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Product-service-system design thinking for port healthcare: a case study with container lashers in the port of Antwerp

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ABSTRACT

The port of Antwerp executes its container lashing with specialized dockworker crews called container lashers. These container lashers train in the port training center, OCHA, in order to execute container lashing safely and efficiently. Container lashing is considered labor intensive. Due to the future trends within maritime transportation, the interest in optimized ergonomic training provided for dockworkers rises. A User-Centered Design approach is implemented to gather insights to build a Product-service-system (PSS) solution in a multidisciplinary research context. In order to develop a meaningful PSS, clinical and cultural insights are required. This paper presents the research framework of Design Inclusive Research (DIR) to collect cultural insights from container lashers. Subsequentially, it elaborates on the different stages of DIR to the extent of defining and executing the design tools. For this study, Cultural Probes and user journey maps, in combination with in-depth interviews, are applied to gather, synthesize, and present the information to stakeholders in a validation workshop. The proposed design tools and framework delivered an array of contextual information, leading to a broader understanding of the container lashers' culture and generating impactful solutions.

Keywords: Design Thinking, Healthcare, Maritime Workers, PSS, Research Framework.

INTRODUCTION

Dockworkers in the port of Antwerp are organized and distributed to different shipping companies by an overarching employers' organization called Cepa (Cepa, 2019a). A partnership with the employers' organization and dockworker unions is maintained in order to secure the highest ethical level possible for the dockworkers in the port (Cepa, 2023c). Further in the paper, the study refers to the port of Antwerp as the area of operations and not to the managing organization, Port of Antwerp. To guarantee efficient work behavior strictly following safety legislation, dockworkers undergo intensive training for four weeks. These training sessions are organized at the designated training center, OCHA (Cepa, 2019b). Due to the rapid growth in maritime transportation, a change in organization and training of the labor market within the port is needed (Esser et al., 2020; Hinkka et al., 2016). With the growth in container transportation, an increase in musculoskeletal disorders is noticed (De Carvalho et al., 2016; Lima et al., 2018; Saraji et al., 2004; Sedilla & Matias, 2018). In the port of Antwerp,

manually securing and loosening containers is done by dockworkers, not by the ship's sailors. This is to ensure the safety of the cargo and personnel on the docks and on board a ship.

1. PSS DESIGN FOR OCCUPATIONAL HEALTHCARE

Conventional business models in healthcare experience rising costs, forcing them to rethink their strategy (Porter & Lee, 2013), leading to incremental changes within healthcare. More recent practices deviate from traditional organizational healthcare management practices in favor of a more user-centered design approach (Bate & Robert, 2006; Bowen et al., 2010). In order to design a service for and with patients, Experienced Based Design (EBD) is applied in these cases (Bate & Robert, 2006). This method of participatory service design lacks the design tools to handle "wicked problems" (Rittel & Webber, 1973; Bowen et al., 2010). Recent literature suggests the use of systems thinking to solve these "wicked problems" (Grewatsch et al., 2021). Therefore, a holistic overview is needed to correctly intervene in healthcare as a system, which can be provided by systems thinking (Kauffman, 1980). As product-service-system (PSS) is considered novel in healthcare (Xing et al., 2017), it pertains to following an intuitive design process in the designer's experience (Baines et al., 2017). The possibility exists that tools lose their holistic overview of the problem and under define the different stakeholders during the design process (Yip et al., 2014). Implementation of the PSS design tool within the healthcare sector implies the use of an external facilitator with the correct design methodology knowledge (Yip et al., 2015). Hence, the need for a multi-disciplinary team consisting of physiotherapists and product developers. The PSS toolkit can provide a broad array of tools supporting a systemic design flow (Dewit et al., 2018).

1.1. Aim of the study

The problem within the port of Antwerp concerning container lashers can be perceived as complex and multi-disciplinary. Therefore, the development of a Product-Service-System (PSS) is proposed, aligning with the User Centered Design approach (Salvo, 2001). A multi-disciplinary team, consisting of the department of Product Development and the department of Rehabilitation Sciences and Physiotherapy of the University of Antwerp, will work closely together with employers' organization, Cepa (Cepa, 2019a) and their training center, OCHA (Cepa, 2019b). In this multidisciplinary project, the department of Product Development will focus on gaining cultural insights in order to generate innovative solutions, whereas the department of Rehabilitation Sciences and Physiotherapy will focus on clinical insights. This paper presents a methodology for the multi-disciplinary participatory action research (PAR) approach (Rosskam, 2018) and elaborates on the use of systemic and service design tools to generate insights on the cultural aspects of container lashing and mediating the occupational hazards concerning container lashing.

2. MATERIALS AND METHODS

2.1. Design research methodology

In order to define impactful solutions within the port environment, a methodical design approach is needed. As this study is an element of a larger PhD-project, a structured methodology needs to be implemented. Design research contributes to conceptualizing a research strategy capable of analyzing problems, developing solutions, and communicating

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knowledge for further design and implementation of actions (Simon, 1996). As presented by Horvath (2008), design research is introduced by three different framing methodologies: "Research In Design Context" (RIDC), "Design Inclusive Research" (DIR) and "Operative Design Research" (ODR) (Horvath & Du Bois, 2013). This design research process commences with focusing on knowledge aggregation by executing observations in OCHA and at the docks and conducting approachable interviews with dockworkers. The aggregated knowledge is comprised of logical and concrete assumptions by examining the discovered information against a state-of-the-art literature search concerning PSS and port healthcare. These assumptions lead to the understanding that a user-centered design approach is needed to dive deeper into the experiences, emotions, and expectations of the container lashers. Derived from the assumptions, a theory is made (Horváth, 2008). In this study, the theory states that User-Centered Design and PAR will grant a sufficient and thorough understanding of container lashers' culture. A concept design tool is built to justify and validate the formed theory. The study divides the concept stage of the DIR into four design tools adapted for container lashers, as seen in figure 1: 1) cultural probes, 2) user journeys, and 3) in-depth interviews. These three tools are carried out in three phases:

- building the tool;
- executing the tool;
- evaluating the tool.

