhyyttä vastaan.

Yksi minimalismin olennaisimmista periaatteista on myös monipuolisen virheenmääritystiedon antaminen. Systemaattisessa lähestymistavassa ohjeet eivät olettaneet käyttäjien tekevän virheitä, mutta minimalismissa tiedostetaan, että käyttäjät tekevät luonnostaan virheitä ja käyttävät lisäksi paljon aikaa niiden korjaamiseen (van der Meij 2003, 227). Tämä otetaan huomioon ja käyttäjää autetaan tunnistamaan ja korjaamaan virheet, sekä oppimaan niiden kautta (Carroll ja van der Meij 1996, 75–76). Virheisiin ei silti kannusteta, ja erityisesti käyttäjän edistymistä vaarantavat ja oppimista haittaavat virheet estetään antamalla paljon virhetietoa, kuten varoituksia ja huomautuksia, siellä missä käyttäjät todennäköisimmin tekevät virheitä (mts., 77–79). Kaiken kaikkiaan minimalismin periaate tukea käyttäjän virheiden selvittämistä perusteellisesti on yksi lähestymistavan tärkeimmistä antimista (van der Meij 2003, 217).

Jotta dokumentaatiosta saadaan mahdollisimman käyttäjäystävällistä, tarvitaan oikeista käyttäjistä paljon tietoa. Oikeiden käyttäjien testaaminen ja sisällyttäminen dokumentaatioprosessiin auttaa määrittämään, mitkä ovat käyttäjien todelliset tehtävät (Carroll 1990b, 215), milloin he tarvitsevat vianmääritystietoa, ja missä menevät produktiivisen kokeilevan oppimisen rajat (mts., 75). Käyttäjätestaaminen on erityisen tärkeää nykypäivänä, kun nopeasti kehittyvä teknologia aiheuttaa jatkuvasti uudentyyppisiä ongelmia.

Aikaisemmin mainittujen hyötyjen lisäksi Draper ja Oatley ovat sitä mieltä, että minimalismin soveltaminen ei vaadi paljon muuta tutkimusta kuin muutaman artikkelin lukemisen (2000, 223), ja Karl Smart toteaa, että minimalistisen dokumentaation tarjoaminen voi säästää yritykselle kustannuksia ja tarjota markkinaetua (1998, 321).

Minimalismin periaatteet ovat kuitenkin myös saaneet osakseen kritiikkiä. Kokeileva oppiminen ei sovi sellaisille käyttäjille, jotka haluavat saada nopeita tuloksia itsenäisen seikkailun sijaan (Farkas ja Williams 1990, 183), ja nykypäivän kokeneille teknologian käyttäjille se voi ohjeistustyylinä tuntua jopa holhoavalta (Virtaluoto ym. 2021, 29). Minimalismi on myös keskittynyt suurelta osin vain noviisikäyttäjien ohjeistukseen ja ohjelmistojen dokumentaatioon (mts., 4). Maailma on myös muuttunut suuresti minimalismin syntyajoista, ja dokumentaation ja ohjeistuksen muodot ovat monipuolistuneet. Tuotteet suunnitellaan usein jo tuotantovaiheessa olemaan käyttäjäystävällisiä, minkä Carroll ennusti jo vuonna 1990 (6).

Minimalismin käytännön toteuttamista on kritisoitu siitä, että se on vaikeaa konkreettisten työkalujen ja tutkimuksen puutteen vuoksi (van der Meij 1992, 7). Nykyisin minimalismi myös helposti hukkuu yleisen käyttäjälähtöisyyden sekaan (Virtaluoto et al. 2021, 23). Minimalistisen dokumentoinnin toteuttamiseen vaaditaan myös paljon aikaa ja rahaa, sillä dokumentoijat tarvitsevat tietoa oikeista käyttäjistä tietääkseen heidän tarpeensa, ydintehtävänsä, taustatietonsa ja todennäköiset ongelmakohdat tuotteen käytössä (mp.; Carroll ja van der Meij 1996, 73–74). Toteutus voi myös ontua muutosvastaisuuden vuoksi (Virtaluoto ym. 2021, 23).

