Master's Thesis

Checklists For Everyone: Developing Design Principles For Everyday Organizations

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Abstract

Despite their proven benefits, checklists are minimally used and researched in everyday domains such as hospitality, retail, and education. A lack of design knowledge about checklists in these organizations is one of the barriers to checklist use and research. The aim of this research is to develop design knowledge that can serve as a basis for these organizations to improve checklists for their business processes. After analyzing widely researched checklists in aviation and healthcare industries, we engineered requirements and developed design principles that contribute to the design knowledge of everyday organizations.

The design principles were validated on their applicability by conducting six interviews with potential end-users in the domains of retail, hospitality, and education. The validation shows that two design principles seem reusable, one design principle seems less suitable for reuse, and one design principle seems not suitable for reuse.

This research contributes a set of design principles for checklists to be used in everyday organizations, which results in a potential rise in checklist use and research in these organizations. Future research could analyze other domains, validate design principles in other domains, and use different methods of developing and validating the design principles.

Acknowledgements

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Introduction

Checklists are used everywhere, both in personal life and in professional environments. Examples include checklists for groceries, pre-flight checklists, and the Surgical Safety Checklist developed by the World Health Organization [1], [2], [3]. Benefits of checklist usage are plentiful. For example, they can reduce human error, ensure safety protocols are met, and improve business processes by making clear which steps are taken and in which order [1], [4], [5].

Organizations that operate in environments where safety management is mandatory are called High-Reliability Organizations, as described by *HRO*s [6], [7]. In these organizations, checklists are used to ensure safety protocols are being properly followed, thus preventing accidents from happening. Examples of these HROs are organizations that are operating in nuclear power, offshore drilling, aviation, military special operations, and healthcare [8]. These HROs operate in unforgiving social and political environments, and their technologies are risky and present potential for error. Learning through experimentation is not feasible due to the scale of the possible consequences of said errors. Furthermore, these organizations use complex processes to manage complex technologies [9] and have a preoccupation with the possibility of failure [8] For these reasons, we can assume that HROs rely heavily on checklists. Additionally, extensive research has ensured that the development of checklists for HROs follows certain design conventions and frameworks [10], [11], [12], [13], [14].

However, checklists are also used in organizations that do not have the characteristics of HROs. For example, restaurants often use checklists to ensure every customer is treated in the same manner to maintain a certain quality [15]. Education organizations can rely on checklists for ensuring that teachers give the correct instructions to students [16]. Retail organizations can use checklists to improve their customer experience or to increase productivity and efficiency. For these organizations, which we call *non-HRO*s, it is less of an issue if the entire protocol is not always strictly followed, as the consequences of possible errors are less serious. As becomes clear from their usage, these organizations have different views on checklists than HROs.

1.1 Problem Statement

Despite the proven benefits of checklists, their adoption varies between domains. We see a notable difference in checklist use and research between HROs and non-HROs. This section discusses the barriers to checklist use and research in non-HROs and defines the problem statement of this research.

First, non-HROs may have certain cultures that do not value the use of checklists, because there is less emphasis on whether protocols are strictly followed, since deviating from protocol has less consequences, compared to HROs [6], [7], [9]. These organizations may not have a culture of safety and continuous improvement and are therefore less reliant on checklists.

Furthermore, the design knowledge of checklists in non-HROs is lacking. The available design knowledge of checklists is tailored to the aviation and healthcare industries [10], [12], [13], [17], [18] so there are no standard design principles that can be used for non-HROs. Therefore, non-HROs resort to developing checklists based on experience of their own employees or limited existing theories, if there is any.

Lastly, there is a tight coupling between digital technologies and checklist use, and checklists are often used in environments where organizations rely on digital technologies for executing their business processes. Since non-HROs are less dependent on digital technologies than HROs due to the unforgiving social and political environments HROs operate in, checklist use in non-HROs is also lower [19]. These barriers to checklist use and research lead to the following issues, which form the problem statement of this research.

1. Checklists in non-HROs are less frequently used than they are in HROs [20]. Checklists reduce human error, provide accountability and monitoring, and can be used to train new employees [21]. HROs invest heavily in training on the use of checklists [22]. Due to their ineffectiveness, checklists tend to be seen as unnecessarily bureaucratic by employees of non-HROs. Furthermore, especially in hospitality organizations, employees tend to develop a feeling of redundancy towards checklists. Additionally, hospitality organizations tend to have no IT infrastructure where checklists can be used effectively, as the checklists are not flexible and can not be adjusted once implemented [19].

2. Less research is conducted on the design, development, and validation of checklists in non-HROs than research is conducted in HROs. Research is focused on HROs, with the largest focus being on the aviation and healthcare organizations [5], [8], [23]. Non-HROs are forced through trial-and-error and by applying practical knowledge to develop checklists, because research on checklists for their specific processes is lacking.

Due to the high number of potential barriers to checklist use and research in non-HROs, analyzing, validating, and evaluating all potential barriers is outside the scope of this research. Instead, this research focuses on the lack of design knowledge about checklists for non-HROs.

1.2 Research Aim

We aim to develop design knowledge about checklists for non-HROs. A lack of general design knowledge within non-HROs is one of the many barriers to use and research of checklists in non-HROs. One way of developing design knowledge is by developing design principles for checklists specifically for these types of organizations. By developing a set of standard design principles that can be used by non-HROs, we mitigate this barrier and promote checklist use and research in these organizations.

Research aim

the aim of this research is:

- to develop design knowledge about checklists for non-HROs,
- by developing design principles for checklists,
- which can serve as a basis for non-HROs to improve checklists for their specific business processes,
- so that we promote checklist use and research in non-HROs.

1.3 Research Questions

This research is guided by a main research question (MRQ). The MRQ is derived from the problem statement and research aim, and is divided into four sub-research questions (SQs).

Main research question (MRQ)

How can we develop design principles for checklists to be used in non-HROs?

The MRQ addresses the lack of design knowledge about checklists for non-HROs. By developing design principles, we broaden the design knowledge about checklists to be used in non-HROs. Non-HROs can use these design principles as a starting point when developing checklists for their specific business processes. Furthermore, these organizations can use the design principles to evaluate their current checklists, and modify them where needed.

Sub-research question 1 (SQ1)

Why are checklists specifically used in HROs like aviation and healthcare?

While we can assume HROs rely on checklists, it is important to know if there are domain-specific characteristics that can be attributed to organizations such as aviation and healthcare. Based on a multivocal literature review, characteristics of these organizations and concepts of checklists used in these organizations are identified, where various checklists in industry are compared with each other. The outcome of this research question is a critical synthesis, elaborating on domain-specific characteristics of the aviation and healthcare industries and concepts of checklists used in these organizations, which serve as a basis for the process of modeling these characteristics and concepts. Furthermore, we construct a meta-model [24], [25], [26] which displays the abstract components of checklists used in HROs.

Sub-research question 2 (SQ2)

What concepts and characteristics are currently included in checklists for non-HROs?

After we have identified concepts and characteristics of checklists in HROs, we identify these for non-HROs, based on 6 semi-structured interviews with domain experts from non-HROs. We discuss the concepts of the meta-model with the domain experts. The outcome of this research question is a concept map, which displays the components of checklists used in non-HROs.

Sub-research question 3 (SQ3)

Which requirements should a checklist to be used in non-HROs fulfil?

SQ3 aims at engineering requirements based on the same 6 semi-structured interviews that were used for addressing SQ2. The design goals of the design principles, the scope, and the target audience are determined. The outcome of this research question is a list of requirements that checklists to be used in non-HROs should fulfill.

Sub-research question 4 (SQ4)

Are the developed design principles for checklists in non-HROs applicable?

Based on the meta-model of concepts and characteristics of checklists used in HROs, the concept map of checklists used in non-HROs, and on the requirements, design principles for checklists in non-HROs are developed. Design principles should be validated and are done by conducting structured interviews with potential end-users. The design principles are tested on their applicability [27].

1.4 Research Context and Outline

In order to gain a better understanding of the concepts and research methods used in this research, we explain the broad background against which this research is conducted. We do this by discussing the current state of knowledge in industry. Furthermore, we discuss the application of design principles in our research.

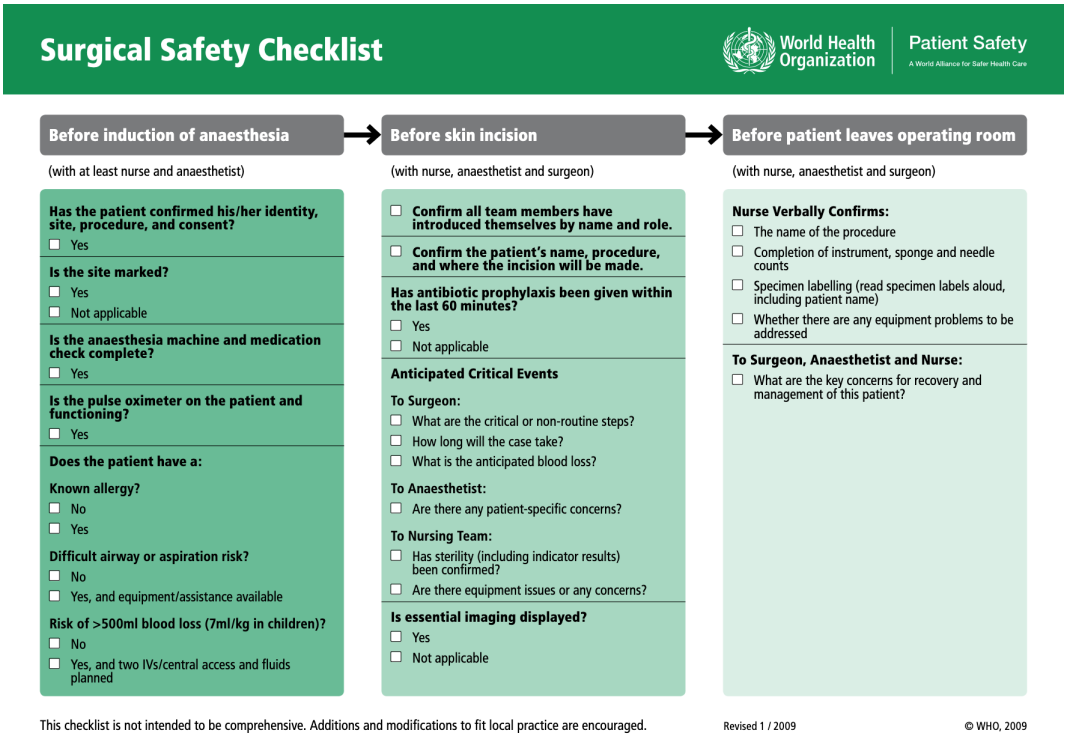
1.4.1 Checklists In Industry

One of the most used and researched example of a checklist in industry is the Surgical Safety Checklist, developed by the WHO [3]. This checklist was developed to decrease the implications that arise after a surgical operation has been executed, by helping medical practitioners in remembering how to correctly execute such an operation. The checklist guarantees patient safety before, during, and after a surgical operation [1]. Figure 1.1 shows the full checklist. Some things stand out: the checklist is not too complex, is divided into different sections based on layout and color coding, and checkboxes are used to encourage users of the checklist to complete the checklist as a whole. Furthermore, an audience is suggested for every section, denoted with parentheses. Furthermore, the bottom of the checklist notes that additions and modifications to fit local practice are encouraged, which is in line with the statement that "... medical checklists will only live up to their potential to improve the quality of patient care if their development is improved and their designs are tailored to the specific needs of the users and the environments in which they are used." [10, p. 223].

Another example is a general pre-flight checklist, which aids aircraft controllers in remembering all necessary and critical steps before take-off [28]. Figure 1.2 shows an example of this general pre-flight checklist. We see that the pre-flight checklist has some differences when comparing the checklist with the Surgical Safety Checklist. It does not utilise color coding and users are not forced to physically check the items. Instead, users are forced to read the checklist items aloud or in silence. The asterisks before some checklist items are not elaborated on [28].

However, while these checklists seem like a fitting solution for the process they concern, several problems with checklist use in these domains can be identified. In medical checklists, checklist problems often concern human factors, such as poor design, inadequate training, duplication with other safety checks, poor integration with existing workflow, and cultural barriers [10]. In aviation checklists, problems reported concern the formatting, layout, item organization, and logical coherence [12]. To mitigate these problems, literature suggest recommended requirements for surgical checklists, ranging from the content and order of the items (max. 7 items per page or section, encouraged use of sections) to the physical construction (A5 paper size, robust cover to handle wear and tear) [18], while aviation checklists should use enough white space and should use a font size that can be read without effort [17].

The specific requirements are inherently linked to the characteristics of the domain the checklist is used in. In a comparative review, the aviation and healthcare industries are compared from a patient



Surgical Safety Checklist

World Health Organization | Patient Safety
A World Alliance for Safer Health Care

Before induction of anaesthesia → **Before skin incision** → **Before patient leaves operating room**

(with at least nurse and anaesthetist)

Has the patient confirmed his/her identity, site, procedure, and consent?
☐ Yes

Is the site marked?
☐ Yes
☐ Not applicable

Is the anaesthesia machine and medication check complete?
☐ Yes

Is the pulse oximeter on the patient and functioning?
☐ Yes

Does the patient have a:

Known allergy?
☐ No
☐ Yes

Difficult airway or aspiration risk?
☐ No
☐ Yes, and equipment/assistance available

Risk of >500ml blood loss (7ml/kg in children)?
☐ No
☐ Yes, and two IVs/central access and fluids planned

(with nurse, anaesthetist and surgeon)

☐ **Confirm all team members have introduced themselves by name and role.**

☐ **Confirm the patient's name, procedure, and where the incision will be made.**

Has antibiotic prophylaxis been given within the last 60 minutes?
☐ Yes
☐ Not applicable

Anticipated Critical Events

To Surgeon:
☐ What are the critical or non-routine steps?
☐ How long will the case take?
☐ What is the anticipated blood loss?

To Anaesthetist:
☐ Are there any patient-specific concerns?

To Nursing Team:
☐ Has sterility (including indicator results) been confirmed?
☐ Are there equipment issues or any concerns?

Is essential imaging displayed?
☐ Yes
☐ Not applicable

(with nurse, anaesthetist and surgeon)

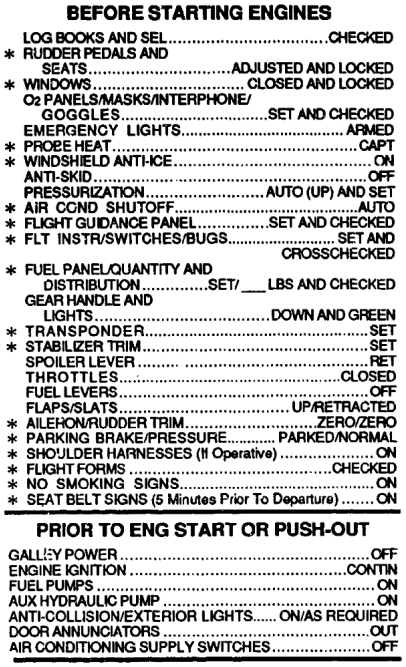
Nurse Verbally Confirms:
☐ The name of the procedure
☐ Completion of instrument, sponge and needle counts
☐ Specimen labelling (read specimen labels aloud, including patient name)
☐ Whether there are any equipment problems to be addressed

To Surgeon, Anaesthetist and Nurse:
☐ What are the key concerns for recovery and management of this patient?

This checklist is not intended to be comprehensive. Additions and modifications to fit local practice are encouraged.

Revised 1 / 2009

Figure 1.1: Surgical Safety Checklist [3].



