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Improving the value of a laboratory system dashboard through user-centred approach

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Abstract

In today's world where the information flow is ever increasing, efficient data visualization is essential. Laboratory Information Management Systems (LIMS) utilize dashboards as a primary tool to optimize information display and enhance user experience.

However, the efficiency of these dashboards is sometimes impeded by usability issues and restricted customization. This thesis assesses the usability of a laboratory dashboard module provided by Whitelake Software Point Oy (WSP) to analyse its usefulness for end-users and pinpoint areas for improvement in the product.

An iterative user-centred methodology was utilized, using semi-structured interviews and interactive demo sessions. Thematic analysis of the gathered data identified multiple themes, such as a steep learning curve and underutilization.

The thesis also found critical areas for enhancement, including improved customisation, interaction with external Business Intelligence (BI) tools, and the introduction of predictive analytics for workload management and resource planning.

The findings emphasize the need for WSP to enhance their overarching procedures, adopt user-centric customizations into the product, and include innovative features to optimize dashboard functionality. The suggested changes hope to resolve the usability limitations, therefore transforming the dashboard into a more intuitive, efficient, and valuable instrument for laboratory users.

Keywords Dashboard, Usability, User-centred design, Customer value, LIMS

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Sammandrag

I dagens värld, där informationsflödet ständigt ökar, är effektiv datavisualisering avgörande. Laboratory Information Management Systems (LIMS) använder dashboards som ett primärt verktyg för att optimera visualiseringen av information och förbättra användarupplevelsen.

Effektiviteten kan dock bli lidande hos dessa dashboards på grund av användbarhetsproblem samt begränsade anpassningsmöjligheter. Denna avhandling försöker utvärdera användbarheten hos en dashboard-modul som tillhandahålls av Whitelake Software Point Oy (WSP) för att analysera dess nytta för slutanvändare och identifiera områden för förbättring.

En användarcentrerad metodik tillämpades, bestående av semistrukturerade intervjuer och interaktiva demosessioner med användarna. Tematisk analys utförd på insamlade data identifierade flertalet problemområden, bland annat en hög inlärningskurva, svårigheter vid den initiala konfigurationen av modulen samt låg utnyttjandegrad.

Avhandlingen fann också flera viktiga förbättringsområden, inklusive utökade anpassningsmöjligheter av dashboard-modulen, integration med externa Business Intelligence (BI)-verktyg samt införandet av prediktiv analys för arbetsbelastningshantering och resursplanering.

Resultaten från avhandlingen understryker behovet av att WSP förbättrar sina övergripande processer, implementerar användarcentrerade förbättringar och inför innovativa funktioner för att optimera dashboardens funktionalitet. De föreslagna förändringarna syftar till att lösa användbarhetsbegränsningarna vilket förvandlar dashboarden till ett mer intuitivt, effektivt och värdefullt verktyg för laboratorieanvändare.

Nyckelord Dashboard, Användbarhet, Användarcentrerad design, Kundvärde, LIMS

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Preface and acknowledgements

This thesis has been in the making for quite some time. The personal journey I have taken throughout the time has included many highlights and also some lowlights. However, finishing this thesis has eased a big burden and granted me some solace in finally having it completed.

I want to thank the school for giving me the opportunity to complete the thesis and helping with the necessary bureaucracy. The personnel were extremely helpful and diligent to get my matters resolved.

I also want to give a big thank you to my professor Marko Nieminen who took valuable time out of a hectic schedule to see this process through in an effective and pragmatic way. We both had our doubts that this process could be completed in the time frame that I had decided but it somehow worked.

I also want to thank my partner for her support and invaluable energy to keep me motivated when the situation was stressing. Finally, I also want to thank my family who has helped me in numerous ways to complete this last step of my journey.

Otaniemi, 18 February 2025
Anders Elf

Abbreviations and acronyms

Abbreviations

BI	Business Intelligence
CAPA	Corrective and Preventive Action
DAS	Data Analysis System
Dashboard	A graphical report of various relevant data
EIS	Executive Information System
FAQ	Frequently Asked Questions
Gizmo	LIMS dashboard object
HCI	Human Centred Interface
KPI	Key Performance Indicator
LIMS	Laboratory Information Management System
RE	Requirement Engineering
SPC	Statistical Process Control
UI	User Interface
WSP	Whitelake Software Point Oy

1 Introduction

This introductory chapter presents the research context. A concise summary of the thesis background and the chosen theoretical framework is presented, including a definitive articulation of the thesis objectives and research questions. The chapter finishes with a delineation of the study's scope and limitations as well as the thesis format.