Carroll kehitti alkuperäiset minimalismiheuristiikat vuonna 1995 Hans van der Meijn kanssa vastauksena konkreettisen työkalun puuttumiseen. Heuristiikat on jaoteltu neljän pääperiaatteen alle, jotka ovat toimintalähtöisyys, tehtävälähtöisyys, virheiden tunnistuksen ja korjaamisen tukeminen, sekä tekemisen, oppimisen ja löydettävyyden tukeminen (Carroll ja van der Meij 1995, 244).

Toimintalähtöisyyden heuristiikkoja ovat mm. käyttäjän päästäminen heti toimeen ja itsenäisen kokeilun tukeminen (mts., 246). Tehtävälähtöisyyden heuristiikkoihin kuuluu esimerkiksi oikeiden tehtävien antaminen käyttäjille (mts., 249). Virheiden tunnistuksen ja korjaamisen heuristiikkoja ovat mm. virheiden estäminen ja vianmääritystiedon antaminen sopivissa paikoissa (mts., 252–254). Tekemisen, oppimisen ja löydettävyyden tukemisen periaatteen tärkein heuristiikka on kirjoittaa lyhyesti ja selittää vain välttämättömät asiat (mts., 256).

Carroll ja van der Meij tarkoittivat heuristiikkansa käytettäväksi jo dokumentaation suunnittelussa ja toteutuksessa, ja heidän mukaansa heuristiikkoja ei pitäisi käsittää tiukkana sääntölistana, vaan pohjana, jonka perusteella kehittää dokumentaatiota erilaisille käyttäjille, ympäristöille ja tuotteille (mts., 244). Virtaluoto, Suojanen ja Isohella jatkoivat listan kehittämistä vuonna 2021, jolloin he julkaisivat uudistetut minimalismiheuristiikkansa, jotka pohjautuvat vuoden 1995 heuristiikoille. He yhdistivät heuristiikoissa minimalismin pääperiaatteita ja teknisen viestinnän parhaita käytäntöjä (Virtaluoto ym. 2021, 23). Uudet heuristiikat jakautuvat kolmeen kategoriaan; ydintehtävät ja toimintaorientaatio, saavutettavuus ja virheiden hallinta (mts., 27–28). Toisin kuin Carrollin ja van der Meijn heuristiikat, uudistettujen heuristiikkojen on tarkoitus toimia myös jo valmiin dokumentaation arvioimiseen joko kesken tuotekehittelyn tai palautteenkeruuvaiheessa (mts., 26). Heuristiikkoja voi käyttää sekä ohjelmistojen että laitteistojen ohjeiden arvioimiseen (mts., 32).

Virtaluoto ja kumppanit jättivät heuristiikoistaan pois kokeilevan oppimisen, sillä he eivät kokeneet sen sopivan nykyajan käyttäjien parempaan taitotasoon ja esimerkiksi raskaan kaluston ohjeisiin (mts., 29). He käsittelevät heuristiikoissa ohjeiden visuaalista puolta ja motivointia, jotka eivät sisälly alkuperäisiin minimalismiheuristiikkoihin. Heuristiikat virheiden hallinnasta ovat myös monipuolisemmat. Uudistetut heuristiikat ovat kaiken kaikkiaan yksityiskohtaisemmat ja käytännöllisemmät kuin Carrollin ja van der Meijn alkuperäiset heuristiikat. Niissä on yhteensä 18 heuristiikkaa, joista monet kiinnittävät arvioijan huomion listalla moneen asiaan saman heuristiikan sisällä.

Virtaluoto ym. testasivat heuristiikkojensa käytettävyyttä raskaan kaluston ohjeiden arvioinnissa työpajassa vuonna 2020 (2020, 242). Työpajan tulosten mukaan heuristiikat sopivat raskaan kaluston ohjeiden arviointiin (mts., 244), mutta koska työpajan kesto oli melko lyhyt, tehdyt havainnot keskittyivät lähinnä saavutettavuuden kategoriaan ja keskustelu jäi melko suppeaksi (mts., 245).