BEFORE STARTING ENGINES

LOG BOOKS AND SEL.....CHECKED
* RUDDER PEDALS AND SEATS.....ADJUSTED AND LOCKED
* WINDOWS.....CLOSED AND LOCKED
O_2 PANELS/MASKS/INTERPHONE/ GOGGLES.....SET AND CHECKED
EMERGENCY LIGHTS.....ARMED
* PROBE HEAT.....CAPT
* WINDSHIELD ANTI-ICE.....ON
ANTI-SKID.....OFF
PRESSURIZATION.....AUTO (UP) AND SET
* AIR COND SHUTOFF.....AUTO
* FLIGHT GUIDANCE PANEL.....SET AND CHECKED
* FLT INSTR/SWITCHES/BUGS.....SET AND CROSSCHECKED
* FUEL PANEL/QUANTITY AND DISTRIBUTION.....SET/___ LBS AND CHECKED
GEAR HANDLE AND LIGHTS.....DOWN AND GREEN
* TRANSPONDER.....SET
* STABILIZER TRIM.....SET
SPOILER LEVER.....RET
THROTTLES.....CLOSED
FUEL LEVERS.....OFF
FLAPS/SLATS.....UP/RETRACTED
* AILERON/RUDDER TRIM.....ZERO/ZERO
* PARKING BRAKE/PRESSURE.....PARKED/NORMAL
* SHOULDER HARNESSES (If Operative).....ON
* FLIGHT FORMS.....CHECKED
* NO SMOKING SIGNS.....ON
* SEAT BELT SIGNS (5 Minutes Prior To Departure).....ON

PRIOR TO ENG START OR PUSH-OUT

GALLEY POWER.....OFF
ENGINE IGNITION.....CONTIN
FUEL PUMPS.....ON
AUX HYDRAULIC PUMP.....ON
ANTI-COLLISION/EXTERIOR LIGHTS.....ON/AS REQUIRED
DOOR ANNUNCIATORS.....OUT
AIR CONDITIONING SUPPLY SWITCHES.....OFF

Figure 1.2: Example of a pre-flight checklist [28].

safety perspective using aspects such as activities, safety, and equipment [22]. In aviation, there is a degree of standardization of equipment of aircrafts, while in healthcare, healthcare professionals have to deal with a wide variety of equipment. Also, aircraft controllers typically perform short tasks, while the duration of tasks that medical practitioners perform can vary greatly. Furthermore, failing to follow protocol and thereby the checklist in aviation context can result in fatalities being over 100 at a time, including the aircraft controllers, while failing to follow the checklist in medical context generally involves one person, and staff fatalities as a direct consequence is rare. These specific characteristics make clear that requirements of checklists for HROs should be engineered based on specific domain characteristics.

There have been efforts to abstract generic checklist types and characteristics based on checklists in industry [29], [30]. Table 1.1 shows generic checklist types with corresponding characteristics, benefits, and requirements/limitations. The pre-flight checklist discussed earlier clearly is a sequential type of checklist, as the checklist serves as a memory aid to direct attention to one item or aspect a a time. Note that such a checklist can be any length, but as we have addressed earlier, brevity increases usability of the list. The Surgical Safety checklist can also be seen as a sequential checklist, based on the same arguments that are used when addressing the checklist type of the pre-flight checklist.

Nowadays, research is more focused on addressing the benefits and drawbacks of a transition from analog checklists to digital checklists [31], [32] with more and more checklists becoming digital. A recent study examined software usage in 243 restaurants in the United States of America. Overall, more than 90% of the surveyed restaurants used software for sales analysis, while only 59% used software for labor scheduling. Furthermore, only 35% used software for training employees [19]. This suggests that these restaurants do not use digital checklists for essential tasks such as labor scheduling and training employees, and that these restaurants could benefit from some sort of standardised checklist that can be modified to their needs. Lastly, the authors of the study state that "... generic, canned information technology solutions may not be the optimum solution. To enhance competitiveness, information technology solutions should address the specific needs for each restaurant firm." [19, p. 268-269]. This sentiment is in line with the sentiment that medical checklists should be tailored to specific needs of the users and the environments in which they are used.

Summary of checklists in industry

Checklist requirements are linked to domain-specific characteristics. Issues with checklists are also linked to domain-specific characteristics. Recommendations for improving checklists are often made with specific checklists in mind, without validating whether the recommendations could also be applied to checklists in other domains. However, there have been efforts to compare checklists with the intention of mitigating issues that affect checklists in multiple organizations.

Table 1.1: Checklist types, characteristics, benefits, and requirements/limitations [29, 30].

Type of checklist	**Characteristics**	**Benefits**	**Requirements/limitations**
Unstructured laundry list	• Unstructured list of items • Can be any length • Order of the items is not important; no optimal order to perform task exists	• Memory aid to ensure items are present or actions are performed	• Allows only a binary response (e.g., present/absent) • Cannot guide multiple steps, or show dependencies
Criteria of merit list	• List of attributes to be ranked and rated	• Memory aid to insure relevant criteria are considered • Decision aid to make objective judgments	• May be difficult to define rating and ranking values
Sequential	• Structured list where step sequence of performance matters • Can be any length but brevity increases usability of the list	• Memory aid to direct attention to one item or aspect at a time • Decision aid to proceed, remedy or stop task since order is important and dependent on previous items	• Allows only a binary response (cannot guide multiple option decision process)
Flowchart/ diagnostic	• Steps or sequences that include branches based on categories or options	• Memory aid to direct attention to one item or aspect at a time • Decision aid to proceed, remedy or stop task • Decision aid to minimize biases • Decision aid where a categorical choice supports multiple pathways	• Supports only simple categorical judgments, not analytic reasoning

1.4.2 Checklist Validation

Insights on validating checklists itself can provide information on what constitutes a good validation of design principles of checklists. The validation of a checklist might be just as important as developing the checklist itself [8]. A recent study validated a sustainability checklist for restaurants by first validating the content of the checklist and then validating whether users could comprehend the checklist items [33]. Validation by interviewing experts is a suitable means of checklist validation [8], [34]. For validating the content of the checklists, individual items are often graded based on a Likert scale, where a certain value is needed for the checklist item to be included in the next revision. Then, it is good practice to test the checklist in industry, for example through qualitative simulation, through real-time observation [8], [11], [35] or by conducting expert interviews [36]. Validating whether checklist items are comprehensible can be done by examining the use of language of the checklist items [33].

1.4.3 Design Principles

One of the goals of this research is the development and validation of design principles. Design principles are commonly used in design science as a means to formalize design knowledge [37]. Design principles are generalized knowledge contributions [38], which provide knowledge about creating instances of IT artefacts [39]. They can be used to "... convey design knowledge that contributes beyond instantiations applicable in a limited use context" [40, p. 4039]. Design principles can thus be used to broaden the design knowledge about the topic on hand, and are developed in a way so that they can be applied universally within the research topic. For developing the design principles, we do not necessarily use a definition, since literature describes several definitions that do not suite this research. Literature states that different categories of design principles can be identified, as some design principles focus on the purpose of the principle, while other design principles focus on the properties of the principle [40]. In this research, we do not use these categories and corresponding notation. Instead, we make use of shortened versions to increase the readability and accessibility of the principles, accompanied by textual explanations.

1.4.4 Research Outline

The structure of this research is as follows. The rest of chapter 1 addresses the contributions that the outcome of this research has. Chapter 2 introduces the research phases, research methods and addresses threats to validity. In chapter 3, we present a domain analysis of checklists in HROs and non-HROs. In chapter 4, we define the design principles. Chapter 5 elaborates on the validation of the design principles. In chapter 6, we discuss implications, threats to validity, and any additional findings that we discovered. Lastly, chapter 7 concludes this thesis with answering the research questions, discussing limitations, and giving directions to future work.

1.5 Contributions

The outcome of this research has several contributions. First, this research provides an overview of the state of the art regarding checklist concepts in HROs and state of the industry regarding checklist concepts in non-HROs, which can serve as a theoretical basis for further research regarding checklists in non-HROs. Also, this research provides a set of design principles for checklists, based on academic literature and expert interviews. These design principles can be applied to checklists in non-HROs, serving as a basis for organizations to develop their own checklists. Furthermore, this research mitigates one of the barriers to checklist use and research by developing design knowledge of checklists in non-HROs.

2

Research Approach

This section includes the research approach followed and the research methods used. Figure 2.1 gives a high-level overview by showing which research method is used in which phase and which research question is answered in which phase. Problem investigation and dissemination are not addressed through a research method. The problem investigation is based on a preliminary literature review and the dissemination of this research is not based on a research method.

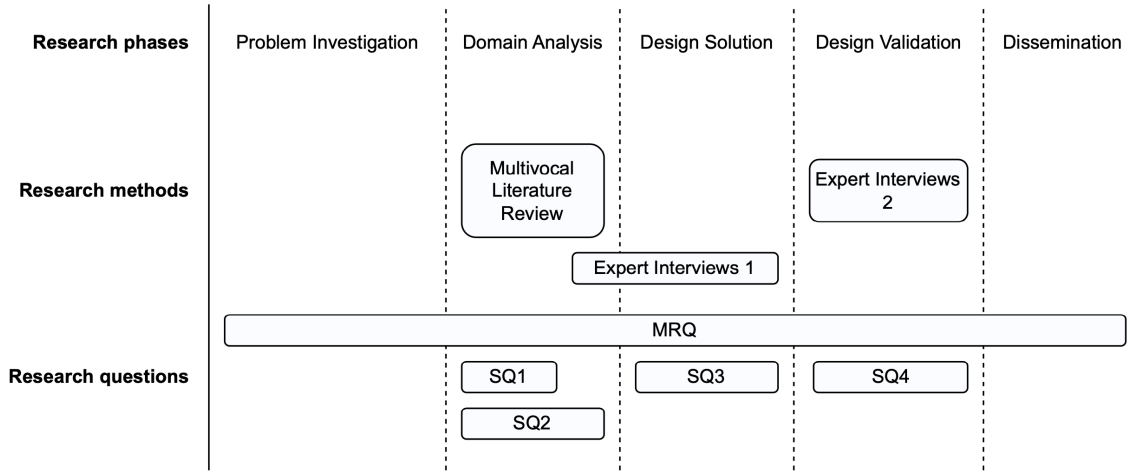


Figure 2.1: Research phases, methods, and questions

2.1 Research Phases

This research is divided into five phases, that naturally overlap each other. Since we are developing design knowledge, the phases are based on the design science methodology by Wieringa [36], [41]. An overview of all research activities and corresponding data artefacts can be found in figure 2.2.

Problem Investigation: The first phase consists of a preliminary literature review, which is used to identify the research problem. Based on the research problem, the research aim is derived and

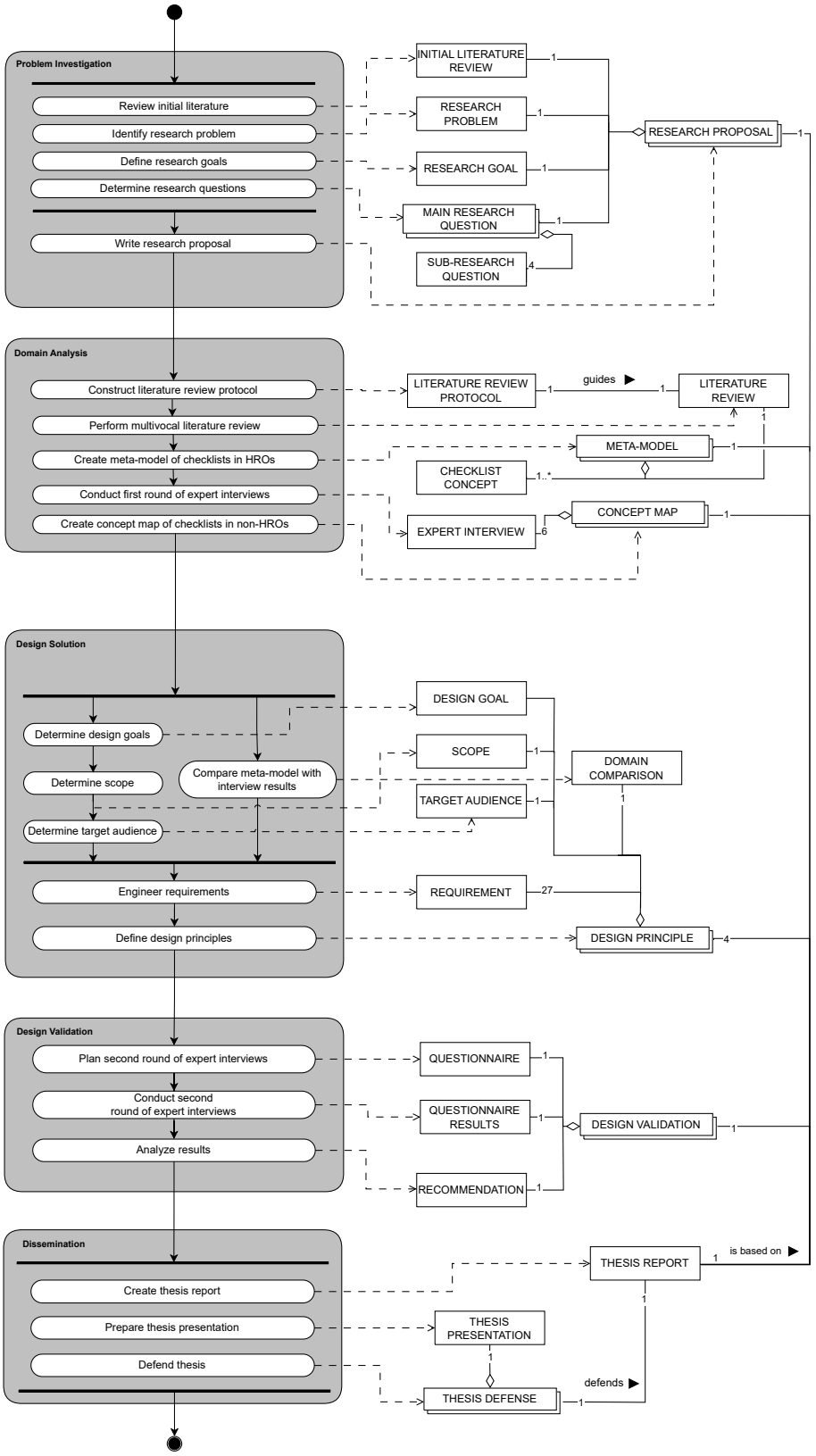


Figure 2.2: Process Deliverable Diagram of the research activities and corresponding data artefacts

the research questions are specified. Additionally, the research approach is further specified.

Domain Analysis: Based on a multivocal literature review, we focus on checklist usage in aviation and healthcare, and on the concepts and characteristics of checklists used in these domains. The focus is on aviation and healthcare, because research on checklists is most often focused on these industries [20]. We use academic literature to derive domain-specific concepts of the aviation and healthcare industries. Grey literature was addressed to find positive and negative experiences of the use of checklists in industry, which was lacking in academic literature. The result of this phase is a meta-model, displaying the abstract components of checklists used in HROs.

Design Solution: Based on 6 exploratory semi-structured interviews with domain experts in non-HROs, we map which concepts and characteristics checklists in non-HROs include. This can be seen as state of the industry. Expert interviews are used, because they can provide valuable insights for problem investigation, evaluation, and validation of the design artefact [36]. Furthermore, interviews appear to be one of the most effective techniques for eliciting requirements [42]. The exploratory semi-structured interviews are transcribed using Word Online[1] and are coded using NVivo[2], following procedures and guidelines explained by [43], [44], [45]. Based on the model that shows which concepts and characteristics checklists in non-HROs include, we engineer design requirements. Furthermore, we compare the state of the art with the state of the industry, and develop design principles for checklists to be used in non-HROs [37], [39], [40], [46].

Design Validation: For validating our design principles, we conduct structured interviews with 6 domain experts that could use the design principles for improving checklists that they are working with. In order to make a sound comparison, organizations of the same domains as the exploratory interviews are interviewed. The design principles are validated using a framework by [27], focusing on applicability of the principles.

Dissemination: The last step of the study is writing about the findings of this research. We address the outcomes of all sub-research questions and address the MRQ. Furthermore, we address the implications of the research, elaborate on limitations, and provide directions for further research. The outcome of this phase is this thesis report.