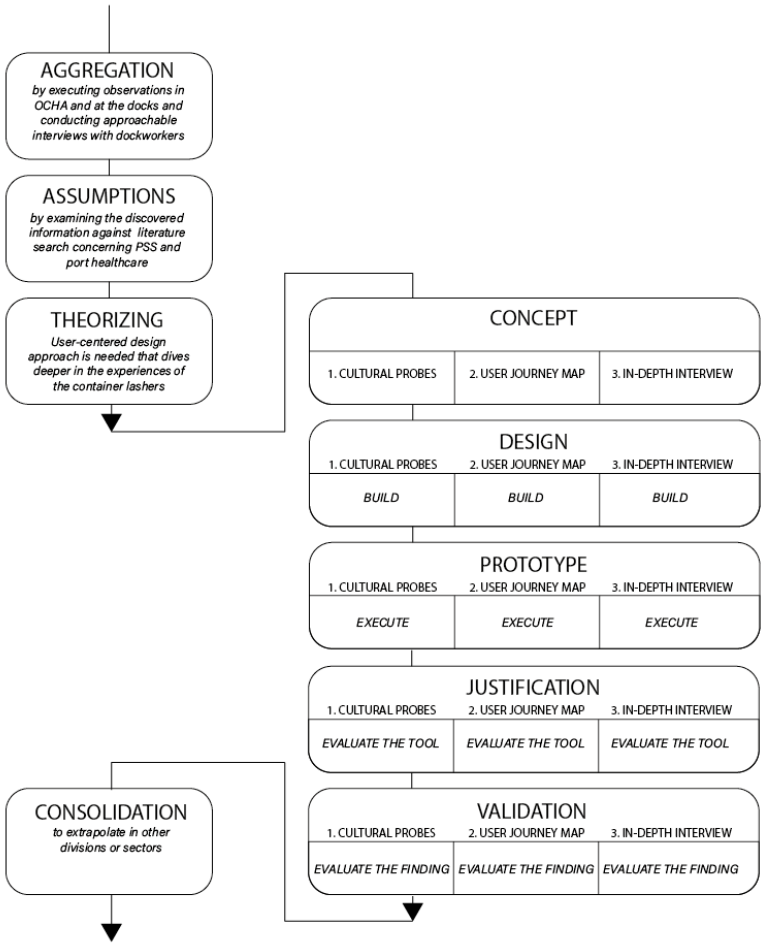

Figure 1. Research framework of DIR as seen in the PhD thesis of Ivo Dewit (Dewit, 2019) interpreted by the study.

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The building phase of the three design tools links to the design stage in the DIR, as figure 1 depicts. The executing phase is associated with the prototype stage of the DIR. The evaluation and last phase of the design tool connects to the justification or validation stage in the DIR. In the next two stages the design tool prototypes will be evaluated from two perspectives: justification of the theory and validation of the theory. Examining the design tools' scientific eligibility can prove the justification of the tool. The justified design tool is validated within the relevant population of container lashers or container terminal management. This validation of the design tool results in useful insight leading to the consolidation of the design research to extrapolate in other divisions or sectors.

2.2. Cultural Probe

To counter the limitations that come with the Covid pandemic (Atalan, 2020), the use of a cultural probe is opted (Bill Gaver, 1999). The use and construction of a cultural probe is quite versatile (Thoring et al., 2013). Therefore, the cultural probe handed out to container lashers consists of a physical diary and the ability to send visual, written and spoken messages regarding the topic in the dairy. Insights gathered by the cultural probe are used to build a user journey map (Bradley et al., 2021) explaining the work life of container lashers with its advantages and thresholds. By presenting the participants with an alternative medium of communication, the app WhatsApp, the study tries to filter strong emotions from the rationale to receive contextual information. Communication with and by the participants is performed in their mother tongue, Dutch. A call for participants is distributed between the two participating shipping companies: DPworld (DPworld, 2021) and MPET (MPET, 2021).

The diary consists of five chapters, representing a week in the work life of the participant. Participants will record their daily life for five weeks in a row. As previously mentioned, the diary is designed using the three phases of: (1) build, (2) execute and (3) evaluate. (1) In the building phase, themes for the five chapters are constructed using the Six Thinking Hats Model for Critical Thinking and Problem Solving by Edward De Bono (De Bono, 1992). The diary applies the thinking hats as a theme per chapter. (2) Subsequently, in the executing phase, the chapters are arranged further down in the diary, the questions become more emotional, personal, and challenging. The subsequent pages slim down to not discourage the participants in recording their experiences. When completed, the dairy will show an overlap of all the timetables for every chapter, seen in figure 2. (3) As an evaluation phase, the diary concludes with a short questionnaire regarding the process of filling it in. Three questions are asked in this section: "What did I find comprehensive and what was not comprehensive?", "Which chapters were difficult to answer?" and "What was the average duration of daily filling in the diary?

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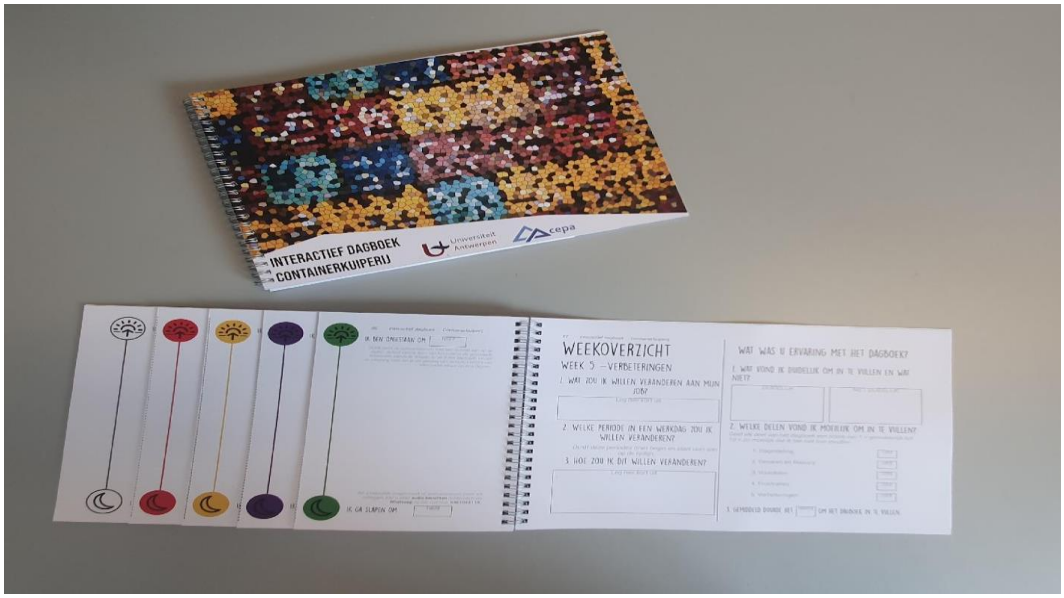

Figure 2. Photograph of diary displaying the summary timetables.

The first chapter represents the white hat of objectivity and fact-finding and asks the general question of "What does my workday look like?". Participants are asked to record the structure of their workday, their tasks that day, when they took a break and a timetable representing their whole day from waking up to going back to sleep. The second chapter manages experiences recorded in dangerous and high-risk situations. Here is where the structure of the diary differs with the Six Thinking Hat Model (De Bono, 1992). The chapter represents the black hat of caution, pessimism and somberness but is pictured in a reddish theme as it also can be merged with the red hat that represents feelings, hunches and intuitions. Two general questions are asked. "What is a dangerous situation for me?". In figure 3, participants are asked to map onto a mannequin where they perceive pain and write next to the area on the body a number that corresponds with the numeric rating scale of pain (NRS) (Karcioglu et al., 2018). CR10 Borg score (Shariat et al., 2018) is used to understand the severity of the hazardous situations mapped out on the timetable.