Virtaluodon ja kumppaneiden lisäksi myös Hanna Heinonen, Jenni Virtaluoto, Tiia Suomivuori, Kristian Forsman, Tuomas Kangas ja Sanni Siltanen ovat yhdistäneet minimalismin ja laitteistot vuoden 2022 tutkimuksessaan, jossa he tutkivat minimalististen periaatteiden soveltamista hissien huolto-ohjeiden esittämiseen huoltoteknikoille, ja totesivat, että moni minimalistinen periaate soveltuu laitteistojen huolto-ohjeisiin (2022, 497). Tutkimuksessa teknikot pystyivät valitsemaan ohjeistuksen yksityiskohtaisuuden tason ja saadun informaation määrän oman taitotasonsa mukaan kosketusnäytöllisestä puhelimesta (mts., 489). Esitystapa oli käyttäjä- ja käyttökeskeinen, sekä noudatti minimalistista periaatetta antaa käyttäjille mahdollisuus ryhtyä heti toimeen ja antaa heille kaikki tarvittava tieto tavalla, joka ei pakota käyttäjää lukemaan tälle tarpeetonta tietoa (mts., 486).

Vaikka Heinonen ja kumppanit totesivat tutkimuksessaan monien periaatteiden soveltuvan laitteistojen huolto-ohjeisiin, on moni periaate myös sopimaton raskaan kalustojen dokumentaatioon. Suoraan toimeen pääseminen ja vallan antaminen käyttäjälle valita oman ohjeistuksensa määrä voi johtaa vaaratilanteisiin raskaiden koneiden käytössä. Kuten Virtaluoto ym. toteavat, kokeileva oppiminen on myös riskialtista monimutkaisten koneistojen käytössä (2021, 24). Käyttäjän taitoihin ja älyyn luottaminen, sekä hieman vaillinaisten ja mahdollisimman lyhyiden ohjeiden kirjoittaminen voi myös johtaa onnettomuuksiin, ja lailliset vaatimukset ja standardit käyttäjädokumentaatiolle ovat usein ristiriidassa näiden periaatteiden kanssa. Vajavainen tai harhaanjohtava ohjeistus otetaan usein oikeudessa esille, kun käsitellään raskaan kaluston käytössä tapahtuneita onnettomuuksia (Ross 2015), jolloin mahdollisimman kattava ja käyttäjää jopa aliarvioiva dokumentaatio on koneen valmistajalle laillinen puolustuskeino.

Jotkut minimalismin periaatteista taas sopivat raskaan kaluston ohjeisiin hyvin, kuten tiedon löydettävyys ja ohjeiden modulaarisuus ja ytimekkyys. Monipuolisen vianmääritystiedon ja varoitusten antaminen käyttäjälle sopii raskaaseen kalustoon erityisen hyvin sen käytön riskialttiuden vuoksi, sekä siksi, että virheistä koituvat kustannukset voivat kasvaa suureksi teollisuuslaitteiden käytössä.

3 Tutkimusmenetelmä ja aineisto

Tässä tutkimuksessa käytetään menetelmänä heuristista arviointia. Heuristisessa arvioinnissa tavoitteena on löytää tuotteesta tai käyttöliittymästä käytettävyysongelmia (Korvenranta 2005, 113). Arvioijat käyvät läpi tuotetta käyttäen apunaan heuristiikkoja, jotka ovat lista periaatteita tai sääntöjä, joita tuotteen pitäisi noudattaa (Suojanen ym. 2015, 78). Arvioija listaa löytämänsä käytettävyysongelmat, sekä heuristiikat, joita ongelmat rikkovat, ja arvioivat ongelmien vakavuuden numerolla (mts., 80). Vakavuuden arviointi auttaa priorisoimaan käytettävyysongelmien ratkaisun, ja lisäksi arviointiin voidaan sisällyttää myös mahdollisia ratkaisuja ongelmiin (Korvenranta 2005, 115). Jos arviointiin osallistuu monta henkilöä, arviointi usein päätetään keskustelulla, jossa osanottajat käyvät läpi löydöksiään (mp). Ihanteellinen arvioijamäärä on 3–5 henkilöä (Nielsen 1990, 255), ja arvioijien erilaiset ammattitaustat ja pätevyydet (Virtaluoto ym. 2021, 32), sekä mahdollisimman selkeät ja yksiselitteiset heuristiikat parantavat arvioinnin tulosta (Paz ym. 2013, 120).