Lastly, the Ethics and Privacy Quick Scan of the Utrecht University Research Institute of Information and Computing Sciences was conducted. Whilst the Quick Scan identified issues, this project was allowed to proceed after additional human scrutiny by the moderator of the Ethics and Privacy Quick Scan. The full ethics report and the approval mail can be found in appendix B.

2.2 Research Methods

Table 2.1 shows that different research questions are answered by applying different research methods. Not every research method is suitable for each research question. The research methods are explained in the next section, justiyfing the choice of the research method.

[1] https://www.microsoft.com/en-us/microsoft-365/free-office-online-for-the-web
[2] https://lumivero.com/products/nvivo/

Table 2.1: Research methods used for answering the research questions

Research questions		**Research methods**	
		Multivocal Literature Review	Expert Interviews
MRQ	How can we develop effective and useful design principles for checklists to be used in non-HROs?	✓	✓
SQ1	Why are checklists specifically used in HROs like aviation and healthcare?	✓	
SQ2	What concepts and characteristics are currently included in checklists for non-HROs?	✓	✓
SQ3	Which requirements should a checklist to be used in non-HROs fulfil?		✓
SQ4	Are the developed design principles for checklists in non-HROs useful and effective?		✓

2.2.1 Multivocal Literature Review

The domain analysis is done by using academic literature to address why checklists are used in HROs such as aviation and healthcare organizations. We look at the differences in checklist characteristics, why certain design principles are used, and which domain-specific aspects can be abstracted. The academic literature is used to analyze concepts and characteristics of checklists in HROs. These are tightly related to the characteristics of the organizations. Because we look for information on checklists in different domains, we use Google Scholar[1], as the content on Google Scholar is not focused on one specific domain. The literature search protocol can be found in appendix A.1. Grey literature is addressed to gain insights into daily practice of checklists. Certain guidelines regarding assessing grey literature were followed [47]. The quality assessment criteria can be found in appendix A.2. The grey literature addressed is mostly focused on negative experiences of checklist use, because the academic literature is lacking in this aspect. The direct output of the multivocal literature review is a long list and a short list. The long list contains sources that seem usable for this research, based on title and abstract. Inclusion and exclusion criteria from the literature search protocol are applied, resulting in a short list. The short list served as a basis for the domain analysis. Both the long list and the short list can be found in appendix A.3.

[1] https://scholar.google.com

2.2.2 Expert Interviews

Analysis of checklists in non-HROs: The first round of expert interviews addresses checklist use in non-HROs (SQ2). Non-HROs that will be included are a hospitality checklist provider, a coffee and lunch shop, a primary school, a grammar school, a brick-and-mortar game shop, and a second hand clothing shop. We have chosen for organizations active in hospitality, education, and retail, covering three domains. Other domains such as agriculture, law, information technology, and creative industries are left out of this research. Hospitality and retail organizations were researched because organizations in these domains are fairly accessible. We chose education because of convenience sampling, due to time limitations [48]. Data on the type of organization and the participants is shown in table 2.2. Different organizations from the same domain were interviewed in order to increase the validity of the interview results. Only employees that were already using checklists in their work routine were interviewed. Due to privacy concerns, the names of the organizations are not mentioned, according to the consent form in appendix C. Transcriptions of the interviews in Dutch can be found in appendix C.

Table 2.2: Data on participants and their organizations for the domain analysis and design solution

Interview	Type of non-HRO	Participant's role in the organization	Location	Participant's checklist experience (years)
1	Education	Employee	Offline	8
2	Education	Employee	Offline	16
3	Hospitality	Founder	Online	21
4	Hospitality	Store manager	Offline	6
5	Retail	Store manager	Offline	2
6	Retail	Employee	Offline	4

The interviews validate the problem statement and contribute to collecting design knowledge of checklists [36]. The interviews are semi-structured and follow a protocol which can be found in appendix C. The interview protocol is based on guidelines described by [49], [50]. The concepts of the meta-model constructed by answering SQ1 are systematically addressed by the participants. The output of this set of expert interviews forms the basis of requirements that checklists in non-HROs should fulfill (SQ3). Prioritization of the requirements is done using the MoSCoW method [51]. The requirements form the basis on which the design principles will be developed.

Validation of the design principles: The second round of expert interviews focuses on validating the developed design principles for checklists in non-HROs (SQ4). The developed design principles are validated by conducting a set of 6 structured interviews with potential end-users. Table 2.3 shows data of the participants. The design principles are presented to the potential end-users, are discussed using a framework provided by [27], and are evaluated using a Likert scale.

Table 2.3: Data on participants and their organizations for the design validation

Interview	Type of non-HRO	Participant's role in the organization	Location	Participant's checklist experience (years)
1	Retail	Employee	Offline	3
2	Retail	Employee	Offline	2
3	Education	Employee	Offline	37
4	Education	Employee	Offline	4
5	Hospitality	Store manager	Offline	20
6	Hospitality	Employee	Offline	3

We evaluate the applicability of the design principles because it is necessary that the design principles can be applied in different domains. Figure 2.3 shows the evaluation criteria of the applicability of the design principles. The applicability of the design principles will be evaluated by looking at **1)** accessibility, **2)** importance, **3)** novelty and insightfulness, **4)** actability and guidance, and **5)** effectiveness. Accessibility is used to measure if potential users understand the design principles. Importance is used to measure the importance of the problems that the design principles try to mitigate. Novelty and insightfulness address whether the design principles have the potential to surprise the target audience by conveying knowledge they do not already know. Actability and guidance address whether the design principles can be carried out in practice. Lastly, effectiveness is used to measure if the design principles can have a positive effect on checklists of the organization. The framework suggests addressing the variables in consecutive order, starting with accessibility and ending with effectiveness. By evaluating the applicability of the design principles, we make sure that organizations from different domains can use the design principles to improve their checklists, thus promoting checklist use and research in non-HROs.

Summary of research approach

This research consists of five phases: Problem Investigation, Domain Analysis, Design Solution, Design Validation, and Dissemination. We conducted a multivocal literature review and two rounds of expert interviews. The multivocal literature review addressed characteristics and concepts of checklists in HROs. The first round of expert interviews addressed checklists in non-HROs. The second round of expert interviews addressed the validation of the developed design principles.

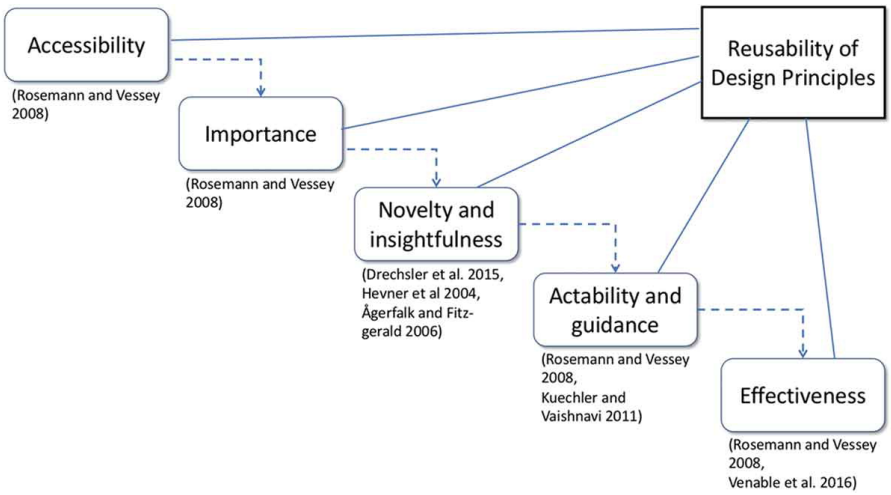


Figure 2.3: Evaluation criteria of applicability of design principles [27]

2. RESEARCH APPROACH

3

Domain Analysis

We present a domain analysis in which the usage of checklists in aviation and in healthcare is elaborated on. Important concepts are expressed in **bold** to underline their importance. We compose a concept table that includes all concepts described below [26]. Furthermore, we construct a meta-model which displays the concepts of checklists used in aviation and healthcare. After that, we analyze the exploratory semi-structured interviews with domain experts and elaborate on the usage of checklists in non-HROs. We conclude this chapter by mapping the concepts of the meta-model on the checklists used in non-HROs.

3.1 Checklist Usage in Aviation and Healthcare

In the aviation industry, checklists are used primarily for operations where every operation needs to be executed in the exact order of items, without deviating from protocol. Most aviation checklists are used as cognitive aids to guide users in remembering tasks, with the goal of reducing human error due to distraction or fatigue [52], [53]. A distinction in **checklist type**s can be made: normal checklists are used for routine operations and non-normal or emergency checklists are used when a problem arises and a need for problem mitigation arises, such as engine failure or sudden change of weather conditions [5], [22], [54]. Also, a checklist concerns one more **process**es, which should be executed correctly and in the right sequence [21], [55]. In case of non-normal checklists, quick access to the correct checklist is a necessity. To ensure quick access to the correct checklist, checklists are sorted by their **checklist objective** [56]. Examples of objectives are safely landing a crashing plane, checking on disturbances, or locating a fuel leak. Additionally, since airplane fleets are developed by different organizations in the world, not all checklists are designed to be effective for every situation [14]. This leads to the introduction of **checklist condition**s: for example, the "B-32 Check List" is suitable for use with 100 octane fuel only [14]. To ensure full checklist compliance, all **checklist item**s are assigned to one or more **operator**s [12], [29]. Furthermore, electronic checklist systems have been developed to replace paper-based checklists, resulting in a shift of the **representation** of checklists [1], [5]. Literature states that "... 65% of the pilots

surveyed said that certain procedures they were to use to respond to emergency and abnormal situations were complicated and difficult to use" [57]. Therefore, it is recommended to divide the checklist items into **section**s, so that the operators can understand the checklist more easily [57].

Literature on the design of medical checklists is extensive. Medical checklists should be designed around different stages of the checklist life cycle: **1)** conception, **2)** determination of content and design, **3)** testing and validation, **4)** induction, training and implementation and **5)** ongoing evaluation, revision and possible retirement [10]. Like in the aviation industry, most of the medical checklists serve as cognitive aids in helping medical practitioners remember a task or a series of tasks [18], [58], [59]. Choosing the correct **checklist type** is often based on cognitive limitations: **1)** we may forget one or more tasks, **2)** we remember a task but due to distraction or fatigue we do not remember to carry it out, or **3)** we remember the task, remember to carry it out, but execute the action incorrectly [22]. Which method should be applied when deciding how a **checklist item** should be accomplished, can also vary. For example, an **operator** can first execute the task and then confirm, or can first read the task and then do. These are **accomplishment method**s [10]. Furthermore, while performing a critical part of a surgery, an operator will probably read the task aloud and then do the task. However, a less important task, like putting on surgical gloves, will probably be read and be done in silence. These differences in how a task is executed can be classified as **means of accomplishment** [10], [35]. Additionally, the **item sequence** of a **section** dictates in which order the tasks of the checklist should be carried out. For example, the item sequence can be arbitrary, sequential, iterative, or parallel [10], [20]. As with the aviation checklists, medical checklists can be presented using different modalities. Paper, poster and electronic are examples of these **presentation modalities** [1], [10], [20],[35]. More and more paper-based checklists are being replaced with electronic versions [29].

The previously described concepts are summarised in table 3.1 below. This table serves as a basis for the meta-model, shown in figure 3.1. The first column lists the concepts as used in the meta-model, while the second column gives a brief description and some examples. All concepts are written in capital letters. The concepts in the table are ordered by appearance in the meta-model.

The meta-model consists of 11 concepts. Most concepts are standard concepts without sub-concepts. Examples are PROCESS, SECTION and CHECKLIST ITEM. CHECKLIST itself is an complex open concept, consisting of SECTION and CHECKLIST PROPERTY. CHECKLIST PROPERTY itself is further specified through a disjoint generalisation: each unique CHECKLIST PROPERTY can only consist of exactly one specific concept. However, when looking at the cardinalities, one CHECKLIST can have zero to many CHECKLIST PROPERTIES. ACCOMPLISHMENT METHOD is a complex closed concept; we do know some examples, but the sub-concepts are not relevant in this context. For more information about the syntax of this type of meta-model, see [26].

Table 3.1: Concept table of checklists in HROs

Concept	Description
PROCESS	A set of tasks needed to be executed. Can be predefined, or ad-hoc.
CHECKLIST	Typically a list of action items or criteria arranged in a systematic manner, allowing the user to record the presence/absence of the individual items listed to ensure that all are considered or completed [5].
CHECKLIST PROPERTY	Defines all possible properties that a checklist might have. A checklist can have none or multiple properties, depending on the situation.
CHECKLIST TYPE	Described as the operational use of the checklist. Examples are normal situations and non-normal situations [54], [10].
CHECKLIST CONDITION	Defines under which conditions a particular checklist should be used [56].
CHECKLIST OBJECTIVE	Sometimes also called purpose. Defines the use of the checklist. Examples are: memory aid, evaluation, teamwork facilitation and confirmation [10], [35], [20].
CHECKLIST REPRESENTATION	Describes how the contents of a checklist is conceptualised. Examples are: paper, poster and electronic [1].
SECTION	Includes one or more checklist items, which are ordered based upon a particular item sequence [57].
CHECKLIST ITEM	Describes the item that needs to be accomplished. Examples are; a task, a checkbox, an open text area and a Likert-scale. A means of accomplishment describes how a checklist item should be accomplished. Examples are: written, read aloud and read in silence.
OPERATOR	Defines the individual or groups of individuals that handle the checklist items [12], [29].
ACCOMPLISHMENT METHOD	Validates with which procedure the checklist item should be accomplished. Examples are Do and Confirm and Read and Do [10], [35].

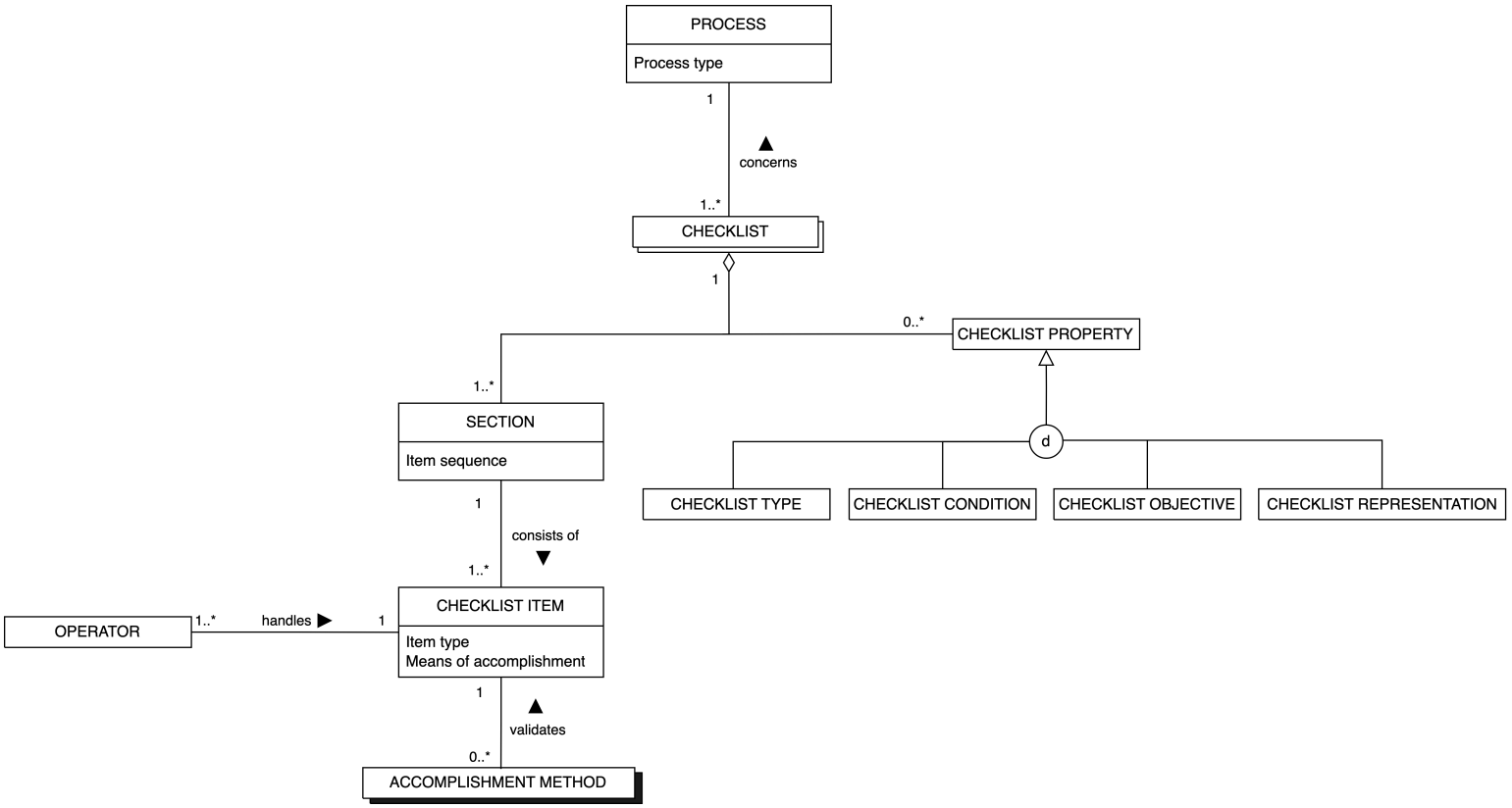


Figure 3.1: Meta-model of concepts in checklists used in HROs

3.2 Checklist Usage in Non-HROs

Table 3.2 maps all concepts of the meta-model in figure 3.1 for each non-HRO that we have interviewed. Each interview addressed one checklist used in each non-HROs. The choice of the checklist was arbitrary and depended mostly on which checklist was available for examination or which checklist was used the most in the organization. For quantitative data that presents the number of occurrences of each instance of each concept, see table 3.3. The **processes** that the checklists concerned varied. This is no surprise, since organizations of three different domains were interviewed. However, five out of six checklists concerned opening or closing (part of) the location. Regarding **process and checklist types**, the most common checklist type is "Normal" and all checklists concern a predefined process type, as opposed to non-normal checklists in case of emergency or ad-hoc processes.