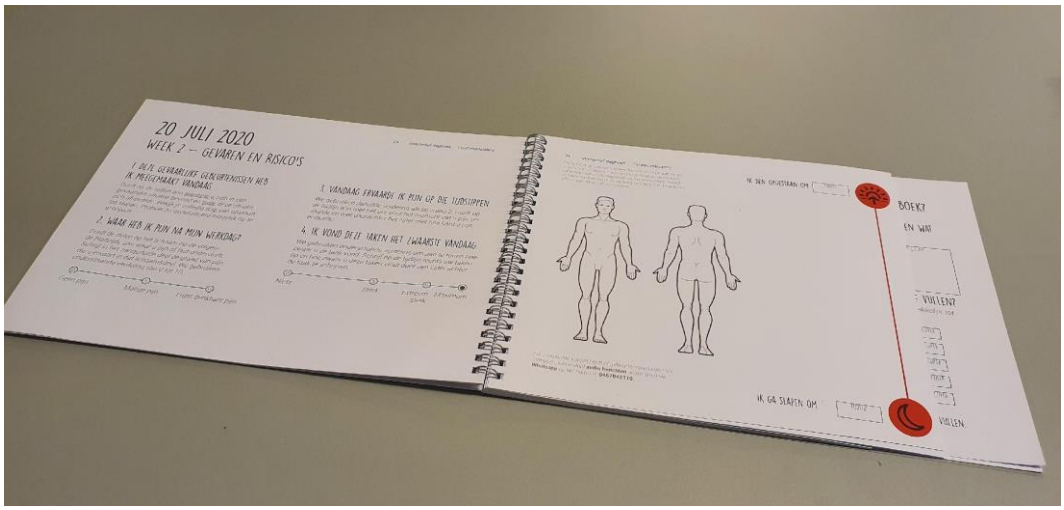

Figure 3. Photograph of diary displaying the diary's second chapter: Danger and Risks.

The following chapter depicts an overview of the benefits and perks of the profession and therefore can be linked with the yellow hat of hope and optimism from De Bono's model (De Bono, 1992). This third chapter of the diary searches for answers for four questions: 1) "When did I feel happy today?", 2)"How did I feel myself today?", 3)"What do I like about my job?" and 4)"What do I find important about my job?". The Differential Emotions Scale DES (Izard, 1977)

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is used to understand the emotional state of the participants. Following the benefits of container lashing, the next chapter is dedicated to finding possible frustrations present in the workplace. An overlap between the red and yellow hat is made in this chapter. Hence this chapter will focus merely on the more negative aspects as dislikes and frustrations and is therefore depictured in purple. Three questions are examined in this chapter: 1)"When do I feel frustrated?", 2) "Which tasks makes me frustrated?" and 3) "What do I perceive as negative about my job?". The final chapter provokes participants to think about improvements to make their work life better. This chapter is inspired by the green hat of creativity and inventiveness from the Six Thinking Hat Model (De Bono, 1992).

2.3. Visualization of the diary

Insights from the diaries are synthesized into one user journey map (Bradley et al., 2021), explaining the work life of the container lasher by depicting it in a single workday. The same three phases are applied here: (1) Construct, (2) Execute, and (3) Evaluate(1) In order to build the user journey map, the written information is digitized in Microsoft Excel to make it easier to assess the diversity of answers and channel them into one user journey. (2) In the executing phase, the user journey map is presented to the population. This presented customized circular user journey map emphasizes the repetitive nature of container lashing and the potential impact on their general health. (3) To evaluate the tool, the user journey map is verified by the participating container lashers. To visualize the benefits and frustrations of the profession, word clouds are composed. The word clouds are built by placing the most repeated word in the middle of the word cloud. In the executing phase, the word clouds are presented to the population. Word clouds are written in Dutch, as the tool is directly verified with the participating container lashers. This action is performed in the evaluation phase.

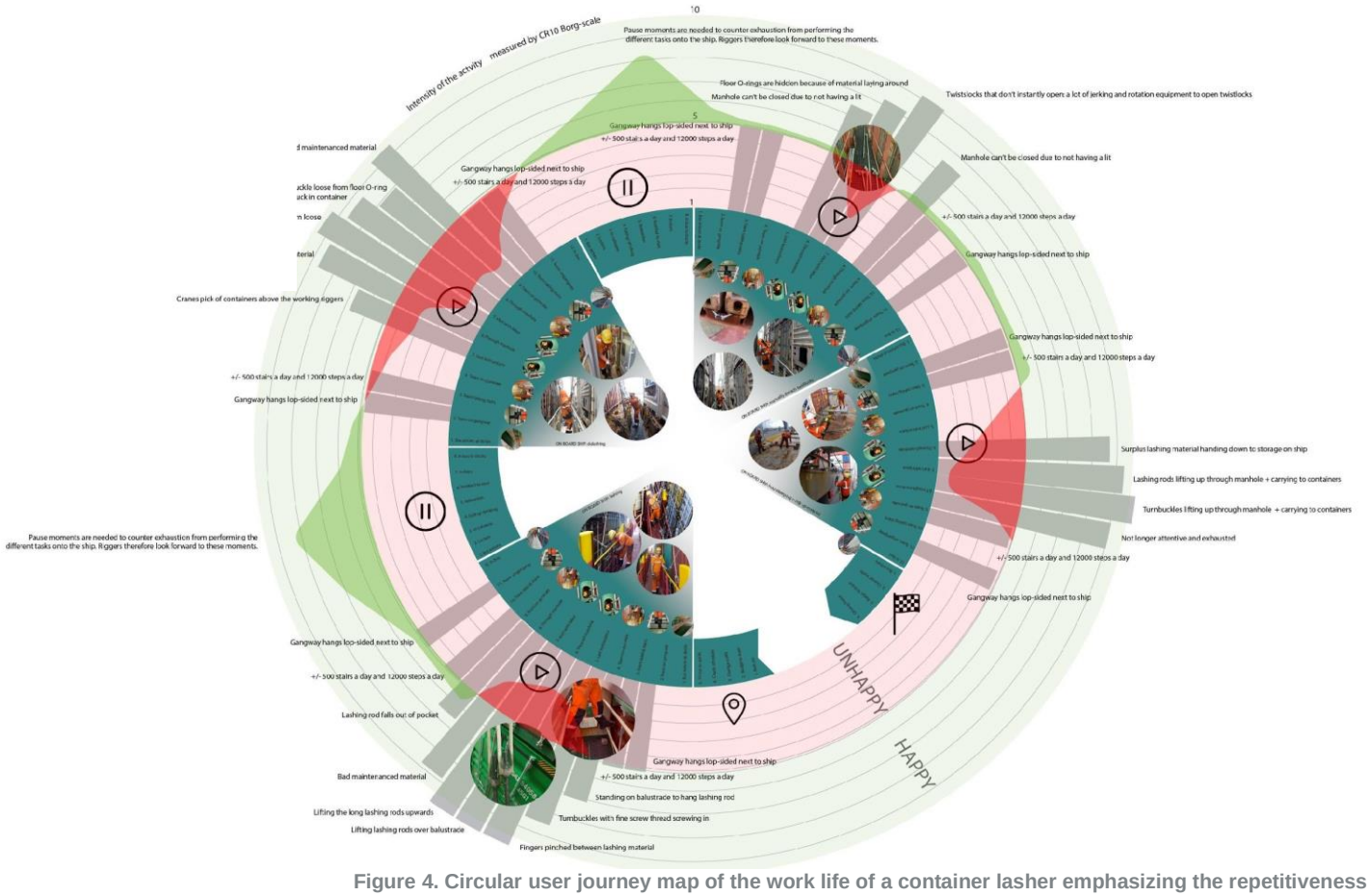

Figure 4. Circular user journey map of the work life of a container lasher emphasizing the repetitiveness experienced.

2.4. In-depth interviews

To understand the profession of container lashing with its benefits and limits, a verification of the constructed user journey map is required. The previously mentioned three phases are applied here: (1) Build, (2) Execute and (3) Evaluate. (1) Preparations and organization of the interview is allocated under the building phase. A week prior to the interview, the participant receives an online package containing infographics explaining the in-depth interview. The interviews take place in an online setting where the interviewer and participant talk using Microsoft Teams. The received infographics are parallel elaborated using the online tool Miro (Miro, 2021). (2) In the executing phase, the goal of the interviews is to correct all misinterpreted data from the user journey map and word clouds. Every task presented in the user journey map is reviewed together with the participant. Remarks noticed by the participant are noted. (3) Evaluation of the tool is done afterward by the interviewer. The interview analysis is divided into different steps:

- Record the interview.
- Combine insights with those from the diaries.
- List concrete and potential problems.
- Pinpoint toward efficient / implementable changes mentioned by the participant.