Heuristisen arvioinnin hyötyjä ovat sen helppous, intuitiivisuus, sekä pieni resurssien tarve (Nielsen 1990, 255). Heuristiikkoja on helppo muokata arvioitavan tuotteen mukaan (Suojanen ym. 2015, 80), niitä voidaan hyödyntää milloin tahansa tuotekehityksen aikana (Nielsen 1990, 255), ja arviointi voidaan yhdistää muihin menetelmiin (Virtaluoto ym. 2021, 31). Loppukäyttäjät eivät kuitenkaan ole mukana arvioinnissa, ja arvioinnissa painottuu loppujen lopuksi aina arvioijan subjektiivinen mielipide. Nielsenin käytettävyysheuristiikat ovat tunnetuin heuristiikkalista (1990), mutta Suomessa erilaisia heuristiikkoja on kehitetty esimerkiksi käyttöohjeiden kääntämiseen (Purho 2000) ja mobiilisovellusten käyttäjädokumentaation arvioimiseen (Rautava 2018).

Tässä tutkimuksessa aineistona toimii vuonna 2006 julkaistu ja 296 sivua pitkä Liebherr R 934 C-Litronic kaivinkoneen käyttöohje. Käyttöohjeet on ladattu sivutolta https://www.pdfmanual4trucks.com/liebherr/. Keskityn arvioinnissa ohjeen lukuihin 3.3 *Operation*, 3.4 *Working with the machine* ja 4 *Malfunctions*. Tarkastelen myös manuaalin muita osia sekä manuaalia kokonaisuutena silloin kun arvioitava heuristiikka sitä vaatii. Luvut 3.3 ja 3.4 käsittelevät koneen käyttöä ja sisältävät paljon ohjeistavaa tietoa, ja luku 3.4 sisältää vianmääritystietoa.

Tässä tutkimuksessa tutkitaan Virtaluodon, Suojasen ja Isohellan uudistettujen minimalismiheuristiikkojen soveltuvuutta raskaan kaluston käyttöohjeiden arvioimiseen. Tutkimuksessa arvioidaan kaivinkoneen käyttöohjeita hyödyntäen minimalismiheuristiikkoja. Jokaisella yksittäisellä heuristiikalla etsitään käytettävyysongelmia, ja löydetyt ongelmat ryhmitellään minimalismiheuristiikkojen kolmeen kategoriaan relevantin heuristiikan alle. Heuristiikkojen alla käsitellään myös yleisesti heuristiikan soveltuvuutta raskaan kaluston ohjeiden arvioimiseen, sekä mahdollisia ongelmia ja parannusehdotuksia. Vaikka tutkimuksessa ei keskitytä löytämään käytettävyysongelmia ohjelmisto-ohjeiden näkökulmasta, myös sellaiset ongelmat ja parannusehdotukset tuodaan esille, jotka käsittelevät listan yleistä käytettävyyttä pelkän raskaan kaluston sijaan.

Vaikka ihanteellinen määrä osallistujia heuristisessa arvioinnissa on 3–5, suoritan arvioinnin tässä tutkimuksessa yksin. Koska tutkimuksen tarkoitus testata minimalismiheuristiikkoja, eikä korjata kaivinkoneen käyttöohjeita tai löytää kaikkia sen mahdollisia käytettävyysongelmia, koen yhden ihmisen panoksen olevan riittävä tutkimuskysymykseen vastaamiseen. En myöskään anna käytettävyysongelmille vakavuusluokitusta, koska niiden funktio olisi auttaa ongelmien korjaamisen priorisoinnissa, joka ei sisälly tämän tutkimuksen laajuuteen.