Regarding **checklist properties**, we see that only one organization uses a **checklist condition**. The researched checklists are most often used as a mnemonic device or as memory aid, but **checklist objectives** are varying. The differences seem to be related to the domain of the organization. We see accountability in both educational checklists and in one hospitality checklist. Accountability is not present in the other hospitality checklist or in the retail checklists. Interviewee 3, a teacher who uses the checklist for oral examination, also talks about other reasons why they use the checklist: *"...in addition to it being a mnemonic device, I also use the checklist to make it clear to students what choices I make and how I assess the student. This results in transparency and accountability for the student, which students tend to appreciate."* Interviewee 5 reports that their checklists are mostly used because of cost reduction. They say the following: *"Introducing our employees to our digital checklists has resulted in employees getting to understand the tasks they need to execute much faster. Training a new full-time employee this way can save as many as 25 hours per month, for each new employee"*. Some companies use paper checklists and some companies use digital checklists. **Representation** is highly dependent on the type of company and the company's IT infrastructure. Interviewee 6 describes their choice of representation as follows: *"We choose paper because we don't see any value in a digital checklist. Besides, paper works best for us."* Other companies have a strong preference for digital checklists. For example, interviewee 5 states the following: *"Our checklists are all digital, because the content of the checklists must be easy to modify. Also, some checklists are only accessible to users with certain rights, such as managers. These kinds of things are difficult to realize with paper checklists."*

Only the third interviewee states that they use **sections** for organizing their checklist. This is as to be expected, since the corresponding process -oral examination of a modern language- is more elaborate than other processes reviewed, therefore increasing the number of checklist items. Also, this process consists of multiple topics, such as fluency of speech and vocabulary. Other processes reviewed were not divided into different topics. **Item sequence** varies, based on the process itself. **Checklist items** also vary, but most checklist items were either tasks or checkboxes. Regarding **operators**, we see a clear difference. For example, interviewee 3 states that they are user, manager

and creator of the checklist, since they are the only one using the checklist; Interviewee 4 is team supervisor, but is only a user of the checklist; Interviewee 1 is store manager, user and manager.

All interviewees stated that the checklist items are first **read and then done**, as opposed to **done and confirmed**. Interviewee 1 states: *"Almost always, only one employee is opening the store. So it would not make sense to confirm the checklist item with the team, since there is no one to confirm to."* How the checklist items are being **accomplished**, differs across all interviewed organizations. Some physically tick off a checklist item when the task is completed, while others read in silence and only make a mental note when a task is completed. Furthermore, all interviewees stated that the checklist they use is **self-made**. Some interviewees used their own experiences as the basis for the development of the checklist, while other interviewees used existing theories or protocols. The decision to use own experience or existing theories and protocols is highly dependent on the process the checklist concerns and on the experience the interviewee has within the related domain. For example, interviewee 5 states: *"Because I have 21 years of experience with using and developing checklists for hospitality, we know best which requirements such checklists should meet."* Furthermore, interviewee 3 said: *"There is a fair number of books on teaching. So of course, I first looked at existing literature and theories. However, I found that the theories were often too complicated for what I want, so I decided to come up with my own system."*

Summary of domain analysis

Checklists in HROs are primarily used as cognitive aids and to ensure protocol is strictly followed. A checklist has several related concepts, such as the type, condition, objective, and representation. There exist different types of checklist items, and checklist items can be accomplished through different means and by different methods. The listed concepts are also present in checklists in non-HROs.

Table 3.2: Characteristics of checklists in non-HROs

Concept	**Interview 1**	**Interview 2**	**Interview 3**	**Interview 4**	**Interview 5**	**Interview 6**
Domain	Retail	Retail	Education	Education	Hospitality	Hospitality
Process	Store closing	Store opening	Oral examination	Location closing	Kitchen opening	Kitchen opening
Process type	Predefined	Predefined	Predefined	Predefined	Predefined	Predefined
Checklist type	Normal	Normal	Normal	Normal	Normal	Normal
Checklist condition	-	-	-	-	Not applicable in certain circumstances	-
Checklist objective	Memory aid, following protocol	Memory aid	Accountability, following protocol, data analysis, transparency, overview	Accountability, memory aid	Overview, accountability, onboarding new people, reducing costs, empowering new employees	Memory aid
Checklist representation	Electronic (PC)	Paper	Paper	Paper	Electronic (tablet)	Paper
Section	-	-	Multiple	-	-	-
Item sequence	Arbitrary, sequential	Sequential	Sequential	Arbitrary, sequential	Arbitrary, sequential	Arbitrary, sequential
Checklist item	Tasks, checkboxes	Tasks, checkboxes	Tasks, checkboxes, open text areas, scale	Tasks, checkboxes, open text areas	Tasks, checkboxes, open text areas, media files	Tasks, checkboxes
Operator	Store manager, User, Manager	Employee, User	Teacher, User, Manager, Creator	Supervisor, User	Founder, Owner, Manager, Creator	Store manager, User

Continued on next page

Table 3.2: Characteristics of checklists in non-HROs (Continued)

Accomplishment method	Read and Do	Read and Do	Read and Do	Read and Do	Read and Do	Read and Do
Means of accomplishment	Written	Read in silence	Written	Read in silence	Written	Read in silence
Level of personalization	Medium (items can easily be altered)	-	Medium (items can easily be altered)	-	High (checklists tailored to specific users, user identification system)	-
Level of standardization	Self-made, based on existing protocols	Self-made, based on own experience	Self-made, based on existing theories	Self-made, based on own experience	Self-made, based on own experience	Self-made, based on own experience

Table 3.3: Number of occurrences for concepts of checklists in non-HROs

Concept	Instance	Occurrences
Domain	Retail	2
	Education	2
	Hospitality	2
Process type	Predefined	6
Checklist type	Normal	6
Checklist condition	Not applicable in certain circumstances	1
Checklist objective	Memory aid	4
	Accountability	2
Checklist representation	Electronic	2
	Paper	4
Section	Multiple	1
Item sequence	Sequential	6
	Arbitrary	4
Checklist item	Tasks	6
	Checkboxes	6
	Open text areas	3
Operator	User	5
	Manager	4
	Creator	2
Accomplishment method	Read and Do	6
Means of accomplishment	Written	3
	Read in silence	3
Level of personalization	None	3
	Medium	2
	High	1
Level of standardization	Self-made	6
	Based on existing protocols / theories	2
	Based on own experience	4

4

Design Solution

We present four design principles. The design principles are developed through a simple series of steps, which can be found in figure 4.1. We use the standardized process modeling language BPMN [60] for displaying the process. The first two steps, executed concurrently, consist of determining the design goals, scope, and target audience, and comparing the meta-model in figure 3.1 with the interview results in table 3.2. After these steps, we engineer requirements based on the outcomes of the previous steps. Then, we prioritize the requirements by applying the MoSCoW method [51]. The last step consists of defining the design principles by thematically grouping the requirements.

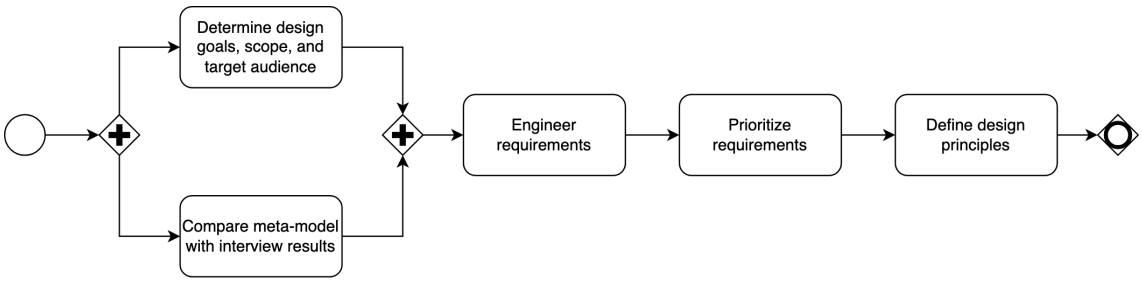


Figure 4.1: Development process of the design principles

4.1 Comparison of Meta-model with Interview Results

Checklists used in HROs differ from checklists used in non-HROs. Also, there are differences in how checklists are used between HROs and non-HROs. However, there are also similarities between checklists in HROs checklists in non-HROs. Aviation organizations do not use sections for dividing checklist items or groups as much as they should [57], and only one of out all interviewed non-HROs uses sections. As for representation, we see a clear shift from paper-based checklists to electronic checklists in both aviation and healthcare organizations, while in non-HROs, we see mixed results, with only two checklists being electronic. The other four checklists are paper-based. When examining checklist type, we see that checklists in HROs are both being used in non-normal

and in normal situations, while the researched checklists in non-HROs all concerned normal, routine operations. Regarding checklist objective, there is a clear difference. In aviation, most checklists are used as memory aid, while in non-HROs, we see that checklist are also used for other objectives, such as accountability, data analysis, and reducing costs.

4.2 Scope, Design Goals and Target Audience

The design principles that we develop can be applied to checklists for different business processes. Furthermore, these principles are not tied to any particular type of business process or domain. However, it is unreasonable to expect that the design principles are applicable to checklists of every business process. Also, domain-specific characteristics influence whether the design principles can be applied to checklists. For example, mandatory checklists introduced by compliance institutions, such as HACCP food safety checklists [61], do not benefit from applying the design principles as much as self-made checklists, and are therefore left out of the scope of the design principles. Checklists that are either self-made, based on existing theories, or developed through a combination of both, can all benefit from applying the design principles. However, due to the complex nature of checklists [1], it is possible not all design principles can be applied to a certain checklist, or not all design principles can have a positive effect on the checklist. For example, improving a paper-based checklist is more difficult than improving a digital version of the same checklist. Coffee and lunch rooms with few employees tend to use paper-based checklists, due to the simple nature of a paper-based checklist or the lack of a need for digital checklists.

The design principles contribute to the design goals of the research, whereas the design goals help in promoting checklist use and research in non-HROs. We defined two design goals. Both deal with modifying checklists in order to increase their use.

Design goal 1 - Avoid checklist fatigue: Predictable, repetitive tasks can lead to human error through distraction, as the human mind is not well suited for memorization and repetitive tasks [32], [62]. Therefore, it is important to design a checklist so that it is simple to carry out. We avoid checklist fatigue by ensuring every checklist item is relevant, and by removing unnecessary checklist items. If users are routinely presented with irrelevant or inapplicable checklist items, users will find a way to deviate from the norm [8].

Design goal 2 - Maximize checklist compliance: Checklist non-compliance occurs if users do not understand the value of a checklist. It is therefore important to discuss why and how a checklist is used within the team that is using the checklist [63]. Furthermore, checklists that do not completely represent the business process it should concern are prone to issues such as failure to check items for completed tasks, falsely checking items when tasks were not performed, and inaccurately checking items for incomplete tasks. Therefore, checklists should be sensitive to context or case and checklists items should be easily measurable.

We define the target audience of the design principles by examining the level of checklist experience of employees. The design principles should be usable by employees with different levels of

checklist experience. Employees that have just started working in a company should feel that the design principles are not too complicated and that the principles can guide them in creating, evaluating and modifying checklists. On the other hand, making the principles too minimal and too easy to understand will result in employees with substantial checklist experience not seeing the value of the principles. Therefore, it is important to find a balance between simplicity and complexity. We do this by making the design principles itself fairly simple, but we elaborate on the principles by addressing the related requirements.

4.3 Requirements

We have determined the scope, the design goals, and the target audience. Furthermore, we compared the meta-model in figure 3.1 with the interview results in table 3.2. We engineered requirements based on the outcomes of these steps. Prioritization of the requirements is done using the MoSCoW method, because MoSCoW provides accurate results with a medium sized dataset and is easy to implement [51]. Requirements that were extracted from multiple interviews, or were deemed important, are marked as either *Must have (M)* or *Should have (S)*. Requirements that were rather arbitrary (R18) or not concise (R4) are marked as *Won't have (W)*. Requirements that seemed interesting, but were extracted from only one source, are marked as *Could have (C)*. For traceability purposes, the source interview is added to the corresponding requirement. The interview data can be found in table 2.2. The requirements can be found in table 4.1.

Table 4.1: Requirements for the design principles

ID	**Requirement**	**Source**	**Prioritization**
R1	There should be a possibility to add ad-hoc checklists	3	C
R5	Keeping track of the completion of checklist items should be constituted by making the checklist electronic	5	C
R6	The color palette of the checklist should be calm and not overly colorful	5	C
R11	Modifications to the checklist by users should be encouraged	5	C
R14	The checklist should be personalized for specific users	3	C
R23	A checklist condition should be displayed on the checklist	3	C
R24	A checklist should have multiple sections	1	C
R3	The checklist layout should be clear	2, 6, 5	M

Continued on next page

Table 4.1: Requirements for the design principles (Continued)

R8	The checklist should be easily accessible to all users	1, 2, 3, 4, 5, 6	M
R12	The checklist medium should be based on the preferences of the user	1, 4, 5	M
R13	The checklist should be based on existing theories or on own experience	1, 2, 5	M
R15	The means of accomplishment of checklist items should be based on the preferences of the users	1, 2, 3, 4, 5, 6	M
R19	The checklist should concern exactly one process	1, 2, 3, 4, 5, 6	M
R20	The checklist should be based on the process type it is concerned with	1, 2, 3, 4, 5, 6	M
R22	The checklist objective should be aligned with the business process it is concerned with	1	M
R2	Checklist items should be provided with an additional explanation by means of text, audio, video or pictures	3, 5	S
R7	Checklist synchronization should be possible	5	S
R9	Multiple checklists should be used in a company, all of which should look the same	5	S
R10	There should be an intrinsic motivation to use the checklist	5	S
R17	Technical terms should should be avoided if possible	3, 4, 5	S
R21	The item ordering should be based on the process the checklist is concerned with	1	S
R25	The checklist should be open to changes	2, 4	S
R26	Unnecessary items should be kept to a minimum	3, 6	S
R27	Employees should be able to customize checklist items	1, 2	S
R28	All checklist items should use the same sentence structure	3, 5	S
R4	The checklist should feel more human-like to the users	5	W
R18	The checklist item types should be at least a task and a checkbox	1, 2, 3, 4, 5, 6	W

4.4 Design Principles

The design principles were defined by analyzing and thematically grouping the requirements. We included requirements that are marked with *Must have (M)* or *Should have (S)* as priority. Requirements that are marked with *Could have (C)* or *Won't have (W)* could be included in later adaptations

of the design principles. The design principles are listed below, with the thematically related requirements as explanation of each design principle. The design principles contribute to fulfilling the design goals of this research. An overview of the design principles, the design goals and the corresponding requirements can be found in table 4.2.