3. FINDINGS AND DISCUSSION

3.1. Deep dive into the container lashers work routine

The erratic nature of container vessel traffic in Antwerp's port makes it difficult to create a generic work schedule that can be implemented in every work shift. Shipping companies must organize themselves on the fly when and where a ship can unload its cargo. Therefore, the work schedule of container lashing teams is variable depending on the traffic in the port at that particular moment. Overlapping the three work shifts, four general tasks in container lashing arise: 1) Container lashing, 2) Container delashing, 3) Twist lock opening, and 4) Lashing equipment housekeeping. Associated with the container vessels entering the port and the unloading and loading of cargo onto these ships, the tasks performed by container lashing teams can differ every day. In general, every container lasher begins the workday by entering the main building with a personal security keycard. Container lashers clothe themselves in the appropriate work clothing (Cepa, 2019a). Afterward, the whole team assembles before the team leader, also known as the foreman. The assignment is explained to the team. A vehicle transports the container lashing team to the designated container vessel. Container lashers climb aboard the latter, or gangway, and move to the assigned sector on the ship. They perform their tasks while the foreman supervises the team. A duo of container lashers ascends, using the appropriate manholes, the lashing platforms between the stacked containers. When the tasks are handled, everybody assembles on the ship and leaves the ship in one group. The same vehicle brings them back to the main building where they wait for their next task. As container lashing is reliant on the unpredictable container vessel traffic in the port, it is difficult to map out the amount of pause or rest that container lashers receive. An estimate of the mean duration of a resting moment can be calculated from the participant data. The mean resting time (standard deviation [SD]) a container lasher receives between tasks is 75 minutes (41). The resting time ranges from 15 minutes to 180 minutes.

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3.2. Psychological hazards & work-related stress in container lashing

Due to the variety of container vessel designs and the recent increase in maritime vehicles (Eyres & Bruce, 2012a, 2012b), a container lasher's work environment can change heavily according to the container vessel. This has several implications for the well-being of the container lasher. Every situation occurs while working on an assignment on a ship. Two categories can be established from the participants' data: 1) hazardous situations resulting from performing the four main tasks: "lifting of lashing rods over the railing onto the platform"; "turnbuckles that cannot be manually opened by one container lasher" and "the bad condition of lashing equipment" and 2) hazardous situations resulted from a bad maintained work environment: "the gangway is suspended lopsided"; "container cranes that sweep overhead the container lashers"; "the poor conditions of lashing platforms and broken manholes". The depicted pain can also be divided in two divisions: chronic pain (longer than six months) and acute pain (less than six months) (Allegri et al., 2012). Participants perceive chronic pain only in the upper extremity of their body: neck, shoulders, trapezoid muscle, scapula, upper back, lower back, elbow, biceps, triceps, forearm and wrist. Acute pain is experienced in the upper and lower extremities: head, elbow, hand, fingers, knee, shinbone, and foot. Participants expressed the seriousness of their perceived pain by rating it using the NRS (Karcioglu et al., 2018), as shown in figure 5. One negative aspect: ill-maintained equipment is written down by ten participants. The second most noted negative aspect is the fact that container lashers work in every weather condition (repeated four times). "Experience of pain while working" and "housekeeping" are repeated three times. Poor communication with dock workers, poor communication with management and poor communication with other work shifts are all repeated twice. Also, the negative aspects: "putting yourself in danger to place a lashing rod" and "start and stop times are not respected" are written down twice. "Housekeeping" is recorded by seven participants as a frustration. The second highest repeated frustration is "communication with stowage and crane operators", which is repeated four times. Another aspect of container lashing that can lead to frustrations for three participants is "the scheduling of lashing teams". Frustrations repeated by two participants are: "working over the ergonomic reference," "finishing work from the previous shift before beginning my own work," and "container lashers who arrive too late at work."

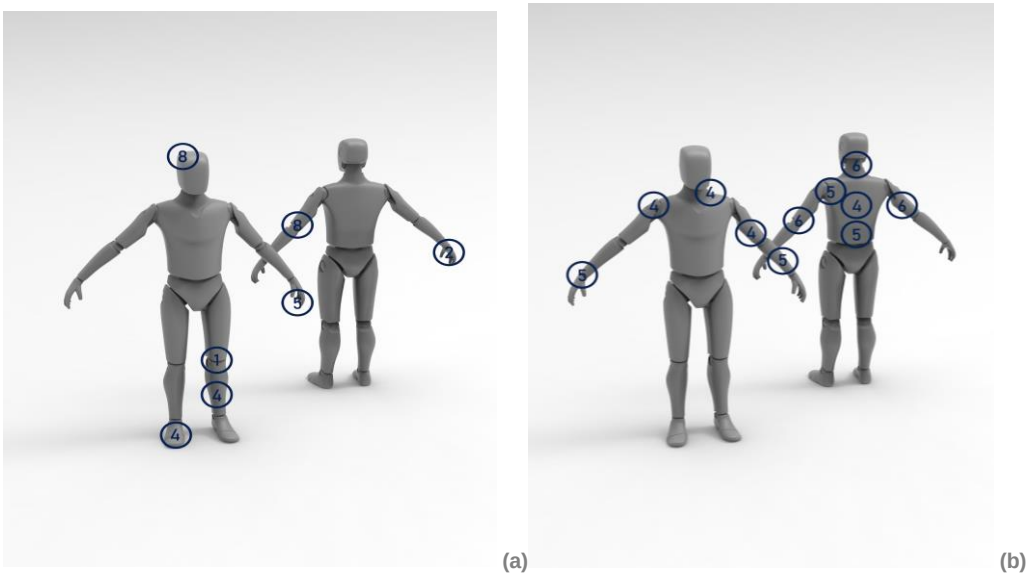

Figure 5. Chronic (a) and acute (b) pain illustrated onto 3D mannequins. Large circles represent the mean NRS.

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3.3. Proud ownership of the “container lasher” title

From the twelve categorized emotions described by the DES (Izard, 1977), participants experience six of them: interested, happy, surprised, angry, disgust and fear. From the fifteen diaries, happy was filled in 34 times followed by thirteen hits for interested, twelve hits for angry, nine hits for surprised, four hits for disgust and one hit for fear. Every participant formulated multiple emotions for minimal one day in the week. The most repeated positive aspect is collegiality, which was written down by nine participants. Other positive aspects that were written down by more than one participant were: the chance to stop earlier (repeated five times), relative freedom at the job (three times), exercise (two times), well-paying job (two times) and responsibility on the job (two times). Perfection in performing the job is seen as the most important aspect (written down by six participants) followed by communication and safety (both five times), collegiality (three times) and allocation of tasks, responsibility and supervision of beginning container lashers (two times). Participants describe 28 different improvements for container lashing. Improvements written down more than ones are listed in this paragraph: “more personnel on the job” (five times), “the regulation of fixed lashing count per person per day” (four times), “improving communication and medical support” and “the support for stowage and crane operators” (three times) and “more regularly check-ups for lashing equipment”, “rearranging work schedule so container lashing can start 1 hour earlier than crane operators”, “nominate container lashing as heavy load labor” and “more thorough examination of insights of container lashers with 15 years of experience or more” were repeated twice.