Virtaluoto ym. toetavat, että ydintehtäviin liittyvien heuristiikkojen soveltaminen vaatii arvioijalta tietämystä käyttäjistä ja tuotteen ominaisuuksista (2021, 32). Minulla ei ole ensikäden kokemusta kaivinkoneiden käytöstä tai dokumentoinnista, mutta olen kirjoittanut ja päivittänyt samantyyppisten raskaiden koneiden dokumentaatiota, joten koen olevani pätevä suorittamaan tutkimusaineistolle heuristisen analyysin. Löydökseni ensimmäisessä kategoriassa *Ydintehtävät ja toimintaorientaatio* ovat kuitenkin todennäköisesti suppeammat kuin koneen käytön asiantuntijan.

4 Minimalismiheuristiikkojen käytettävyys

Suurin osa heuristiikoista, jotka ovat ongelmallisia raskaan kaluston ohjeiden arvioinnissa, löytyvät ensimmäisestä kategoriasta *Ydintehtävät ja toimintaorientaatio*. Ensimmäisessä heuristiikassa 1.1 kysytään, keskittyykö dokumentaatio käyttäjän aitoihin ydintehtäviin. Raskaan kaluston ohjeissa tavat keskittyä ydintehtäviin ovat hyvin rajatut, sillä kaikki mahdolliset koneeseen liittyvät tehtävät on ohjeistettava yhtä tarkasti, ja ydintehtäviä ei realistisesti voi myöskään sijoittaa manuaalin alkuun, sillä niillä on oma looginen paikkansa ohjekirjan järjestyksessä. Toinen sopimaton heuristiikka on 1.6, jossa kysytään, annetaanko käyttäjälle täsmäohjeistusta, joka sopii suoraan käsillä olevaan tilanteeseen. Välittömän avun antamisen keinot ovat myös raskaan kaluston manuaalissa rajalliset, ja näistä tärkein on tiedon löydettävyys, joka sisältyy jo listan muihin heuristiikkoihin. Heuristiikan 1.4 alussa taas peräänkuulutetaan tarvetta päästää käyttäjä heti työskentelemään, joka voi raskaan kaluston kanssa olla turvallisuusriski. Loput kategorian heuristiikoista (tehtävien todenmukainen rakenne, käyttäjän motivointi ja dokumentaation saatavuus) ovat soveltuvia raskaan kaluston ohjeille.

Toisen kategorian *Saavutettavuus* heuristiikat ovat kaiken kaikkiaan soveltuvia raskaan kaluston dokumentaation arvioimiseen. Heuristiikat käsittelevät dokumentaation kielellisiä, rakenteellisia ja visuaalisia tekijöitä, jotka ovat tärkeitä kaikessa dokumentaatiossa ja joita on helppo arvioida ohjeesta myös terveellä maalaisjärjellä ilman kovin laajaa kokemusta koneesta tai sen dokumentoinnista. Heuristiikkoja voisi täydentää muutamalla yleisellä lisäyksellä, kuten esimerkiksi lisäämällä kysymyksen selvistä viittaussuhteista dokumentaation sisällä, mutta ne ovat myös käytettäviä nykyisessä muodossaan.

Kolmannen kategorian *Virheiden hallinta* heuristiikat olivat suurimmalta osin käytettäviä raskaan kaluston ohjeiden arviointiin. Ne käsittelevät virhetietoon liittyviä asioita kuten varoituksia ja virhetiedon sijaintia, jotka ovat tärkeitä sekä ohjelmistojen että laitteistojen ohjeille. Tähän kategoriaan kuuluvat myös heuristiikat tarpeellisista turvamääräyksistä ja lainsäädännöstä sekä vianmääritystiedosta, jotka ovat erityisen olennaisia raskaan kaluston kohdalla. Ainut suoranaisen ongelmallinen heuristiikka on heuristiikka 3.1, joka kysyy, onko virheet estetty dokumentaatiossa. Kysymyksen asettelu on melko epämääräinen, ja se ei anna arvioijalle mitään konkreettista tekijää, jota tarkastella manuaalissa. Tavat, joilla virheitä voidaan estää raskaan kaluston ohjeissa (esim. ymmärrettävä kieli ja varoitukset), tulevat jo esille muissa listan heuristiikoissa. Kategoriaan voisi lisätä heuristiikat varoitusten käyttämisessä tarvittavissa kohdissa ja oikeanlaisen tiedon sisällyttämisestä varoitukseen ja huomautuksiin.