Table 4.2: Design principles, design goals, and requirements

ID	Design Principle	Design Goals	Requirements
DP1	Focus on the user	Avoid checklist fatigue	R2, R8, R10, R12, R15, R17
DP2	Keep it simple	Avoid checklist fatigue	R3, R9, R19, R26, R28
DP3	Tailor it to the organization	Maximize checklist compliance	R13, R20, R21, R22
DP4	Update where possible	Maximize checklist compliance	R7, R25, R27

4.4.1 Design Principle 1 - Focus On The User

Checklists that are not being used properly are often perceived more as a hindrance by their users than they are a tool to support business processes. Unclear checklist items or vague tasks could be a reason for the lack of checklist use. According to R2, checklist items should be provided with an additional explanation through text, audio, video or pictures, if users do not seem to understand the checklist items. Additional explanations help new users of the checklist in understanding how checklist items should be accomplished. R8 states that accessibility of checklists should be taken seriously. This means making sure the checklist can be used by all users that should use the checklists. R10 expresses the need of intrinsic motivation to use a checklist. If a checklist is self-made, employees are more likely to feel a sense of ownership, which could increase intrinsic motivation. R12 focuses on whether the checklist should be digital or on paper. Generally, employees should use a paper format if employees feel an electronic version does not provide any value. Likewise, they should use an electronic version if checklist synchronization or checklist personalization is preferred. Furthermore, it is up to employees to decide how they want to tick off the checklist items, whether physically or mentally, as expressed by R15. This results in more flexibility of using the checklist, which could increase intrinsic motivation. Lastly, R17 states that technical terms should be avoided, if possible. A checklist that contains an unnecessary large number of technical terms does not encourage new users to use the checklist.

Design principle 1: focus on the user

Intrinsic motivation of employees can ensure checklists are successfully being used as a tool for supporting business processes. Focusing on the user by modifying the checklist to the needs and preferences of employees can increase intrinsic motivation of employees and can help in avoiding checklist fatigue.

4.4.2 Design Principle 2 - Keep It Simple

Simple, easy-to-understand checklists encourage checklist use and can mitigate the false impression that tasks are well understood [1], [2]. As R3 suggests, the checklist layout should be clear. Avoid excessive use of colours. If the use of colours is mandatory, rethink the layout and structure of the checklist before using colours. If using multiple checklists throughout a company, R9 suggests the checklists should have the same look and feel. This increases familiarity and makes it easier for employees to use the checklists [62]. However, checklists that all look the same may contribute to the uninspiring, bureaucratic image that a checklist can have. Therefore, little elements that contribute to the nature of the process can help mitigate this image. R19 states that the checklist should concern exactly one process, as it makes sense that similar process items should be grouped in one checklist [64]. Cognitive issues arise when a checklist is too long or too complex, as Miller's law states that the average person can only keep 7 items in their working memory [62]. Therefore, R26 states that unnecessary items should be kept to a minimum. Additionally, R28 suggests that all checklist items should be written with the same sentence structure, as this increases familiarity and ease of reading, which in turn reduces the time it takes to complete the checklist.

Design principle 2: keep it simple

Simple, easy to understand checklists encourage proper checklist use. Keeping checklists simple by developing a clear checklist layout and by ensuring checklists concern one business process can improve the readability and comprehensibility of checklists. Additionally, keeping checklists simple can help in avoiding checklist fatigue.

4.4.3 Design Principle 3: Tailor It To The Organization

A checklist not being sensitive to context or case is a frequently recurring problem of checklist use [1]. Therefore, it is recommended to ensure that the checklist type, item sequencing and checklist objective are aligned with the business process it is concerned with, as suggested by R20, R21 and R22. This includes integrating checklists with other IT systems and operational processes that the organization is using or following. Furthermore, checklists should either be based on existing theories or on self developed knowledge as a result of extensive experience in using similar checklists, as stated by R13. Tailoring a checklist to an organization can ensure employees see a

checklist as a valuable tool for supporting their business processes and can reduce non-compliance of checklists.

Design principle 3: tailor it to the organization

Checklists that are not fully integrated into operational processes of an organization, are less likely to be properly used. Tailoring checklists to the organization ensures checklists are relevant and reduces non-compliance of checklists.

4.4.4 Design Principle 4: Update Where Possible

Business processes can change, which means that the checklists that concern these processes should also change to make sure the checklists are compliant with the business processes. Adjustments to checklists can be encouraged by creating a culture where feedback about the checklist is given, making the checklist open to changes, as R25 suggests. Developing such a culture can be realized by creating feedback loops, in which employees provide input regarding checklist items, the checklist as a whole or other aspects. In the same manner, employees should be able to customize checklist items (R27), but only if that is preferred and to a certain extent. Lastly, if multiple instances of the same checklists are used, synchronization of the instances should be possible, denoted by R7. This is only viable if the organization is using electronic versions of the checklist.

Design principle 4: update where possible

Due to their relation with the organizations in which they are used, checklists are prone to change. Creating an environment where checklists are continuously evaluated and improved, can reduce non-compliance of checklists.

Requirements were engineered by analyzing the first round of expert interviews. These requirements formed the basis on which the design principles were developed. When examining the requirements for each design principle, we notice that DP3 and DP4 represent less requirements than DP1 and DP2. One explanation is that the interview protocol favors questions regarding focusing on the user and keeping it simple. Another explanation is that the participants were more interested in talking about the technical details of the checklist (DP1 and DP2) and less about the process the checklist concerned (DP3 and DP4). In order to address whether the design principles can be applied in different domains, we validated the design principles using a framework [27]. The next chapter presents the results of this validation.

5

Design Validation

In this section, we present the validation of our design principles. The design principles are validated by conducting structured interviews with 6 potential end-users. The validation focuses on the reusability of the design principles, according to a framework provided by [27]. For each design principle, we addressed **1)** accessibility, **2)** importance, **3)** novelty and insightfulness, **4)** actability and guidance, and **5)** effectiveness. Participants were asked to rate one statement for each variable on a Likert scale, where 1 = "Fully disagree", and 5 = "Fully agree". The questionnaire can be found in appendix C. We used a Dutch version of the questionnaire in order to make sure the participants fully understood the design principles and corresponding explanations. An English version of the questionnaire can also be found in appendix C. Data of the participants can be found in table 2.3 in chapter 2. We focused on finding participants with different levels of checklist experience to increase the validity of the results. All statements were positively formulated.

5.1 Interview Results

The results of the questionnaire are displayed in a diverging stacked bar chart, shown in figure 5.1. It displays the relative frequency of responses per variable for all design principles. The scored variables are listed on the y-axis, while the relative frequencies of the responses are listed on the x-axis. By displaying this figure, we get a general indication as to how the variables are perceived by the participants, without distinguishing between design principles. Full agreement and agreement is interpreted as positive reactions, while neutral, disagreement and fully disagreement is interpreted as negative reactions. Due to readability purposes, Novelty and insightfulness is written as "Novelty" in the figures. In the same way, Actability and guidance is written as "Actability".

We see that in general, all variables except Novelty and insightfulness have received positive reactions, ranging from approximately 60% to 70%. Overall, Novelty and insightfulness has received approximately 80% negative responses, with the most responses being fully disagreeing. A reason for the negative responses for Novelty and insightfulness could be the simplicity of the design principles. Experience in working with checklists might have also caused participants to not perceive

the design principles as novel, as the participants were already familiar with the design principles, albeit inadvertently.

Effectiveness and Actability and guidance have received the lowest number of positive responses (60%). When comparing the two variables with each other, we see that Actability and guidance has received more responses that were fully disagreeing, while Effectiveness has received more responses that were fully agreeing. Generally speaking, we can state that the design principles are perceived as easy to carry out. Furthermore, the design principles seem easy to understand and the problems that the design principles try to mitigate are deemed important. Lastly, the participants feel that the design principles can have a positive effect on the checklists they work with.

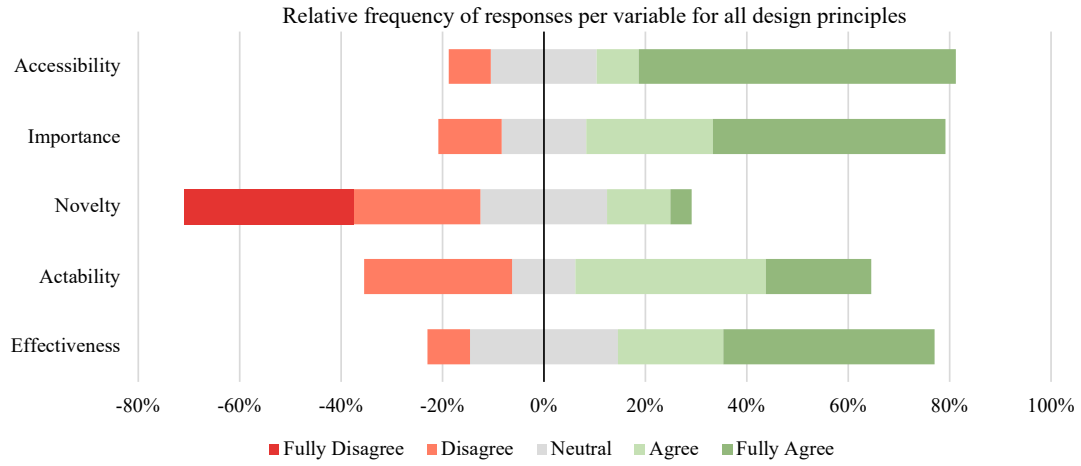


Figure 5.1: Interview results for each variable of all principles

Since the data is ordinal, we analyze the central tendency of the data by computing the median and the mode. We ignore the mean and standard deviations, because these variables cannot be computed with ordinal data [65]. The computed median and the mode for each variable can be found in table 5.1. Each variable consists of 24 items. As expected from figure 5.1, all variables except Novelty and insightfulness have high (4-5) median and mode values, meaning that all variables except for Novelty and insightfulness are agreed upon. Regarding statistical dispersion, we see that all variables have an interquartile range (IQR) of 2, meaning that all variables are equally spread out over the scale.

To get a better understanding of how the individual design principles are perceived, and to examine any differences between the variables for the design principles, we split the variables for each design principle. Figure 5.2 shows the relative frequency of responses for each variable. The variables are generally perceived as positive, with Novelty and insightfulness again being the exception. Furthermore, we see that Actability and guidance of DP1 (Focus on the user) and DP3 (Tailor it to the organization) have received predominantly negative responses. This is contrary to Actability and guidance of DP2 (Keep it simple) and DP4 (Update where possible), as these variables have

Table 5.1: Central tendency and dispersion of all variables for all principles

Variable	Median	Mode	Q1	Q3	IQR
Accessibility	5	5	3	5	2
Importance	4	5	3	5	2
Novelty and Insightfulness	2	1	1	3	2
Actability and Guidance	4	4	2	4	2
Effectiveness	4	5	3	5	2

received positive responses. We could argue that DP1 and DP3 are less concise than DP2 and DP4, which would explain the lower scores for Actability and guidance. Furthermore, we see that DP3 has received generally negative responses for all variables, with Importance being the only variable that has received a majority of positive responses. We could argue that participants can see the importance of the problem that this design principle is trying to mitigate, but the manner of wording and phrasing leads to low Accessibility and Actability and guidance scores. DP3 has received the highest number of positive reactions on Novelty out of all Novelty scores, but the reactions for this design principle are still mostly negative. Additionally, we see that Novelty of DP2 has received the highest number of negative responses out of all Novelty scores, which confirms DP2 is perceived as the least surprising by the participants.

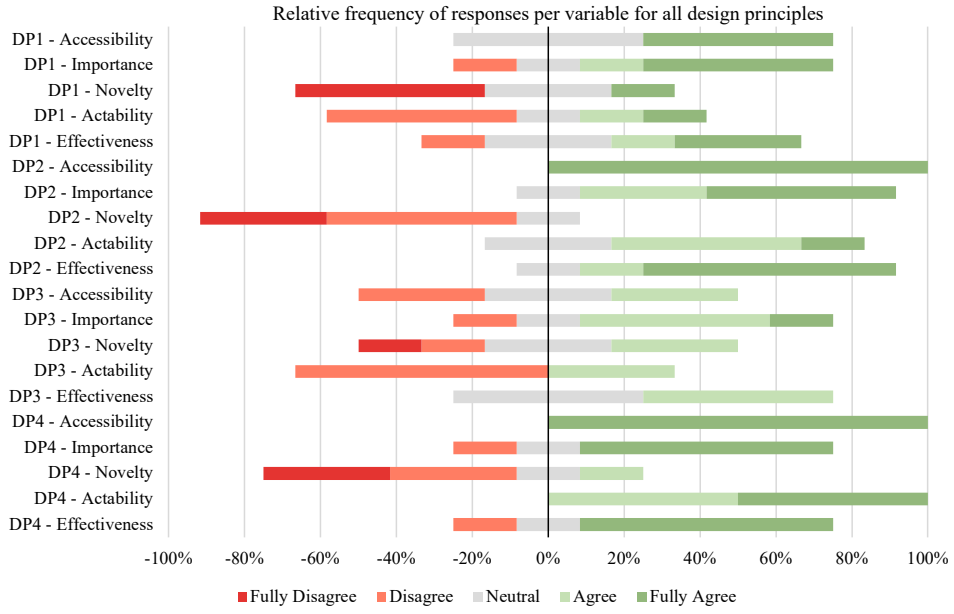


Figure 5.2: Interview results for each variable of all design principles, split by design principle

To make a direct comparison of the design principles, we computed the average Likert scores for each design principle, as shown in table 5.2. We weighted "Fully disagree" as -2, "Disagree" as -1, "Neutral" as 0, "Agree" as +1 and "Fully agree" as +2. A score of -12 would mean all responses are fully disagreeing, a score of 0 would mean all responses are neutral on average, while a score of 12 would mean all responses are fully agreeing. To compute the average Likert score for each design principle, we divided the scores by the total number of variables for each design principle. The scores confirm that DP2 and DP4 have the highest number of positive reactions with scores of 5.4 and 6, respectively. DP1 has an average score of 2.4, while DP3 has the lowest number of positive reactions with a score of 0.8.

Table 5.2: Average Likert scores of the design principles

ID	Design principle	Average score
DP1	Focus on the user	2.4
DP2	Keep it simple	5.4
DP3	Tailor it to the organization	0.8
DP4	Update where possible	6

5.2 Additional Feedback

Besides scoring each variable, participants provided additional feedback on the design principles and the variables. Regarding DP2 (Keep it simple), one participant emphasized the importance of keeping checklists simple and understandable, and could also recognize the importance of the problem that this principle could mitigate, which is non-compliance of checklists. Furthermore, two participants were not sure what DP3 (Tailor it to the organization) entailed. It could have been due to the translation to Dutch (freely translated to *Pas aan aan de organisatie*), but it most likely had to do with the unconcise phrasing of the design principle. The participants did not fully understand *what* exactly had to be tailored, and *to what* it should be tailored. One participant interpreted the design principle as tailoring the checklist items to the cultural environment of the organization, while the other participant would tailor the checklist items to the business process the checklist concerned.