3.4. Container lashing experiences seen from a different perspective

The user journey map is comprised by the researcher with data from the diaries. It is divided into the four general tasks performed by container lashers: 1) Lashing containers, 2) Delashing containers, 3) Pulling twist locks open and 4) Housekeeping of lashing equipment. The user journey map differentiates between rest breaks (pause pictogram) and working (play pictogram). The internal dark blue ribbon is divided per tasks into different checkpoints. Every checkpoint is explained with an illustration. The larger illustrations in the middle, made by the research team or are acquired from participants, explain the specific task.

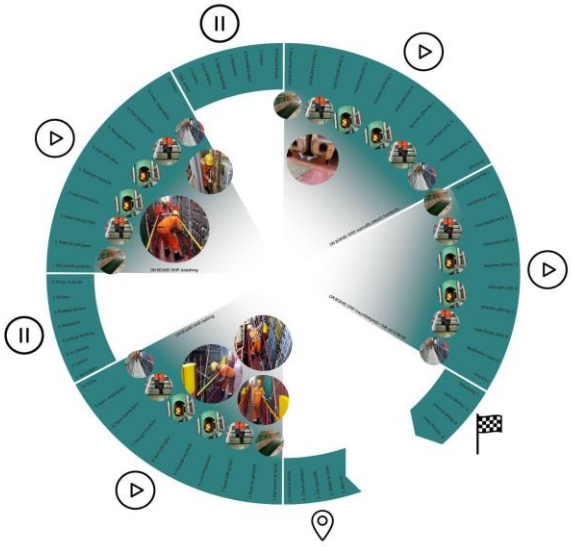

Figure 6. Segment of Lashing enlarged on the user journey map to illustrate the different checkpoint in one task.

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When moving outward on the customer journey, linked to a checkpoint, grey rectangles rise from the dark blue ribbon. These rectangles represent different hazardous situations that were written down by participants, earlier explained in 2.2. The higher the rectangle extrudes from the middle, the higher its CR10 Borg score is (Shariat et al., 2018). Throughout the user journey map, five situations are labeled with the score of ten: “lifting of lashing rods over the railing onto the platform” and “lifting long lashing rods upwards” categorized under the task of lashing; “turnbuckles that cannot be manually opened by one container lasher” categorized by the task of delashing and “pinching fingers between lashing equipment” and “lifting lashing equipment through manhole” categorized under the task of housekeeping.

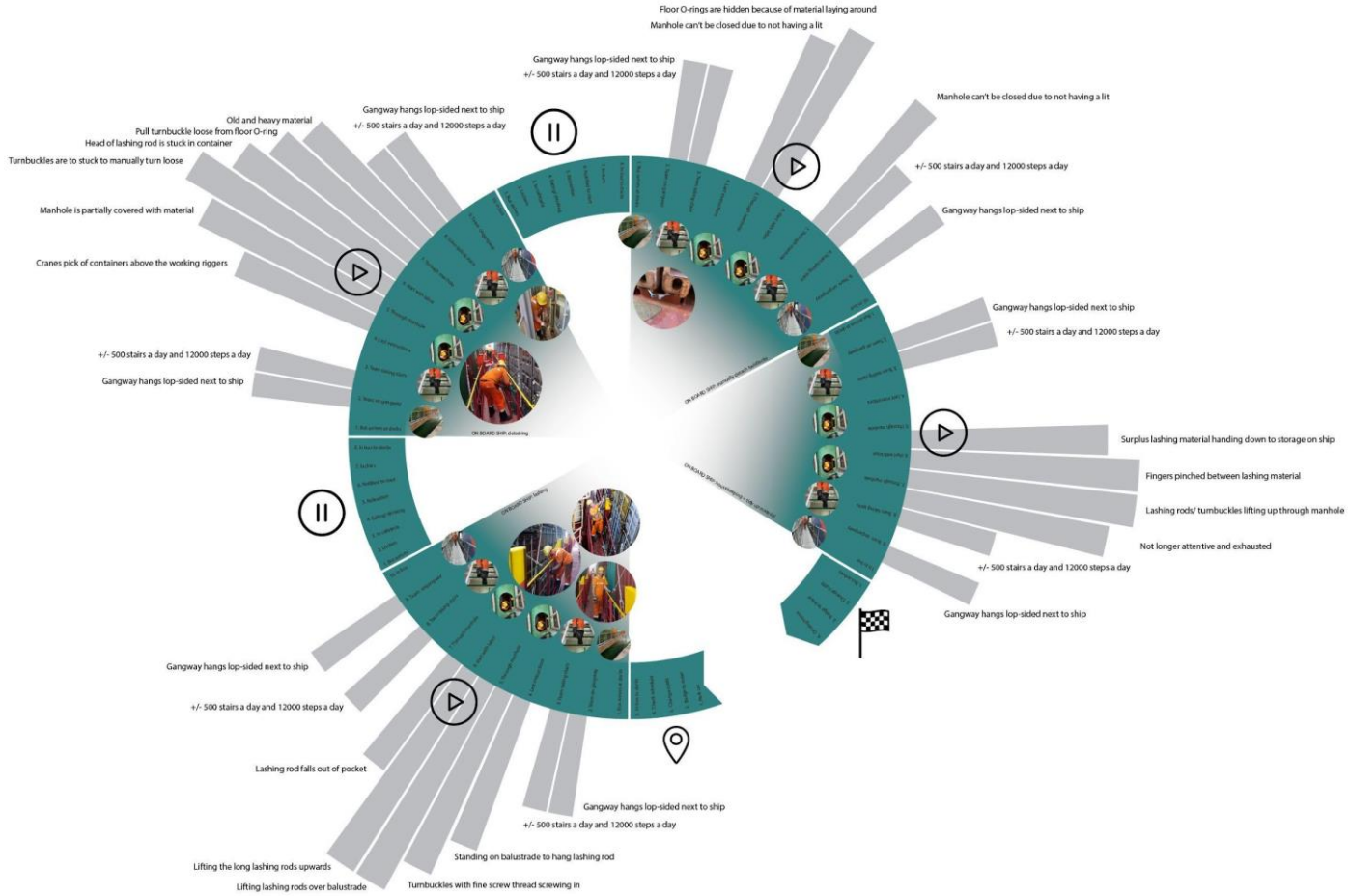

Figure 7. Segment of Delashing enlarged on the user journey map to illustrate the hazardous situations according to the checkpoints.

From the information about positive and negative aspects of container lashing a prediction was made about the emotional state of a container lasher during the workday. This prediction is projected on top of the user journey map as upper layer. The layer is divided into two ribbons: green for happy and red for unhappy. From statements in the diaries the curve predicts peaks or happy moments in between work tasks and during opening twist locks. Valleys or unhappy moments are predicted to occur during the work tasks, more specifically during the high rated hazardous situations.