Kokonaisuudessaan heuristiikkalista on käytettävä, sillä sen kysymykset ohjaavat arvioijan huomion sekä ohjeeseen kokonaisuutena että sen pienempiin yksityiskohtiin. Tällöin löydetyt käytettävyysongelmat ovat monipuolisia, eivätkä ne keskity vain selkeimpiin puutteisiin. Konkreettiset ja monipuoliset kysymykset ovat erityisen hyödyllisiä arvioijalle, jolla ei ole paljon kokemusta heuristisista arvioinneista. Heuristiikat myös etenevät arvioijalle loogisesti: erityisesti toisessa kategoriassa *Saavutettavuus* edetään koko ohjeen rakenteesta pienempiin tekijöihin, kuten otsikoihin ja kuviin. *Virheiden hallinta* on myös hyvä osio päättämään listan, sillä monet sitä edeltävät heuristiikat sisältyvät omalla tavallaan myös virheiden hallintaan, ja nämä ovat silloin jo arvioijan edettyä viimeiseen kategoriaan käsitelty.

5 Päätelmät

Tämän tutkimuksen tavoitteena oli tarkastella, soveltuvatko Virtaluodon, Suojasen ja Isohellan uudistetut minimalismiheuristiikat raskaan kaluston käyttöohjeiden arviointiin. Tulosten perusteella voidaan sanoa, että heuristiikat ovat suurimmalta osin soveltuvat. Lähes jokaista heuristiikkaa neljää lukuun ottamatta pystyi suoraan käyttämään kaivinkoneen manuaalin arvioinnissa, ja löydetyt käytettävyysongelmat olivat moninaisia. Useimmat heuristiikat käsittelevät asioita, jotka ovat tärkeitä kaikenlaisessa dokumentaatiossa tuotteesta riippumatta, ja heuristiikkojen kysymykset ovat arvioijalle konkreettisia. Jotkut heuristiikat ovat myös erityisen olennaisia raskaan kaluston kannalta, kuten heuristiikat kategoriassa *Virheiden hallinta*, sekä erityisesti heuristiikka lainsäädännöstä ja standardeista. Ongelmalliset heuristiikat ovat keskeisempiä ohjelmistoille ja joskus myös muotoiltu hieman epämääräisesti.

Heuristiikkalista ei nykymuodossaan erottele, mitkä heuristiikat ovat soveltuvia ohjelmistoille ja mitkä laitteistoille, ja tämän tutkimuksen mukaan voisi olla perusteltua kehittää kaksi erillistä listaa näihin kahteen tarkoitukseen. Virtaluoto, Suojanen ja Isohella kehittivät heuristiikkansa toimimaan monipuolisena työkaluna, jota voi soveltaen käyttää monenlaisien tuotteiden arviointiin (2021, 32). Kuitenkin koska teknisen viestinnän ala koostuu karkeasti jakaen kahdesta eri puolesta, kaksi eri listaa näille kahdelle alalle vähentäisi tarvittavan ajatustyön määrää ja aikaa, ja listan muokkaamisessa voitaisiin keskittyä soveltamaan sitä nimenomaiselle tuotteelle, jota ollaan arvioimassa. Tekniset viestijät tulevat myös monenlaisista koulutustaustoista, ja kaikilla heistä ei välttämättä ole valmiuksia helposti erottaa heuristiikoista ne, joita ei voi soveltaa esimerkiksi raskaaseen kalustoon.

Koska olin tässä tutkimuksessa ainut osanottaja, jolla ei ole pitkää ammatillista kokemusta raskaan kaluston saralta, tulevaisuudessa tutkimusta voisi laajentaa ottamalla arvioijiksi suuremman joukon alan ammattilaisia. Virtaluoto ym. myös ehdottavat, että oikeita käyttäjiä voisi ottaa tutkimukseen mukaan arvioimaan ohjeita ennen ja jälkeen sen, kun niitä on kehitetty heuristiikkojen avulla (2021, 32). Koska heuristiikat on tarkoitettu toimimaan kaikenlaisen dokumentaation arvioinnissa, niitä olisi syytä myös testata ohjelmistojen ohjeiden parissa.