1.1 Background

The word "dashboard" was used in a completely different context historically before receiving its current definition (Janes, 2013, p. 2). In the 19th century, the phrase "dashboard" referred to a board positioned in front of a carriage to prevent mud from splattering into the vehicle due to the horse's hooves. The advancement of automobiles resulted in the progression of dashboards, which now provide essential information about the vehicle's performance instead. Visual indicators are employed to display system statuses and potential issues. In a comparable manner, dashboards within an organizational context visually present information crucial for decision-making processes in a clear and comprehensible style. (Janes, 2013, p. 2)

Contemporary dashboards are essential instruments of data visualization, especially in business intelligence, healthcare, and other data-centric fields. By consolidating key performance indicators (KPIs) and essential metrics in one interface, dashboards enhance decision-making, can facilitate real-time monitoring, and improve operational efficiency (Cotgreave, 2016, p. 2). A well-designed dashboard provides an intuitive display for even extraordinarily complex information, allowing users to quickly interpret trends, patterns, and outliers (Few, 2006, p. 4).

Despite their potential, many dashboards can, and will often, suffer from suboptimal design, prioritizing excessive data presentation over actionable insights (Few, 2006, p. 6). Poorly designed dashboards overwhelm users with unnecessary complexity, leading to inefficiencies in data interpretation and decision-making and even data validation. In order to develop effective dashboards, it is essential to follow best practices, including the selection of suitable visualizations, consistency in the design elements, and clarity of data through interactivity and filtering options (Elias & Bezerianos, 2012, p. 3).

A key component of dashboard usability is adherence to a user-centred design methodology. Studies have shown that dashboards designed with user experience (UX) principles in mind—such as interactive elements, intuitive navigation, and relevant data prioritization—lead to improved efficiency and

engagement (Yi, 2023, p. 7). In clinical settings, for example, dashboards have been successfully used to streamline healthcare workflows, reduce cognitive overload, and improve patient outcomes by presenting critical information in real time (Khairat et al., 2018, p. 2).

The progression of dashboards has been shaped by advancements in information visualization. Card, Mackinlay, and Shneiderman (1999) underscore the necessity of developing dashboards that leverage human cognitive capacities, employing visual components to facilitate swift understanding and informed decision-making (p. 14). Moreover, dashboards gain from the incorporation of design thinking methods, emphasizing iterative refinement based on user feedback (Brown et al., 2011, p. 5).

As organizations increasingly depend on data-driven insights, the effective use of dashboards becomes ever more important. An effectively designed dashboard can not only display data but also improve user engagement, streamline workflows, and facilitate strategic decision-making (Orts, 2004, p. 3).

This thesis is executed in partnership with Whitelake Software Point Oy (WSP), a firm that specializes in Laboratory Information Management Systems (LIMS). The dashboard module of WSP is a fundamental part of its default LIMS product, intended to facilitate laboratories in the effective visualization and analysis of data. Initial observations and customer comments indicate that the module is underutilized and fails to fully satisfy user expectations regarding usability and usefulness.

1.2 Purpose and the research questions

RQ1: How are users experiencing using the dashboard?
RQ2: What is the value of the dashboard for the users? Current and future?
RQ3: What is required to improve the dashboard to meet the identified user requirements?

The research questions will be developed based on the literature review and the interviews. Questions two and three will also be split into considerations of internal views and external views. The internal factors look into it from inside the company and the more technical aspects while the external views look more into the needs of the customers. The thesis will use a variety of methods and will be executed in a practical manner. The process will be iterative and therefore the scope and limitations of the thesis will be based on the findings during the thesis process. The theoretical content is mostly

based on the concepts of dashboards themselves and theories about user-centred design, usability, and customer value. As the research questions are directly associated with WSP's product, the results of the study will be quite specific to the company and do therefore not garner value directly for other organizations. However, the ideas are still generic and could be applied to any organization using dashboards and wanting to improve them, seeking to reveal usability issues and pinpoint other value-enhancing features. These insights will hopefully enhance WSP's offerings and may also give some value in best practices for laboratory dashboard design.