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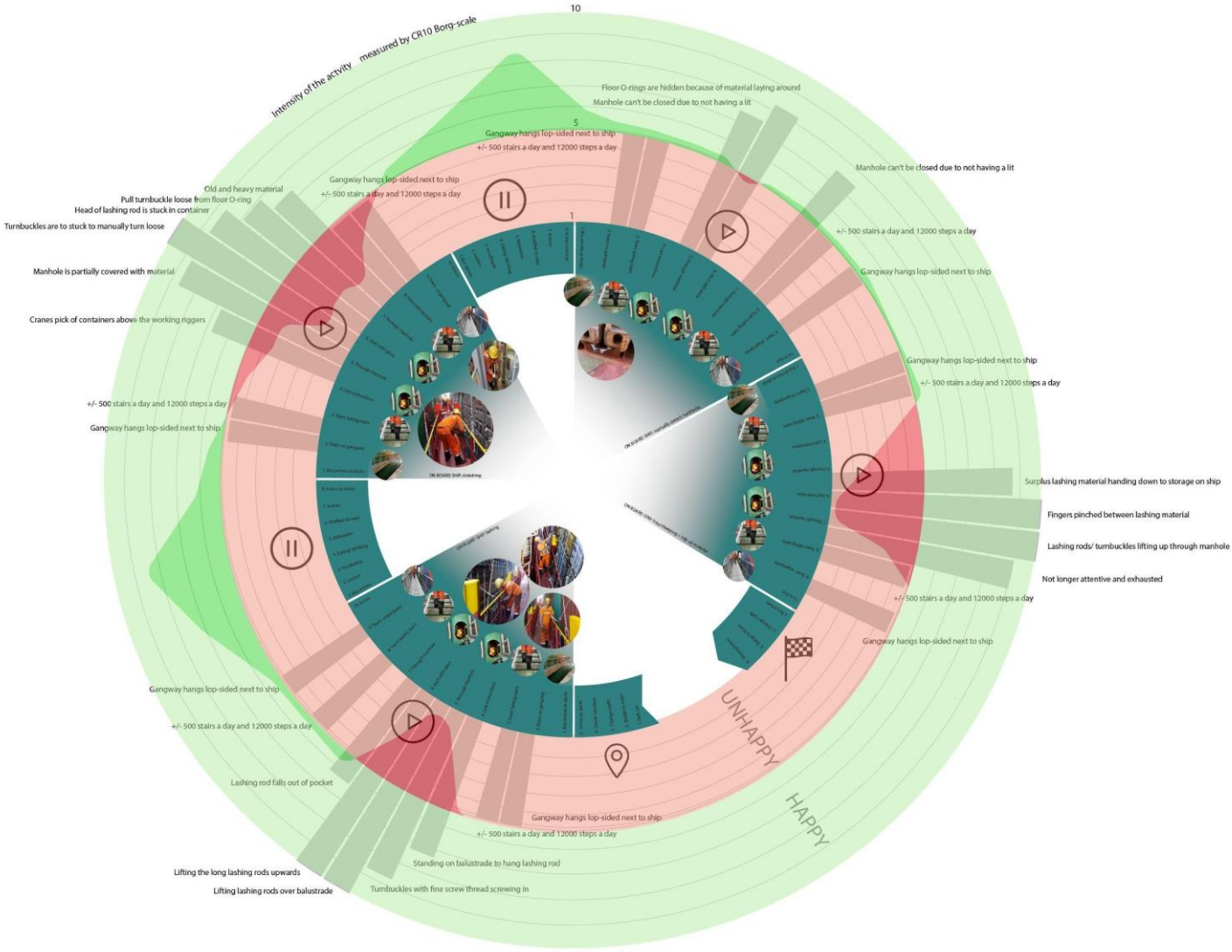

Figure 8. Segment of Lashing enlarged on the user journey map to illustrate the mental prediction curve drawn on top.

In the in-depth interviews, both foremen and container lasher agreed with the general structure of the user journey map. The container lasher verified all the activities, suggesting for certain hazardous activities to be readjusted on the CR10 Borg scale (Shariat et al., 2018). One foreman pointed out that there are more checkpoints in between the tasks. These checkpoints needs to be included, as hazardous situations can also happen in these parts of the container vessel. Both foremen as container lasher explained that the most happy moments during a workday are associated with the break in between work. They emphasize that these moments are to counter exhaustion from working on the ship. One of the foremen thoroughly evaluated every word cloud to make sure the statements were relevant for the further steps in the project. The participant suggested to remove statements contradicting each other or are out of the scope of the project. The most statements were erased in the word cloud presenting the solutions generated by the participating container lashers.

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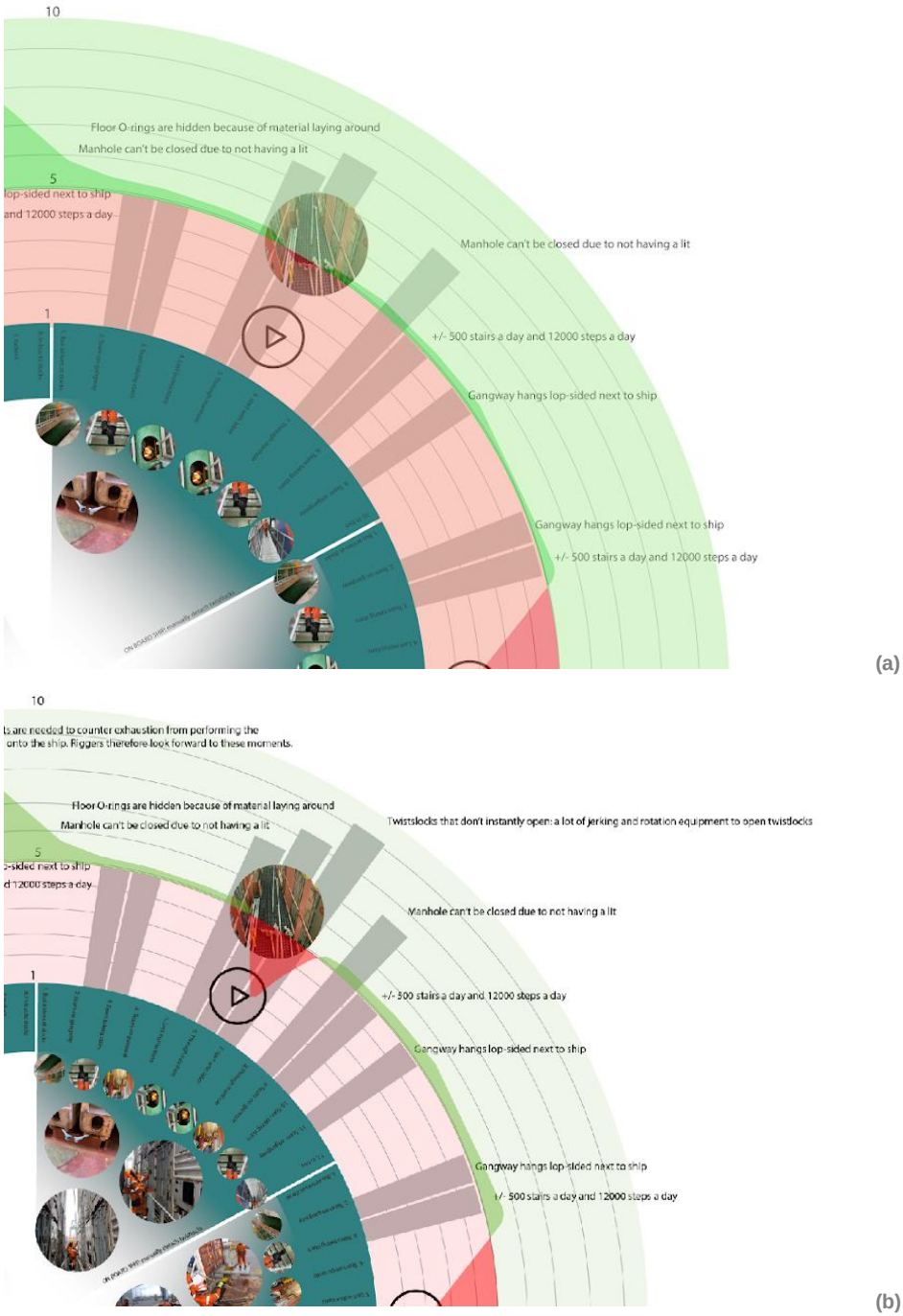

Figure 9. Comparison with initial user journey map (a) and the revised user journey map (b), illustrating differences in possible hazardous situations occurring in the task: Pulling Twist Locks.