Summary of design validation

All design principles have received mainly negative responses for Novelty and insightfulness, while the design principles have received mainly positive responses for the other variables. All variables have an interquartile range of 2 and are therefore equally spread out over the scale. The participants think that *Focus on the user* and *Tailor it to the organization* are more difficult to carry out in practice than *Keep it simple* and *Update where possible*.

6

Discussion

In this section, we first discuss our research results by providing implications that can be drawn from the results. We then address threats to validity of this research, and elaborate on any additional findings that could be useful for fellow practitioners.

6.1 Implications

Implication 1: Non-HROs are improving their checklists. The participants showed negative responses regarding Novelty and insightfulness for all developed design principles. This implies that the developed design principles are not new to the users, suggesting that employees in non-HROs are already improving their checklists, whether aware or unaware of the design principles.

Implication 2: Some design principles can be applied to checklists in non-HROs. The results show us that *Keep it simple* and *Update where possible* have received positive reactions for all variables. We are therefore confident that these two design principles can be applied to checklists in non-HROs in domains other than retail, hospitality, and education, which implies that we have created design knowledge about checklists for non-HROs. Applying these checklists promotes checklist use and research in non-HROs.

Implication 3: Some design principles need further research and development. The participants showed neutral to slight positive reactions to design principles *Focus on the user* and *Tailor it to the organization*. This suggests that these design principles could be applied in other domains, but should be researched and developed further.

6.2 Threats to Validity

Several threats to validity can be identified. It is therefore good practice to place the results of this research in the context of its limitations. Construct validity concerns identifying correct operational measures for the concepts being studied. Internal validity addresses external factors that may have

influenced the dependent variables. Lastly, external validity concerns defining the domain to which a study's findings can be generalized.

Ensuring construct validity can be realized by validating the design principles based on a set of evaluation criteria by [27]. Furthermore, the multivocal literature review is guided by a literature search protocol found in appendix A.1 and guidelines regarding assessing grey literature found in appendix A.2, based on academic sources. Additionally, our research approach is based on a widely used design science framework [36], and we applied triangulation to ensure our results are not dependent on one source.

In order to ensure the dependent variables are not influenced by external factors such as wrong use of methodologies or bias, we validated the concepts found in literature that we used in the rest of the research by conducting expert interviews. Furthermore, we compared each concept found in literature with the corresponding concepts found in industry, which ensured we used the same definition of the relevant concepts.

The threat to external validity is present because we speak of non-HROs as a general concept, but we do not interview organizations from all domains that can be classified as non-HROs, since doing so would be out of the scope for this project. In this research project, we leave out domains as agriculture, engineering, and law, among others. However, we mitigate this treat by comparing checklists from a broad range of domains with each other, both from academic literature and industry. The developed design principles are based on this comparison and reflect the concepts and characteristics of many different domains and organizations.

6.3 Additional Findings

There are outcomes of this research that do not directly contribute to the research aim or fall within the scope of this research. However, addressing these outcomes can still provide value to fellow practitioners. We engineered requirements that were not included for developing the design principles, marked with *Could have (C)* or *Won't have (W)*. These requirements still provide some insights in how certain non-HROs view checklists as tools for supporting their business processes. For example, R1 states that a possibility to add ad-hoc checklists should be available, which was coming from a non-HRO active in hospitality. However, no other non-HROs interviewed shared this sentiment. It is therefore possible hospitality organizations need to address ad-hoc processes more than other non-HROs. Furthermore, R4 states that checklists should feel more human-like to the users. While this requirement is not concise, it does show that employees of this organization are prone to checklist fatigue and should make sure using checklists is paired with intrinsic motivation.

7

Conclusion

Checklist use and research in non-HROs is minimal, despite proven benefits of checklist use. One of the barriers to checklist use and research is the lack of design knowledge about checklist design in non-HROs. The aim of this research was to develop this design knowledge, that can serve as a base for non-HROs to improve checklists for their specific business processes. We developed design knowledge by developing design principles, based on requirements we engineered. This research was guided by our MRQ and four SQs, which are answered below.

7.1 Answering the Research Questions

SQ1

Why are checklists specifically used in HROs like aviation and healthcare?

Aviation and healthcare heavily rely on checklists for their routine operations. We see that most checklists are used as cognitive aids to guide users in remembering tasks, in order to reduce human error. Checklists are needed in HROs, because human error can have severe consequences in these organizations.

SQ2

What concepts and characteristics are currently included in checklists for non-HROs?

Checklists in non-HROs include roughly the same concepts as checklists in HROs. However, there are some differences in characteristics of checklists in non-HROs and HROs, most notably the differences in objective and representation.

SQ3

Which requirements should a checklist to be used in non-HROs fulfil?

We engineered 27 requirements, which are thematically grouped to represent four design principles. A checklist to be used in non-HROs should fulfill requirements that concern focusing on the user, keeping it simple, tailoring it to the organization, and updating where possible.

SQ4

Are the developed design principles for checklists in non-HROs reusable?

The validation of the design principles shows that two design principles are reusable. One design principle is less suitable for reuse due to lack of Novelty and insighfulness and Actability and guidance. One design principle is not suitable for reuse due to overall neutral responses.

MRQ

How can we develop design principles for checklists to be used in non-HROs?

We constructed a meta-model that displays concepts and characteristics of checklists in HROs and we discussed these concepts with domain experts in non-HROs. Through a comparison, we engineered requirements, and developed design principles by defining the scope, design goals, and target audience of the design principles. We validated the design principles with domain experts in terms of five evaluation criteria. The results indicate that *Keep it simple* and *Update where possible* are design principles that can be applied to different domains. *Focus on the user* and *Tailor it to the organization* could be applied to different domains, but further research and development is needed. We therefore recommend applying design principles *Keep it simple* and *Update where possible* to checklists, and further research and develop design principles *Focus on the user* and *Tailor it to the organization* before applying these to checklists.

7.2 Limitations

The outcomes of this research are dependent on several aspects, both methodological and conceptual. In this section, we discuss several limitations that may have influenced the outcomes of this research. First, the process of engineering requirements is a subjective topic and is highly human dependent [66]. The requirements engineered for this research are impacted -whether positively or negatively- by human aspects, such as personality, motivation, and communication. Similarly,

the process of constructing a meta-model is a subjective and human dependent topic, as there are multiple ways to model the same concepts.

Furthermore, not all domains were addressed to validate the solution due to time limitations. It is therefore possible that the design principles do not apply to all organizations in all domains. In the same vein, not all checklists of HROs were analyzed for constructing the meta-model.

Also, due to the complex nature of checklists, it is difficult to ensure a model of the concepts for all checklists is complete. For example, there could be more types of concepts that are missing in this meta-model, or we modeled concepts that were not as important as we thought they were.

7.3 Future Work

In this section, we provide directions to future research for fellow practitioners. Validating the design principles in a wider range of domains with different domain-specific characteristics could provide useful insights as to how organizations other than retail, hospitality and education perceive the design principles. Also, a more extensive validation with more organizations per domain could result in a more grounded validation of the design principles. Additionally, frameworks for validating the design principles that focus on different aspects of the design principles could make for a robuster validation. Phrasing the design principles in different ways could also result in different perceptions of the design principles.

Developing the design principles in a different way could also provide different results. For one, more domains could be analyzed, as well as more organizations for each domain. Furthermore, there are more barriers to checklist use and research in non-HROs than we tried to mitigate in this research. As we have seen from the validation of the design principles, avoiding checklist fatigue and maximizing checklist compliance by applying design principles can be useful in certain situations. However, the design goals can also be realized by applying organizational strategies, such as staff training and demonstrating the value of checklists to employees [18], [67]. Therefore, an investigation of mitigating other barriers to checklist use and research in non-HROs could provide interesting insights.

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[65] S. Jamieson, "Likert scales: How to (ab) use them?," *Medical education*, vol. 38, no. 12, pp. 1217–1218, 2004.

[66] D. Hidellaarachchi, J. Grundy, R. Hoda, and K. Madampe, "The effects of human aspects on the requirements engineering process: A systematic literature review," *IEEE Transactions on Software Engineering*, 2021.

[67] E. Anthes, "The trouble with checklists: an easy method that promised to save lives in hospitals worldwide may not be so simple after all," *Nature*, vol. 523, no. 7562, pp. 516–519, 2015.

Appendix A

Research Approach

A.1 Literature Search Protocol

Table A.1: Literature search protocol

Steps	**Artefact**
Search terms	*"Domain analysis", "Checklist usage", "Checklists in healthcare", "Checklists in aviation", "Checklists in restaurants", "Checklists in education", "Checklist problems", "Checklist design", "Checklist validation", "Checklist usage", "Checklists and IT", "IT usage in industry", "IT and regulation"*
Search strategy	Forward snowballing, backward snowballing
Databases	Google Scholar
Inclusion & exclusion criteria	Language: English Publication year: 2000 - 2021 Discusses at least one of the following topics: • domain analysis • comparing aviation and healthcare industries • methods or approaches to checklist design • methods or approaches to checklist validation • checklist usage in industry • IT intensity in industry • regulation in industry Academic articles Accessible with UU account
Stopping criteria	Theoretical saturation, effort-bounded
Selection approach	Determine basic search, create additional search queries, read titles and abstracts, create long list, define inclusion and exclusion criteria, derive short list

A.2 Quality Assessment Criteria for Grey Literature

Table A.2: Quality assessment criteria for grey literature

Criteria	Questions
Authority of the producer	Is the publishing organization reputable?
	Is an individual author associated with a reputable organization?
	Has the author published other work in the field?
	Does the author have expertise in the area? (e.g., job title principal software engineer)
Methodology	Does the source have a clearly stated aim?
	Does the source have a stated methodology?
	Is the source supported by authoritative, contemporary references?
	Are any limits clearly stated?
	Does the work cover a specific question?
	Does the work refer to a particular population or case?
Objectivity	Does the work seem to be balanced in presentation?
	Are the statements in the source as objective as possible?
	Are the conclusions supported by data?
Date	Does the source have a clearly stated date?
Linkage of related sources	Have key related grey literature or formal sources been linked to or discussed?
Novelty	Does the source enrich or add something unique to the research?
	Does the source strengthen or refute a current position?
Outlet type	1st tier grey literature (measure = 1) - high credibility (books, magazines, theses) 2nd tier grey literature (measure = 0.5) - moderate credibility (annual reports, presentations, videos, wiki articles) 3rd tier grey literature (measure = 0) - low credibility (blog, email, tweet)

A.3 Long List

Long list

Aa Title	Reference	Topic
A comparative examination of information technology usage in the restaurant industry	Huber, Marsha M., Murat Hancer, and R. Thomas George. "A comparative examination of information technology usage in the restaurant industry." Journal of Foodservice Business Research 13.3 (2010): 268-281.	IT intensitivity in industry
Aviation and healthcare: a comparative review with implications for patient safety	Kapur, Narinder, et al. "Aviation and healthcare: a comparative review with implications for patient safety." JRSM open 7.1 (2015): 2054270415616548.	Comparison of aviation and healthcare
A Science of Checklists: Creation of a Checklist Taxonomy	H. Aydin, “A science of checklists: Creation of a checklist taxonomy,” master’s thesis, VU Amsterdam, 2017	Checklist usage in industry
Adoption of green fertilizer technology among paddy farmers: A possible solution for Malaysian food security	Adnan, Nadia, et al. "Adoption of green fertilizer technology among paddy farmers: A possible solution for Malaysian food security." Land use policy 63 (2017): 38-52.	IT intensitivity in industry
Airline business models and networks: regulation, competition and evolution in aviation markets	Gillen, David. "Airline business models and networks: Regulation, competition and evolution in aviation markets." Review of Network economics 5.4 (2006).	Regulation in industry
Approaches to business process analysis: a review	Biazzo, Stefano. "Approaches to business process analysis: a review." Business process management journal 6.2 (2000): 99-112.	Process Mapping
Assessment of ICT Usage in Healthcare Service Systems: A Case Study of the Federal Medical Centre (FMC) Yenagoa in Bayelsa State, Nigeria	Ceo, Owaba, et al. "Assessment of ICT Usage in Healthcare Service Systems: A Case Study of the Federal Medical Centre (FMC) Yenagoa in Bayelsa State, Nigeria." International Journal of Computer Science Trends and Technology 6.1 (2013).	IT intensitivity in industry
Checking the lists: A systematic review of electronic checklist use in health care	Kramer, Heidi S., and Frank A. Drews. "Checking the lists: A systematic review of electronic checklist use in health care." Journal of biomedical informatics 71 (2017): S6-S12.	Checklist usage in industry
Checklist Design Reconsidered: Understanding Checklist Compliance and Timing of Interactions	Kulp, Leah, et al. "Checklist design reconsidered: Understanding checklist compliance and timing of interactions." Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. 2020.	Checklist Design
Commercial Aircraft Electronic Checklists: Benefits and Challenges (Literature Review)	Myers III, Paul L. "Commercial aircraft electronic checklists: benefits and challenges (literature review)." International Journal of Aviation, Aeronautics, and Aerospace 3.1 (2016): 1.	Checklist usage in industry
Design science research in information systems	Hevner, Alan, et al. "Design science research in information systems." Design research in information systems: theory and practice (2010): 9-22.	Checklist Validation

Aa Title	Reference	Topic
Designing a checklist for an e commerce website using Kansei Engineering	Goh, Kim Nee, et al. "Designing a checklist for an e-commerce website using Kansei Engineering." Advances in Visual Informatics: Third International Visual Informatics Conference, IVIC 2013, Selangor, Malaysia, November 13-15, 2013. Proceedings 3. Springer International Publishing, 2013.	Checklist Design
Development and validation of the SURgical PAtient Safety System (SURPASS) checklist	de Vries, Eefje N., et al. "Development and validation of the SURgical PAtient Safety System (SURPASS) checklist." BMJ quality & safety 18.2 (2009): 121-126.	Checklist Design
Domain analysis in information science: eleven approaches–traditional as well as innovative	Hjørland, Birger. "Domain analysis in information science: eleven approaches–traditional as well as innovative." Journal of documentation (2002).	Domain Analysis
Domain analysis: An introduction	Prieto-Diaz, Ruben. "Domain analysis: An introduction." ACM SIGSOFT Software Engineering Notes 15.2 (1990): 47-54.	Domain Analysis
Emergency and Abnormal Checklist Design Factors Influencing Flight Crew Response: A Case Study	Burian, Barbara K. "Emergency and abnormal checklist design factors influencing flight crew response: A case study." Proceedings of the International Conference on Human-Computer Interaction in Aeronautics 2004. Vol. 1. 2004.	Checklist Design
Employee Perception of the Impact of Information Technology Investment in Organisations: a survey of the hotel industry	Lo, Bruce, and Cede Sri Darma. "Employee Perception of the Impact of Information Technology Investment in Organisations: a survey of the hotel industry." Australasian Journal of Information Systems 7.2 (2000).	IT intensitivity in industry
Health care, aviation, and ecosystems: A socio-natural systems perspective	Durso, Francis T., and Frank A. Drews. "Health care, aviation, and ecosystems: A socio-natural systems perspective." Current Directions in Psychological Science 19.2 (2010): 71-75.	Comparison of aviation and healthcare
Health care, technology and federalism	Outterson, Kevin. "Health care, technology and federalism." W. Va. L. Rev. 103 (2000): 503.	Regulation in industry
Health-health analysis: A new way to evaluate health and safety regulation	Lutter, Randall, and John F. Morrall. "Health-health analysis: A new way to evaluate health and safety regulation." Journal of Risk and Uncertainty 8 (1994): 43-66.	Regulation in industry
History of science in science education: Development and validation of a checklist for analysing the historical content of science textbooks	Leite, Laurinda. "History of science in science education: Development and validation of a checklist for analysing the historical content of science textbooks." Science & Education 11 (2002): 333-359.	Checklist Validation
Information technologies in healthcare: Enhancing or dehumanising doctor–patient interaction?	Botrugno, Carlo. "Information technologies in healthcare: Enhancing or dehumanising doctor–patient interaction?." Health 25.4 (2021): 475-493.	IT intensitivity in industry
Information Technology and Industry Concentration	Bessen, James. "Information technology and industry concentration." (2017).	IT intensitivity in industry