The study uses qualitative research methodologies to explore the subject matter extensively, providing a full grasp of the fundamental concepts, patterns, and perspectives. The researcher is employed within the company, consequently interviews were considered as the best approach for the thesis. This allows the researcher to develop the research questions further based on the findings during the research. The qualitative research methods also allow the researcher to gather in depth views from different sections of the company and from its customers that are from quite different fields and have vastly different processes.

1.3 Scope & Limitations

The scope of this thesis work is limited to a mostly qualitative approach and examination of the research problem. The point of the thesis is to find requirements to implement and improve the dashboards in the LabVantage product, which the company offers. Therefore, the scope is limited to only the dashboards in one company and one product. Additionally, the work is limited to how a customer or end-user can gain as much value as possible and that the usability and value increases for the dashboard.

Keynote is that the work required to implement customer value should be evaluated so that it is feasible. Therefore, no solutions will be implemented during this thesis and instead the results and ideas that are found during the study will be presented to the board of the company for further review. From this point onward the results will potentially be presented to the partner company that develops the base of the product used so that these ideas can be implemented into the product.

The researcher will also talk about the dashboard module to as the feature in the product. Technically the dashboards are not a separate module in the sense of the software but a functionality already available in the core product. However, to as the focus lies on the dashboard as one entity the term module was chosen.

1.4 Contents and Structure

This thesis is structured into five distinct sections, each designed to build upon the other in a logical progression. The first section functions as an introduction, offering a clear overview of the research background and also specifying the study's goals. This part establishes the value of the topic and specifies the main questions that the researcher intends to address. This approach contextualizes the study and offers an outline for the reader to comprehend the sections that follow.

The second section concentrates on the literature review and thoroughly examines the current body of information relevant to the study's subject. It diligently examines previous research and theoretical models, providing a basis for comparing them to the current study. This part introduces the product essential to the research, examining its key features, market significance, and its influence on the results of the study. The section also presents a brief summary of the company, including its primary business processes and relevant operational practices connected to the research. This part creates a solid foundation for the study's conclusions by integrating the essential theory as well as practice. This part will also contain sections in cursive that are the researchers own that aim to ground the research in the theme of the study and give reasons of why this is important for the study.

The third section presents the research methodology utilized in this thesis. It offers a comprehensive explanation of the research design, detailing the justification for employing a qualitative approach and the data gathering processes, including the semi-structured interviews. A comprehensive description of the planning, execution, and analysis of these interviews is included to ensure transparency and reliability and any considerations taken.

The fourth section presents the results of the semi-structured interviews and the interactive sessions. These findings have been thematically analysed and grouped in to chosen themes. The themes are explained and also supported by supporting examples from the interviewees. By adding direct quotes, the validity of the results is higher, and the examples given adds more insight to the findings.

The last part discusses the most important results and afterwards compare them with the insights gained from the literature review in the second section. By synthesizing theoretical and empirical data, this section provides a nuanced understanding of the research problem. Significant themes and patterns discovered during the investigation are emphasized, providing important insights into the topic. Furthermore, the findings are translated into practical recommendations tailored to the company. These

recommendations attempt to fulfil the objectives stated in the introduction and offer practical answers to the problems found throughout the study. This section also addresses the study's limitations, identifying areas requiring future investigation to improve the generalizability of the findings. It is important to note that the implementation of the recommendations falls outside the scope of this thesis. By providing a critical evaluation of the study's contributions and its constraints, this section ensures a balanced and reflective conclusion.

Overall, the structure of this thesis is designed to guide the reader through a logical and cohesive narrative, ensuring that each section builds upon the previous one to deliver a comprehensive and well-rounded analysis of the research topic.

2 Literature review

This section will outline the significant literature pertinent to this topic. A few sections are italicized, indicating the researchers' inputs in explaining the significance of the literature for the thesis and to establish a coherent narrative.

2.1 User-centred Design

User-centred design (UCD) is a design concept and iterative process, that places users at the core of product creation. It guarantees that throughout its lifetime the design is guided by user demands, goals, and comments (Abras et al., 2004, p. 2). Donald Norman first used this term in the 1980s, and later it became somewhat well-known (Norman & Draper, 1986).