4. DESIGN INCLUSIVE RESEARCH IN THE PORT OF ANTWERP

To further specify the thought process behind the justification and validation stages in DIR, the study differentiates between internal and external justification and validation (Mizrahi & Buckwalter, 2014). The theory in this study is considered internally justified by the competence of the researcher of the study having the ability to conduct scientific research within Design Thinking and having a profound understanding of contemporary design methodologies. External justification of the theory can be obtained by constant practicing a holistic approach, therefore having the ability to extrapolate to similar professions and by the external recognition from companies within the port of Antwerp. The study performs method validity, to vindicate internal validity. It searches for understanding of design thinking and design methodologies to adopt the correct design tools for container lashers in port

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environments. The use of Cultural Probes (Bill Gaver, 1999) provides the ability to gain more intimate information about the cultural and emotional aspects of container lashing, being conform with the User Centered Design approach stated by the assumptions. To externally validate the practiced theory, the design tools are extensively evaluated by peer experts in Design Thinking and participants representing container lashing. Feedback given by peer experts provides the optimal information to find errors in lay-out and application of the tool and correct them. Feedback from participants emphasized on adjusting certain nuances extracted from the diaries by evaluating the user journey map and grading their experience with recording their work life in the diaries.

The Cultural Probe aims to collect unbiased information about the cultural aspects of container lashing and therefore focusses on gaining more intimate information (Stickdorn et al., 2018). It is crucial to lower the threshold to complete the diary as truthful and detailed. The study therefore focusses on transparent explanations of methodology, reduction of page size per chapter and providing feedback sections for every participant. Participants question the relevance of elaborating in the diary about the benefits, frustrations and improvements in container lashing, suggesting to address these themes in interviews to fully express the severity of the matter. In the later conducted in-depth interviews participants change little to the user journey map composed using the Cultural Probes. Also the previously mentioned chapters are not further elaborated in the in-depth interviews.

The framework of DIR illustrates nine stages to conduct structured research (Horváth, 2008). The framework is composed in a linear setup. To succeed to another stage, the previous stage needs to be substantiated. The presented study is built with the DIR framework in mind. A design process can be a hazy and muddled process to better understand the reality wherein the user lives. This study is no exception on the rule and experiences setbacks. Therefore the stages of the framework of DIR are not deliberately executed in the linear sequence as suggested by its authors (Dewit, 2019). The study experiences loops in stages. Due to the complex nature of the port environment, sometimes these loops skipped over stages. Some stages are not intentionally handled. In these stages decisions are made by intuition. Reflection on the framework shows that every stage is actively covered in the study by finding causality in decisions made within the study referring to earlier stages. The last stage in the DIR framework, consolidation, is not actively covered in the study. This stage in therefore not in detail reported in this paper.

5. LIMITATIONS OF THE STUDY

The use of the DIR framework in a ports environment is novel. The introduction to the presented design tools was not proceeding as expected. The study struggled with transparent communication to all the different stakeholders to explain the use and necessity of the design tools. Due to the pandemic outbreak of 2020, physical observations and in-depth interviews were not allowed. A remote solution was found sending and receiving diaries to the participants and having in-depth interviews in a digital format. The use of these design tools can limit the nuance in statements. This led to more measures in order to evaluate the received data. Adjacent, the quality of written information in the diaries was not consistent. Some participants explained their work in great detail, whereas others wrote the bare minimum or even did not fill in the question. This resulted in ten complete diaries, five that were filled in

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between 60% and 80% and five participants who did not fill in the diary or did not send the diary back.

6. CONCLUSION

This paper presents the execution of DIR in a port environment. The research framework provides a structured approach that can guarantee critical and holistic insights about container lashers. The use of Cultural Probes results in broader understanding in the culture of a container lasher. Compared to preliminary insights, the diaries provided a thorough categorization of tasks within the profession and emphasized an improvement of communication in the port. Transparent and regular communication with container lashers and their superiors is necessary to moderate the research process and the additional design process. In both occasions a mediator is needed to provide the healthy environment for a proactive discussion and to guard the necessary holistic design approach. Complex and layered problems are reviewed with reticent, therefore preliminary workshops need to clarify the necessity of design tools to participants. Future research should address communication between different layers of employees in the port environment and strengthen the ownership of the project within a port environment to implement injury preventive measures within the profession of container lashing.

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REFERENCES

Allegri, M., Clark, M., De Andrés, J., & Jensen, T. (2012). Acute and chronic pain: where we are and where we have to go. *Minerva Anestesiologica*, 78(2), 222–235.

Atalan, A. (2020). Is the lockdown important to prevent the COVID-19 pandemic? Effects on psychology, environment and economy-perspective. *Annals of Medicine and Surgery*, 56, 38–42. https://doi.org/10.1016/j.amsu.2020.06.010.

Baines, T., Ziaee Bigdeli, A., Bustinza, O. F., Shi, V. G., Baldwin, J., & Ridgway, K. (2017). Servitization: revisiting the state-of-the-art and research priorities. *International Journal of Operations & Production Management*, 37(2), 256–278. https://doi.org/10.1108/IJOPM-06-2015-0312.

Bate, P., & Robert, G. (2006). Experience-based design: from redesigning the system around the patient to co-designing services with the patient. *BMJ Quality & Safety*, 15(5), 307–310. http://doi.org/10.1136/qshc.2005.016527.

Bill Gaver, T. D. and D. P. (1999). Cultural Probes. Interactions, 6(1), 21–29.

Bowen, S., Dearden, A., Wright, P., Wolstenholme, D., & Cobb, M. (2010). Participatory healthcare service design and innovation. Proceedings of the 11th Biennial Participatory Design Conference, 155–158. New York, USA: *ACM Press*. https://doi.org/10.1145/1900441.1900464.

Bradley, C., Oliveira, L., Birrell, S., & Cain, R. (2021). A new perspective on personas and customer journey maps: Proposing systemic UX. *International Journal of Human-Computer Studies*, 148, 102583. https://doi.org/10.1016/j.ijhcs.2021.102583.

Cepa. (2019a). Cepa cvba. Retrieved December 17, 2019 from https://www.cepa.be/.

Cepa. (2019b). OCHA. Retrieved December 17, 2019 from https://www.ocha.be/.

Cepa. (2023c). Cepa cvba. Retrieved February 15, 2023 from https://www.cepa.be/werkgevers/over-cepa/organisatie/.

De Bono, E. (1992). Six thinking hats for schools. UK: *Hawker Brownlow Education*.

Zelck, S.; Dewit, I.; Scataglini, S.; Denteneer, L.; Verwulgen, S. (2023). Product-service-system design thinking for port healthcare: a case study with container lashers in the port of Antwerp. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 182-197.
DOI: 10.4013/sdrj.2022.152.08.