Aa Title	Reference	Topic
Information technology and New Zealand construction industry: An empirical study towards strategic alignment of project and organization	Eliwa, Hassan, Mostafa Babaeian Jelodar, and Mani Poshdar. "Information technology and New Zealand construction industry: An empirical study towards strategic alignment of project and organization." Proceedings of the 18th International Conference on Construction Applications of Virtual Reality (CONVR2018), Auckland, New Zealand. 2018.	IT intensitivity in industry
Information technology and the transformation of industries: three research perspectives	Crowston, Kevin, and Michael D. Myers. "Information technology and the transformation of industries: three research perspectives." The Journal of Strategic Information Systems 13.1 (2004): 5-28.	IT intensitivity in industry
Information technology usage impacts on construction projects' success	Kivrak, Serkan, Gokhan Arslan, and Oytun Cagatay. "Information technology usage impacts on construction projects' success." The 10Th International Conference. 2010.	IT intensitivity in industry
Information technology usage in SMEs in a developing economy	Afolayan, Ademola, et al. "Information technology usage in SMEs in a developing economy." Strategic Change 24.5 (2015).	IT intensitivity in industry
Learning from patient safety incidents: Creating participative risk regulation in healthcare	Macrae, Carl. "Learning from patient safety incidents: creating participative risk regulation in healthcare." *Health, Risk & Society* 10.1 (2008): 53-67.	Comparison of aviation and healthcare
MediCheck - A Domain-Specific Modeling Solution for Medical Checklists	Gieske, P. M. MediCheck-A Domain-Specific Modeling Solution for Medical Checklists. MS thesis. 2020.	Checklist Design, Checklist Validation, Checklist usage in industry, Domain Analysis, Process Mapping
More than a tick box: medical checklist development, design, and use	Burian, Barbara K., et al. "More than a tick box: medical checklist development, design, and use." Anesthesia & Analgesia 126.1 (2018): 223-232.	Checklist Design
Patient safety in the understanding of health care students	Cauduro, Graziela Maria Rosa, et al. "Patient safety in the understanding of health care students." Revista Gaúcha de Enfermagem 38 (2017).	Regulation in industry
Performance impacts of information technology: Is actual usage the missing link?	Devaraj, Sarv, and Rajiv Kohli. "Performance impacts of information technology: Is actual usage the missing link?." Management science 49.3 (2003): 273-289.	IT intensitivity in industry
Process analysis tools for process improvement	Bal, Jay. "Process analysis tools for process improvement." The TQM Magazine 10.5 (1998): 342-354.	Process Mapping
Public health in practice: the three domains of public health	Griffiths, Sian, Tony Jewell, and Peter Donnelly. "Public health in practice: the three domains of public health." *Public health* 119.10 (2005): 907-913.	Domain Analysis
Regulation and incentives in European aviation	Gagnepain, Philippe, and Pedro L. Marín. "Regulation and incentives in European aviation." The Journal of Law and Economics 49.1 (2006): 229-2	Regulation in industry

Aa Title	Reference	Topic
Regulation for aviation safety	Hulínská, Šárka, Vladimír Němec, and Stanislav Szabo. "Regulation for Aviation Safety." International Journal of Interdisciplinarity in Theory and Practice 10 (2016): 2344-2409.	Regulation in industry
Sustainability Indicators in Restaurants: The Development of a Checklist	Maynard, Dayanne da Costa, et al. "Sustainability indicators in restaurants: The development of a checklist." Sustainability 12.10 (2020): 4076.	Checklist Design, Checklist Validation
The Checklist Manifesto: Examples From the Hotel Industry	Smith, Andrew J. "The checklist manifesto: Examples from the hotel industry." (2010): 280-282.	Checklist usage in industry
The checklist—a tool for error management and performance improvement	Hales, Brigette M., and Peter J. Pronovost. "The checklist—a tool for error management and performance improvement." Journal of critical care 21.3 (2006): 231-235.	Checklist usage in industry
The criminalization of human error in aviation and healthcare: A review	Dekker, Sidney. "The criminalization of human error in aviation and healthcare: A review." Safety science 49.2 (2011): 121-127.	Comparison of aviation and healthcare
The Impact of Information Technology Investment on the Hospitality Industry	Darma, Gede Sri. "The Impact of Information Technology Investment on the Hospitality Industry." Seminar Nasional Aplikasi Teknologi Informasi (SNATI). 2004.	IT intensitivity in industry
The problem with checklists	Catchpole, Ken, and Stephanie Russ. "The problem with checklists." BMJ quality & safety 24.9 (2015): 545-549.	Checklist usage in industry
The use of information technology on gaining competitive advantage in Turkish contractor firms	Cakmak, Pinar Irlayici, and Elcin Tas. "The use of information technology on gaining competitive advantage in Turkish contractor firms." World Applied Sciences Journal 18.2 (2012): 274-285.	IT intensitivity in industry
Three approaches to design engineering in the health domain: a systemic perspective	Pannunzio, Valeria, Maaike Kleinsmann, and Dirk Snelders. "Three approaches to design engineering in the health domain: a systemic perspective." Proceedings of the Design Society: International Conference on Engineering Design. Vol. 1. No. 1. Cambridge University Press, 2019.	Design Engineering in industry
Toward a new horizon in information science: Domain-analysis	Hjørland, Birger, and Hanne Albrechtsen. "Toward a new horizon in information science: Domain-analysis." Journal of the American society for information science 46.6 (1995): 400-425.	Domain Analysis
Towards a Checklist Design Best Practices Checklist	Smith, Jeffrey John. "Towards a Checklist Design Best Practices Checklist." (2012).	Checklist Design
Towards a Science of Checklists	Reijers, Hajo, Henrik Leopold, and Jan Recker. "Towards a science of checklists." Proceedings of the 50th Hawaii International Conference on System Sciences. University of Hawaii, 2017.	Checklist Design, Checklist usage in industry
Validation of the PTSD checklist in an HMO sample of women	Walker, Edward A., et al. "Validation of the PTSD checklist in an HMO sample of women." General hospital psychiatry 24.6 (2002): 375-380.	Checklist Validation

A.4 Short List

see next page

Short list

Aa Title	Reference	Topic
A comparative examination of information technology usage in the restaurant industry	Huber, Marsha M., Murat Hancer, and R. Thomas George. "A comparative examination of information technology usage in the restaurant industry." Journal of Foodservice Business Research 13.3 (2010): 268-281	IT intensitivity in industry
Assessment of ICT Usage in Healthcare Service Systems: A Case Study of the Federal Medical Centre (FMC) Yenagoa in Bayelsa State, Nigeria	Ceo, Owaba, et al. "Assessment of ICT Usage in Healthcare Service Systems: A Case Study of the Federal Medical Centre (FMC) Yenagoa in Bayelsa State, Nigeria." International Journal of Computer Science Trends and Technology 6.1 (2013).	IT intensitivity in industry
Aviation and healthcare: a comparative review with implications for patient safety	Kapur, Narinder, et al. "Aviation and healthcare: a comparative review with implications for patient safety." JRSM open 7.1 (2015): 2054270415616548	Comparison of aviation and healthcare
Checking the lists: A systematic review of electronic checklist use in health care	Kramer, Heidi S., and Frank A. Drews. "Checking the lists: A systematic review of electronic checklist use in health care." Journal of biomedical informatics 71 (2017): S6-S12.	Checklist usage in industry
Checklist Design Reconsidered: Understanding Checklist Compliance and Timing of Interactions	Kulp, Leah, et al. "Checklist design reconsidered: Understanding checklist compliance and timing of interactions." Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. 2020.	Checklist Design
Designing a checklist for an e commerce website using Kansei Engineering	Goh, Kim Nee, et al. "Designing a checklist for an e-commerce website using Kansei Engineering." Advances in Visual Informatics: Third International Visual Informatics Conference, IVIC 2013, Selangor, Malaysia, November 13-15, 2013. Proceedings 3. Springer International Publishing, 2013.	Checklist Design
Development and validation of the SURgical PAtient Safety System (SURPASS) checklist	de Vries, Eefje N., et al. "Development and validation of the SURgical PAtient Safety System (SURPASS) checklist." BMJ quality & safety 18.2 (2009): 121-126.	Checklist Design
Domain analysis in information science: eleven approaches–traditional as well as innovative	Hjørland, Birger. "Domain analysis in information science: eleven approaches–traditional as well as innovative." Journal of documentation (2002)	Domain Analysis
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History of science in science education: Development and validation of a checklist for analysing the historical content of science textbooks	Leite, Laurinda. "History of science in science education: Development and validation of a checklist for analysing the historical content of science textbooks." Science & Education 11 (2002): 333-359.	Checklist Validation
Information technologies in healthcare: Enhancing or dehumanising doctor–patient interaction?	Botrugno, Carlo. "Information technologies in healthcare: Enhancing or dehumanising doctor–patient interaction?." Health 25.4 (2021): 475-493.	IT intensitivity in industry

Aa Title	Reference	Topic
Information Technology and Industry Concentration	Bessen, James. "Information technology and industry concentration." (2017).	IT intensitivity in industry
Information technology and the transformation of industries: three research perspectives	Crowston, Kevin, and Michael D. Myers. "Information technology and the transformation of industries: three research perspectives." The Journal of Strategic Information Systems 13.1 (2004): 5-28.	IT intensitivity in industry
Information technology usage impacts on construction projects' success	Kivrak, Serkan, Gokhan Arslan, and Oytun Cagatay. "Information technology usage impacts on construction projects' success." The 10Th International Conference. 2010.	IT intensitivity in industry
Information technology usage in SMEs in a developing economy	Afolayan, Ademola, et al. "Information technology usage in SMEs in a developing economy." Strategic Change 24.5 (2015).	IT intensitivity in industry
More than a tick box: medical checklist development, design, and use	Burian, Barbara K., et al. "More than a tick box: medical checklist development, design, and use." Anesthesia & Analgesia 126.1 (2018): 223-232.	Checklist Design
Regulation and incentives in European aviation	Gagnepain, Philippe, and Pedro L. Marín. "Regulation and incentives in European aviation." The Journal of Law and Economics 49.1 (2006): 229-2.	Regulation in industry
Sustainability Indicators in Restaurants: The Development of a Checklist	Maynard, Dayanne da Costa, et al. "Sustainability indicators in restaurants: The development of a checklist." Sustainability 12.10 (2020): 4076.	Checklist Design, Checklist Validation
The Checklist Manifesto: Examples From the Hotel Industry	Smith, Andrew J. "The checklist manifesto: Examples from the hotel industry." (2010): 280-282.	Checklist usage in industry
The checklist—a tool for error management and performance improvement	Hales, Brigette M., and Peter J. Pronovost. "The checklist—a tool for error management and performance improvement." Journal of critical care 21.3 (2006): 231-235.	Checklist usage in industry
The criminalization of human error in aviation and healthcare: A review	Dekker, Sidney. "The criminalization of human error in aviation and healthcare: A review." Safety science 49.2 (2011): 121-127.	Comparison of aviation and healthcare
Towards a Science of Checklists	Reijers, Hajo, Henrik Leopold, and Jan Recker. "Towards a science of checklists." Proceedings of the 50th Hawaii International Conference on System Sciences. University of Hawaii, 2017.	Checklist Design, Checklist usage in industry

A. RESEARCH APPROACH

Appendix B

Ethics Material

B.1 Ethics and Privacy Quick Scan

see next page

Ethics and Privacy Quick Scan (version: 5 September 2022)

Section 1. Research projects involving human participants

		Yes	No
P1	Does your project involve human participants? This includes for example use of observation, (online) surveys, interviews, tests, focus groups, and workshops where human participants provide information or data to inform the research. If you are only using existing data sets or publicly available data (e.g. from Twitter, Reddit) without directly recruiting participants, please answer no.	**Yes**	

If no, continue with Section 2; if yes, fill in the following questions.

Recruitment

		Yes	No
P2	Does your project involve participants younger than 18 years of age?	**Yes**	
P3	Does your project involve participants with learning or communication difficulties of a severity that may impact their ability to provide informed consent?[1]		**No**
P4	Is your project likely to involve participants engaging in illegal activities?		**No**
P5	Does your project involve patients?		**No**
P6	Does your project involve participants belonging to a vulnerable[2] group, other than those listed above?		**No**

If the answer to all of P2-P6 is no, continue with P8.

As you are dealing with vulnerable participants (yes to one (or more) of P2-P6) a fuller ethical review is required. Please add more detail on your participants here:

While it could be that this research involves people under 18, these people are not the main focus point of the study and are therefore not classified as participants. Example of this is an observation of a teacher in a classroom setting who teaches people under 18. The teacher itself is the only participant.

[1] For informed consent people need to be able to (1) understand information provided relevant to making the consent decision, (2) retain this information long enough to be able to make a decision, (3) weigh the information, (4) communicate the decision.

[2] Vulnerable people include those who are legally incompetent, who may have difficulty giving or withholding consent, or who may suffer highly adverse consequences if their personal data were to become publicly available or from participating. Examples include irregular immigrants, sex workers, dissidents and traumatized people at risk of re-traumatization.

		Yes	No
P7	Do you intend to be alone with a research participant or have to take sole responsibility for the participants at any point during your research activity?		**No**

If P7 is no continue with P8, otherwise:

 **As you will be alone with or solely responsible for vulnerable participants (yes to P7) a fuller ethical review is required. You may also need a Certificate of Conduct (Dutch: VOG) from the government.** Please add more detail here:

	Yes	No
P8	Does your project involve participants with whom you have, or are likely to have, a working or professional relationship: for instance, staff or students of the university, professional colleagues, or clients?		**No**

If the answer to P8 is yes, please answer P9, otherwise, continue with PC1.

	Yes	No
P9	Is it made clear to potential participants that not participating will in no way impact them (e.g. it will not directly impact their grade in a class)?		

If the answer to P9 is yes, then continue with PC1, otherwise:

 **As participants may think that not participating may harm them (yes to P8 and no to P9), participation may no longer be voluntary. Hence, a fuller ethical review is required.** Please provide more information here:

Consent Procedures		**Yes**	**No**	**Not applicable**
PC1	Do you have set procedures that you will use for obtaining *informed* consent from all participants, including (where appropriate) parental consent for children or consent from legally authorized representatives? (See suggestions for information sheets and consent forms on the website[3].)	**Yes**		
PC2	Will you tell participants that their participation is voluntary?	**Yes**		
PC3	Will you obtain explicit consent for participation?	**Yes**		
PC4	Will you obtain explicit consent for any sensor readings, eye tracking, photos, audio, and/or video recordings?	**Yes**		
PC5	Will you tell participants that they may withdraw from the research at any time and for any reason?	**Yes**		
PC6	Will you give potential participants time to consider participation?	**Yes**		
PC7	Will you provide participants with an opportunity to ask questions about the research before consenting to take part (e.g. by providing your contact details)?	**Yes**		

If the answer to PC1-PC7 is yes, then continue with PC8, otherwise:

Given your responses to the informed consent questions (a no on any of PC1-PC7), a fuller ethical review is required. Please provide more information regarding the questions that are causing this here:

		Yes	**No**
PC8	Does your project involve concealment[4] or deliberate misleading of participants?		**No**

[3] uu.nl/en/research/institute-of-information-and-computing-sciences/ethics-and-privacy

[4] This may for example involve concealment of the study aim, of the identity of the researcher, or subliminal messaging during the study.

If the answer to PC8 no, continue with Section 2, otherwise:

 As you plan to use concealment or misleading (yes to PC8), and this may impact participants' rights to informed consent, a fuller ethical review is required. Please provide more information on the concealment/misleading here:

Section 2. Data protection, handling, and storage

The General Data Protection Regulation imposes several obligations for the use of **personal data** (defined as any information relating to an identified or identifiable living person) or including the use of personal data in research.

		Yes	No
D1	Are you gathering or using personal data (defined as any information relating to an identified or identifiable living person[5])?		**No**

If the answer to D1 is yes, please answer the following questions; otherwise, continue with Section 3.