The framework is built on several key principles that guide designers in creating effective, efficient, and enjoyable systems. According to ISO 9241-210 (2019), these principles include an explicit understanding of users, tasks, and environments, ensuring that designers conduct thorough research to comprehend user needs, behaviours, and work contexts (ISO 9241-210, 2019, p. 5). User involvement throughout the design process is fundamental, requiring engagement in various design phases to provide insights and validate choices (Preece, Rogers, & Sharp, 2002, p. 285). The process must be iterative, undergoing multiple cycles of testing, feedback, and refinement to enhance usability and effectiveness (Preece et al., 2002, p. 286). Furthermore, it is essential to address the whole user experience, considering not only usability but also the emotional and cognitive aspects of user interactions (ISO 9241-210, 2019, p. 5). The inclusion of multidisciplinary design teams ensures a well-rounded approach by incorporating expertise from designers, psychologists, engineers, and other relevant professionals (Abras et al., 2004, p. 4).

The UCD process follows an iterative cycle involving four main stages. The first stage involves understanding and specifying the context of use, which entails identifying user groups, tasks, and environments through ethnographic studies, interviews, and observations (Preece et al., 2002, p. 286). The second stage consists of specifying user requirements, where user needs are defined based on research insights and translated into actionable design specifications (ISO 9241-210, 2019, p. 5). The third stage is producing design solutions, which includes creating wireframes, prototypes, and interactive models to test usability (Benyon, 2010, p. 48). The final stage involves evaluating the design through usability testing, heuristic evaluations, and cognitive walkthroughs to refine the product (Lewis & Rieman, 1994, p. 41).

Implementing this iterative process for dashboards is crucial for maintaining their functionality and efficiency. The requirements specification step is essential for prioritizing items that alleviate user pain points. A dashboard developed without iterative feedback may become excessively complex or deficient in the essential features for the end-user, resulting in ineffective decision-making. Prototyping or creating mock-ups allows designers to investigate various visualization methods and evaluate their effectiveness prior to committing on a final design.

The adoption of UCD provides significant advantages. Systems designed with this approach tend to exhibit increased usability and accessibility, ensuring intuitive interfaces that reduce cognitive load and enhance efficiency (ISO 9241-210, 2019, p. 5). Additionally, well-designed interfaces minimize the need for extensive user training, thus reducing training and support costs (Preece et al., 2002, p. 285). Higher user satisfaction and adoption rates are observed when products are tailored to their needs, leading to greater user engagement and advocacy (Holtzblatt & Beyer, 1993, p. 2). Furthermore, early user involvement helps identify potential issues before they become costly to fix, thereby lowering development costs and reducing the need for extensive redesigns (Abras et al., 2004, p. 11).

In the world of dashboards, these advantages result in quicker decision-making efficiency and accuracy. A dashboard according to the UCD principles is more likely to be utilized effectively by its intended users, whether it is used in a corporate, laboratory, or other context. Organizations may enhance productivity and response times by giving users the possibility to swiftly understand and react to data. A well-designed dashboard diminishes the dependence on comprehensive user guides and training, hence reducing costs and improving overall user happiness.

Despite the many benefits potentially achieved by UCD, there are also several challenges. It can be very resource intensive to conduct extensive user research, not just in cost but in time as well (Abras et al., 2004, p. 11). Furthermore, it is particularly important to balance user needs in comparison to business objectives as they can be complex and user preferences may sometimes conflict with the organizational goals (Preece et al., 2002, p. 286). This leads to the difficulty in managing diverse user groups as it further complicates the design process and therefore will require prioritization of features to cater to all the separate groups simultaneously (ISO 9241-210, 2019, p. 5).

User-Centred Design is therefore an essential approach to creating interactive systems that focus on user needs, enhance the usability, and improve the user experience for the user. While it requires an investment of time and

resources, the long-term benefits can usually be worth it. By integrating iterative design cycles and empirical user research, UCD leads to a much better and effective product while also being mor satisfying to use.

2.2 Usability

Usability is a fundamental concept in human-computer interaction (HCI) and software design, encompassing the effectiveness, efficiency, and satisfaction with which users achieve their goals in a specified context. The International Organization for Standardization (ISO) defines usability as “the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” (ISO 9241-210, 2019, p. 3). This definition highlights usability as a multidimensional attribute that is influenced by both the system itself and the interactions between the user and the system. Despite its centrality in HCI, usability does not have a single, universally agreed-upon meaning. Rather, it encompasses a variety of interpretations depending on context, methodology, and application (Hertzum, 2010, p. 567).