De Carvalho, M. P., Schmidt, L. G., & Soares, M. C. F. (2016). Musculoskeletal disorders and their influence on the quality of life of the dockworker: A cross-sectional study. *Work*, 53(4), 805–812. https://doi.org/10.3233/WOR-162249.

Dewit, I. (2019). Product-service system design a synthesis approach. *University of Antwerp*, Antwerp, Belgium.

Dewit, I., Van Ael, K., De Roeck, D., Baelus, C., De Rijck, R., & Coreynen, W. (2018). PSS Design and Strategic Rollout: tools for product-service systems. BE: *Academic and Scientific Publishers*.

DPworld. (2021). DPworld - Home. Retrieved May 6, 2021 from https://www.dpworld.com/nl/antwerp.

Esser, A., Sys, C., Vanelslander, T., & Verhetsel, A. (2020). The labour market for the port of the future. A case study for the port of Antwerp. *Case Studies on Transport Policy*, 8(2), 349–360. https://doi.org/10.1016/j.cstp.2019.10.007.

Eyres, D. J., & Bruce, G. J. (2012a). Development of ship types. In Eyres, D. J., & Bruce, G. J., Ship Construction, (pp.17–33). Oxford, UK: *Butterworth-Heinemann*.

Eyres, D. J., & Bruce, G. J. (2012b). Ship dimensions, form, size, or category. In Eyres, D. J., & Bruce, G. J., Ship Construction, (pp.11–16). Oxford, UK: *Butterworth-Heinemann*.

Grewatsch, S., Kennedy, S., & Bansal, P. (Tima). (2021). Tackling wicked problems in strategic management with systems thinking. *Strategic Organization*. https://doi.org/10.1177/14761270211038635.

Hinkka, V., Eckhardt, J., Permala, A., & Mantsinen, H. (2016). Changing Training Needs of Port Workers Due to Future Trends. *Transportation Research Procedia*, 14, 4085–4094. https://doi.org/10.1016/j.trpro.2016.05.506.

Horváth, I. (2008). Differences between 'research in design context' and 'design inclusive research' in the domain of industrial design engineering. *Journal of Design Research*, 7(1), 61–83. https://doi.org/10.1504/JDR.2008.018777.

Horvath, I., & Du Bois, E. (2013). Structuring the process of design research -a necessary step towards ensuring scientific rigor. *Proceedings of the International Conference on Engineering Design*, ICED, 53–62.

Izard, C. E. (1977). Differential Emotions Theory. In Izard, C. E., Human Emotions (pp.43–66). Boston, USA: *Springer*.

Karcioglu, O., Topacoglu, H., Dikme, O., & Dikme, O. (2018). A systematic review of the pain scales in adults: Which to use? *The American Journal of Emergency Medicine*, 36(4), 707–714. https://doi.org/10.1016/j.ajem.2018.01.008.

Kauffman, D. (1980). Systems One: An introduction to Systems Thinking. USA: *THL* Associates.

Lima, E., Almeida, J., Alves, A., Pinto, M., & Santos, F. (2018). 362 Dockworkers musculoskeletal injury prevention program on a brazilian terminal. *Musculoskeletal Disorders*, 75(2), 269. http://dx.doi.org/10.1136/oemed-2018-ICOHabstracts.770.

Miro. (2021). Miro - An Online Whiteboard & Visual Collaboration Platform for Teamwork. Retrieved September 13, 2021 from https://miro.com/.

Mizrahi, M., & Buckwalter, W. (2014). The Role of Justification in the Ordinary Concept of Scientific Progress. *Journal for General Philosophy of Science* 2014 45:1, 45(1), 151–166. https://doi.org/10.1007/s10838-014-9243-y.

MPET. (2021). MPET | Home. Retrieved May 6, 2021 from https://www.mpet.be/.

Porter, M. E., & Lee, T. H. (October, 13). The Strategy That Will Fix Health Care. *Harvard Business Review.* Retrieved March 13, 2021 from https://hbr.org/2013/10/the-strategy-that-will-fix-health-care.

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4(2), 155–169. https://doi.org/10.1007/BF01405730.

Rosskam, E. (2018). Using Participatory Action Research Methodology to Improve Worker Health. In Schnall, P. L. Dobson, M. Rosskam, E. Gordon, D R. Landsbergis, P. A. & Baker, D., Unhealthy Work, (pp.211–228). New York, USA: *Routlegde*.

Salvo, M. J. (2001). Ethics of Engagement: User-Centered Design and Rhetorical Methodology. *Technical Communication Quarterly*, 10(3), 273–290. https://doi.org/10.1207/s15427625tcq1003_3.

Saraji, J. N., Hassanzadeh, M. A., Pourmahabadian, M., & Shahtaheri, S. J. (2004). Evaluation of musculoskeletal disorders risk factors among the crew of the iranian ports and shipping organization's vessels. *Acta Medica Iranica*, 42(5), 350–354.

Sedilla, K., & Matias, A. (2018). Prevalence, severity, and risk factors of work-related musculoskeletal disorders among stevedores in a Philippine break-bulk port terminal. *Advances in Intelligent Systems and Computing*, 601, 90–100. https://doi.org/10.1007/978-3-319-60486-2_9.

Zelck, S.; Dewit, I.; Scataglini, S.; Denteneer, L.; Verwulgen, S. (2023). Product-service-system design thinking for port healthcare: a case study with container lashers in the port of Antwerp. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 182-197.
DOI: 10.4013/sdrj.2022.152.08.

Shariat, A., Cleland, J. A., Danaee, M., Alizadeh, R., Sangelaji, B., Kargarfard, M., Ansari, N. N., Sepehr, F. H., & Tamrin, S. B. M. (2018). Borg CR-10 scale as a new approach to monitoring office exercise training. *Work* (Reading, Mass.), 60(4), 549–554. https://doi.org/10.3233/WOR-182762.

Simon, H. A. (1996). The Sciences of the Artificial. UK: MIT Press.

Stickdorn, M., Hormess, M., Lawrence, A., & Schneider, J. (2018). This is Service Design Doing. CA: *O'Reilly Media Inc*.

Thoring, K., Luippold, C., & Mueller, R. M. (2013). Opening the Cultural Probes Box : A Critical Reflection and Analysis of the Cultural Probes Method. 5th *International Congress of International Association of Societies of Design Research*, 222–233.

Xing, K., Rapaccini, M., & Visintin, F. (2017). PSS in Healthcare: An Under-Explored Field. Procedia *CIRP*, 64, 241–246. https://doi.org/10.1016/j.procir.2017.03.068.

Yip, M. H., Phaal, R., & Probert, D. R. (2014). Stakeholder engagement in early stage product-service system development for healthcare informatics. *EMJ - Engineering Management Journal*, 26(3), 52–62. https://doi.org/10.1080/10429247.2014.11432020.

Yip, M. H., Phaal, R., & Probert, D. R. (2015). Characterising product-service systems in the healthcare industry. *Technology in Society*, 43, 129–143. https://doi.org/10.1016/j.techsoc.2015.05.014.

Zelck, S.; Dewit, I.; Scataglini, S.; Denteneer, L.; Verwulgen, S. (2023). Product-service-system design thinking for port healthcare: a case study with container lashers in the port of Antwerp. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 182-197.
DOI: 10.4013/sdrj.2022.152.08.