High-Risk Data

		Yes	No
DR1	Will you process personal data that would jeopardize the physical health or safety of individuals in the event of a personal data breach?		
DR2	Will you combine, compare, or match personal data obtained from multiple sources, in a way that exceeds the reasonable expectations of the people whose data it is?[6]		

[5] This includes people's name, postal address, unique ID, IP address, voice, photo, video etc. When a person can be identified by combining multiple data points (e.g. gender + age + job role), this also constitutes personal data. When a person can be identified by a simple search online (e.g. with the content of a tweet) this also constitutes personal data. Note that Survey tool Qualtrics by default collects IP addresses and that the survey needs to be anonymized before distribution to prevent this.

[6] This is about the combined use of data sets that have been gathered for different purposes (so not within one study), making the data more personal or sensitive. For example, combining participant data with religion or ethnic statistics data from the CBS based on zip code.

Section 3: Research that may cause harm

Research may harm participants, researchers, the university, or society. This includes when technology has dual-use, and you investigate an innocent use, but your results could be used by others in a harmful way. If you are unsure regarding possible harm to the university or society, please discuss your concerns with the Research Support Office.

		Yes	No
H1	Does your project give rise to a realistic risk to the national security of any country?[28]		**No**
H2	Does your project give rise to a realistic risk of aiding human rights abuses in any country?[29]		**No**
H3	Does your project (and its data) give rise to a realistic risk of damaging the University's reputation? (E.g., bad press coverage, public protest.)		**No**
H4	Does your project (and in particular its data) give rise to an increased risk of attack (cyber- or otherwise) against the University? (E.g., from pressure groups.)		**No**
H5	Is the data likely to contain material that is indecent, offensive, defamatory, threatening, discriminatory, or extremist?		**No**
H6	Does your project give rise to a realistic risk of harm to the researchers?[30]		**No**
H7	Is there a realistic risk of any participant experiencing physical or psychological harm or discomfort?[31]		**No**
H8	Is there a realistic risk of any participant experiencing a detriment to their interests as a result of participation?		**No**
H9	Is there a realistic risk of other types of negative externalities?[32]		**No**

[28] For example, research that can be used for autonomous armed vehicles/drones/robots, research on automated detection of objects, research on AI-enhanced forgery of video/audio data.

[29] For example, research on natural language/video/audio processing for automated identification of people's identity, sentiments, or opinions.

[30] For example, research that involves potentially violent participants such as criminals, research in likely unsafe locations such as war zones, research on an emotionally highly challenging topic, research in which the researcher is alone with a not previously known participant in the participant's home.

[31] For example, research that involves strenuous physical activity, research that stresses participants, research on an emotionally challenging topic.

[32] A negative externality is a harm produced to a third party, society in general, or the environment. For instance, intended or unintended negative ethical (e.g. bad governance or management practices), social (e.g. consumerism, inequality) or environmental effects (e.g. large CO_2 footprint or e-waste production) of your project.

If the answer to H1-H9 is no continue with Section 4, otherwise:

 **As you replied yes to one (or more) of H1-H9, a fuller ethical review is required.** Please provide more detail here on the potential harm, and how you will minimize risk and impact:

Section 4: Conflicts of interest

		Yes	No
C1	Is there any potential conflict of interest (e.g. between research funder and researchers or participants and researchers) that may potentially affect the research outcome or the dissemination of research findings?		**No**
C2	Is there a direct hierarchical relationship between researchers and participants?		**No**

If the answer to C1-C2 is yes, continue with Section 5, otherwise:

 **As you replied yes to C1 or C2, a fuller ethical review is required.** Please provide more information regarding possible conflicts of interest and how you mitigate them here:

Section 5: Your information

This last section collects data about you and your project so that we can register that you completed the Ethics and Privacy Quick Scan, sent you (and your supervisor) the summary of what you filled out, and follow up where a fuller ethics review and/or privacy assessment is needed. For details of our legal basis for using personal data and the rights you have over your data please see the University's privacy information. Please see the guidance on the ICS Ethics and Privacy website on what happens on submission.

Z0. Which is your main department?

- • Information and Computing Science
- ○ Freudenthal Institute
- ○ Other, namely:

Z1. Your full name:
Johan Geel

Z2. Your email address:
j.t.geel@uu.nl
Z3. In what context will you conduct this research?

- ○ 1. As a student on a course with course coordinator:
- ○ 2. As a student for my bachelor thesis, supervised by:
- • 3. As a student for my master thesis, supervised by: Prof. dr. ir. H.A. (Hajo) Reijers
- ○ 4. As a PhD student, supervised by:
- ○ 5. As an independent researcher (e.g. research fellow, assistant/associate/full professor)

In case the answer to Z3 is 2:

Z4. Bachelor programme for which you are doing the thesis:

- ○ Artificial Intelligence (Kunstmatige Intelligentie)
- ○ Computing Science (Informatica)
- ○ Information Science (Informatiekunde)
- ○ Other:

In case the answer to Z3 is 3:

Z5. Master programme for which you are doing the thesis:

- ○ Applied Data Science
- ○ Artificial Intelligence
- • Business Informatics
- ○ Computing Science
- ○ Data Science
- ○ Game and Media Technology
- ○ Human-Computer Interaction
- ○ Other:

In case the answer to Z3 is 1, 2, 3, or 4:

Z6. Email of the course coordinator or supervisor (so that we can inform them that you filled this out and provide them with a summary):

anonymised

In case the answer to Z3 is 2 or 3:

Z7. Email of the moderator (as provided by the coordinator of your thesis project):

anonymised

Z8. Title of the research project/study for which you filled out this Quick Scan:

Checklists For Everyone: Developing Design Principles For Everyday Organizations

Z9. Summary of what you intend to investigate and how you will investigate this (200 words max):

We investigate the use of checklists in restaurants, educational organisations, and retail organisations. We do this by examining current checklist use in industries where checklists are seen as a necessity, such as the aviation and health care industries. We derive concepts from these industries, compare them with concepts from restaurants, educational organisations, and retail organisations through expert interviews, and develop a domain-agnostics checklist that can be used in any given domain. We validate this checklist by performing qualitative simulations.

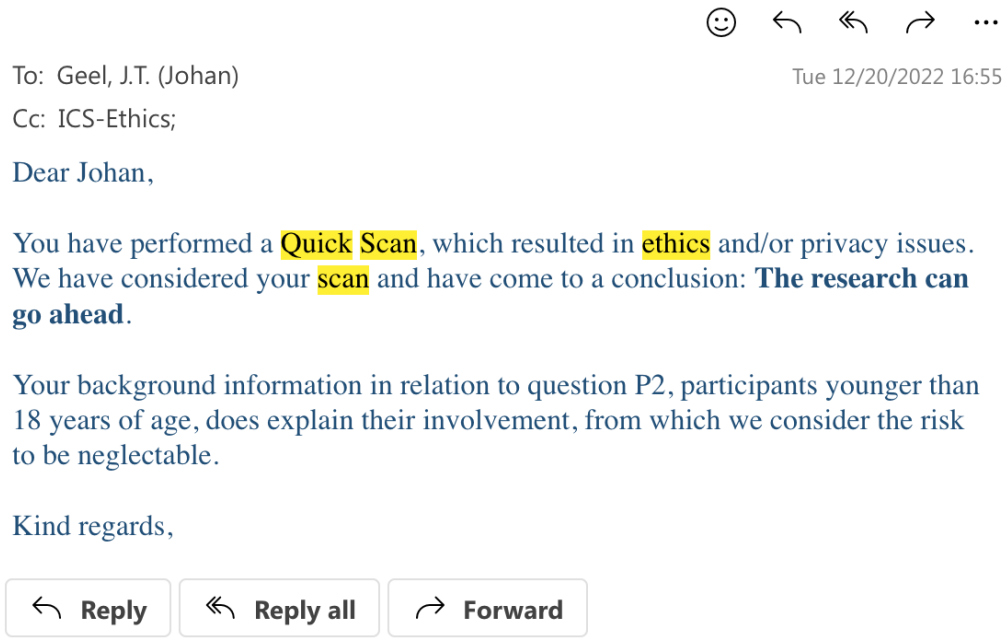
In case the answer to Z3 is 2 or 3:

		Yes	No	Not Applicable
Z10.	In case you encountered warnings in the survey, does your supervisor already have ethical approval for a research line that fully covers your project?		**No**	

In case the answer to Z9 is yes:

Z10. Provide details on the ethical approval (e.g. ethical approval number):

B.2 Ethics Approval Mail


To: Geel, J.T. (Johan)

Tue 12/20/2022 16:55

Cc: ICS-Ethics;

Dear Johan,

You have performed a Quick Scan, which resulted in ethics and/or privacy issues. We have considered your scan and have come to a conclusion: **The research can go ahead**.

Your background information in relation to question P2, participants younger than 18 years of age, does explain their involvement, from which we consider the risk to be neglectable.

Kind regards,

Reply Reply all Forward

Figure B.1: Approval mail for the Ethics Quick Scan

Appendix C

Interview Material

C.1 Transcriptions of Exploratory Interviews

Transcriptions (in Dutch) are view-only available via this link through Open Science Foundation[1].

C.2 Protocol Exploratory Semi-structured Interviews

see next page

[1] https://osf.io

Interview Protocol

INTRODUCTION

- Thank you for your participation
- Research aim
- Structure of this interview
- Do you have any questions beforehand?

BACKGROUND OF INTERVIEWEE

- What is your role in the organization?
- What is your practical experience with checklists?
- What is your relation in regard to this checklist (user, creator, manager)?

USAGE

- Which process does this checklist focus on?
- What is the objective of this checklist (memory aid, evaluation, teamwork facilitation, confirmation)?
- How long has this checklist been in use?
- By whom is this checklist used?
- Is this checklist based on other checklists (standardised in some way) or self-made without looking at other checklists?
    - Is this choice made on purpose?
- Have any other alternatives been considered before deciding on using this checklist?
- Do you prefer to use this checklist on print or digital?
- With which procedure are checklist items accomplished (Do and Confirm, Read and Do)?
- How are checklist items accomplished (written, read aloud, read in silence)?
- What kind of checklist item types are used (task, checkbox, open text area, Likert-scale)?
- Are there any specific restrictions noted as to when to use this checklist?
- What do you like about this checklist?
- Do you think this checklist is effective?
- Have you been in a situation where you wanted to add something to this checklist, because the checklist itself was not sufficient?

POSSIBLE CHANGES

- Do you have any ideas what would improve the current checklist?
- Would you change anything concerning the layout (font size, font style, sections, etc)?
- Would you change anything concerning the representability of the checklist?

CONCLUSION

- Give summary
- Is there something we have not addressed yet that you would like to talk about?
- Thank you for your time

C.3 Consent Form Exploratory Semi-structured Interviews

see next page

Consent Form

INTRODUCTION
Checklists For Everyone: Developing A Domain-Agnostic Checklist

EXPLANATION
Dear …,

Thank you for agreeing to be interviewed as part of the above research project for my master's thesis at the Utrecht University. This consent form ensures that you understand the purpose of your involvement and that you agree to the conditions of your participation.

The purpose of this research is to investigate how checklist principles from the aviation and health care industries can be applied in hospitality organizations, education organizations, and retail stores. In this interview, we ask you questions about how you use checklists in your professional environment. Examples of checklists include a list of tasks for cleaning a restaurant kitchen, or an assessment form for an oral test.

RESEARCH INVESTIGATOR
Johan Geel - j.t.geel@uu.nl
Supervised by Prof. dr. ir. Hajo Reijers - h.a.reijers@uu.nl

CONSENT
1. I understand that the interview will take approximately 45 minutes. I give the researcher permission to take notes during the interview.

2. I understand that participating is voluntary. I understand that at any moment, I can decide not to participate anyway, without giving any reason.

Consent Form

3. I understand that the research data, without any personal information that could identify me, may be shared with others.

4. I understand that I am free to contact any of the people involved in the research to seek further clarification and information at any time. Any collected data of me will be deleted.

5. I give permission for the researchers to undertake audio recording during the interview. The audio files are only accessible to the main researchers and will be destroyed after transcribing.

6. I am free to decide if I want my name and company name mentioned in the research report.

Participant's signature _____ Date _____

Investigator's signature _____ Date _____

C.4 Questionnaire Design Principle Validation, in Dutch

see next page

Ontwerpprincipes voor checklists op de werkvloer

Utrecht University

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1. Focus op de gebruiker	Helemaal mee oneens	Deels mee oneens	Neutraal / geen mening	Deels mee eens	Helemaal mee eens
Ik kan me voorstellen wat dit principe inhoudt.	○	○	○	○	○
Ik begrijp waarom dit principe belangrijk is.	○	○	○	○	○
Dit principe is nieuw voor mij.	○	○	○	○	○
Ik snap hoe ik dit principe zou kunnen toepassen.	○	○	○	○	○
Ik denk dat dit principe effect kan hebben.	○	○	○	○	○

2. Houd het simpel	Helemaal mee oneens	Deels mee oneens	Neutraal / geen mening	Deels mee eens	Helemaal mee eens
Ik kan me voorstellen wat dit principe inhoudt.	○	○	○	○	○
Ik begrijp waarom dit principe belangrijk is.	○	○	○	○	○
Dit principe is nieuw voor mij.	○	○	○	○	○
Ik snap hoe ik dit principe zou kunnen toepassen.	○	○	○	○	○
Ik denk dat dit principe effect kan hebben.	○	○	○	○	○

3. Pas aan aan de organisatie	Helemaal mee oneens	Deels mee oneens	Neutraal / geen mening	Deels mee eens	Helemaal mee eens
Ik kan me voorstellen wat dit principe inhoudt.	○	○	○	○	○
Ik begrijp waarom dit principe belangrijk is.	○	○	○	○	○
Dit principe is nieuw voor mij.	○	○	○	○	○
Ik snap hoe ik dit principe zou kunnen toepassen.	○	○	○	○	○
Ik denk dat dit principe effect kan hebben.	○	○	○	○	○

4. Update waar mogelijk	Helemaal mee oneens	Deels mee oneens	Neutraal / geen mening	Deels mee eens	Helemaal mee eens
Ik kan me voorstellen wat dit principe inhoudt.	○	○	○	○	○
Ik begrijp waarom dit principe belangrijk is.	○	○	○	○	○
Dit principe is nieuw voor mij.	○	○	○	○	○
Ik snap hoe ik dit principe zou kunnen toepassen.	○	○	○	○	○
Ik denk dat dit principe effect kan hebben.	○	○	○	○	○

C.5 Questionnaire Design Principle Validation, in English

see next page

Design principles for workplace checklists

Utrecht University

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1. Focus on the user.	Fully disagree	Partially disagree	Neutral	Partially agree	Fully agree
I can imagine what this principle means.	○	○	○	○	○
I understand why this principle is important.	○	○	○	○	○
This principle is new to me.	○	○	○	○	○
I understand how I could apply this principle.	○	○	○	○	○
I think this principle can make an impact.	○	○	○	○	○

2. Keep it simple.	Fully disagree	Partially disagree	Neutral	Partially agree	Fully agree
I can imagine what this principle means.	○	○	○	○	○
I understand why this principle is important.	○	○	○	○	○
This principle is new to me.	○	○	○	○	○
I understand how I could apply this principle.	○	○	○	○	○
I think this principle can make an impact.	○	○	○	○	○

3. Tailor it to the organization.	Fully disagree	Partially disagree	Neutral	Partially agree	Fully agree
I can imagine what this principle means.	○	○	○	○	○
I understand why this principle is important.	○	○	○	○	○
This principle is new to me.	○	○	○	○	○
I understand how I could apply this principle.	○	○	○	○	○
I think this principle can make an impact.	○	○	○	○	○

4. Update where possible.	Fully disagree	Partially disagree	Neutral	Partially agree	Fully agree
I can imagine what this principle means.	○	○	○	○	○
I understand why this principle is important.	○	○	○	○	○
This principle is new to me.	○	○	○	○	○
I understand how I could apply this principle.	○	○	○	○	○
I think this principle can make an impact.	○	○	○	○	○