Hertzum (2010) delineates six perspectives, or "images," of usability, which capture its complexity. Universal usability focuses on making systems accessible and effective for the widest range of users, considering diverse backgrounds, skill levels, and technological environments (p. 569). Situational usability emphasizes usability as a context-dependent property, wherein effectiveness and efficiency vary according to specific tasks, users, and environments (p. 570). Perceived usability shifts attention to subjective user experiences, arguing that a system’s usability is determined not only by objective measures but also by users’ perceptions and expectations (p. 571). Hedonic usability highlights emotional and aesthetic factors, particularly in entertainment and consumer-oriented products, where enjoyment and satisfaction play crucial roles in user experience (p. 572). Organizational usability considers usability within collaborative environments, accounting for workflow integration and group dynamics (p. 573). Lastly, cultural usability acknowledges that usability expectations and experiences differ across cultural contexts, influencing how designs are perceived and utilized worldwide (p. 574).

These varying perspectives on usability are particularly crucial in the context of dashboards, as they serve as a central interface for users to interact with data. A dashboard that does not account for universal usability risks alienating users with various levels of technical proficiency. Similarly, ignoring situational usability may lead to inefficiencies when dashboards are used in dynamic environments, such as healthcare or business analytics,

where real-time decision-making is essential. Moreover, perceived usability plays a key role in user adoption—if users believe a dashboard is difficult to use, even if it is functionally superior, they may resist its implementation. Therefore, considering multiple images of usability in dashboard design ensures that these systems are both accessible and effective across different user groups and contexts.

The historical evolution of usability has further shaped contemporary usability research and evaluation methodologies. Redström (2006) critiques the increasing emphasis on user-centred design, arguing that while it aims to optimize the fit between users and systems, it risks over-determining user interactions, leaving little room for improvisation and adaptation (p. 125). He posits that by attempting to anticipate all possible user behaviours, designers may inadvertently limit the richness of user experiences. Similarly, Norman (2013) underscores the importance of designing for both discoverability and feedback. He asserts that well-designed systems should make possible actions clear while providing immediate and informative feedback to users, thus reducing cognitive load and facilitating intuitive interactions (p. 31).

The issue of over-determining user interactions is particularly relevant for dashboard usability. Many dashboards are designed with predefined workflows that may not always align with the way users interact with data in real-world scenarios. Allowing flexibility in dashboard design, such as customizable layouts or modular components, can provide users with the freedom to tailor their experience to their specific needs. Additionally, Norman's emphasis on discoverability and feedback is essential for dashboards, as these systems often present complex data that require clear visualization techniques and immediate responsiveness to user inputs. Without such considerations, users may struggle to interpret data effectively, leading to inefficiencies and potential errors in decision-making.

Usability evaluation has been essential in system development, utilizing many approaches to analyse and improve usability. Laboratory usability testing has traditionally been the most rigid method, offering comprehensive insights into interactions between users (Hartson, Andre, & Williges, 2003, p. 5). Heuristic evaluation, pioneered by Jakob Nielsen, gained attention for its efficiency and cost-effectiveness. This method entails specialists in usability evaluate an interface's functionality according to established usability principles, enabling the detection potential usability problems without needing extensive user testing (Nielsen, 1994, p. 25). Alternative expert-driven inspection techniques, such as cognitive walkthroughs and feature inspections, have been extensively utilized to detect usability issues during the first phases of development (Hartson et al., 2003, p. 8).

A well-structured usability evaluation procedure is essential for the successful adoption of dashboards. Dashboards often feature complex, data-focused interfaces necessitating iterative usability testing to confirm they fulfil user requirements. Conventional usability assessment techniques, including laboratory research, yield significant insights but may fail to reflect authentic usage patterns. Heuristic evaluation facilitates the swift detection of usability deficiencies prior to implementation. The integration of various usability evaluation methods guarantees that dashboards are functional, intuitive, and consistent with user expectations, hence enhancing adoption rates and operational efficiency.

An essential concern in usability research is integrating the goals of usability evaluation with overarching business and organization goals. Hornbaek and Frøkjær (2009) propose that usability evaluation should not happen in isolation but rather be closely interconnected to an organization's goals and strategies. Evaluators that precisely addressed business objectives in usability testing reported a reduced number of usability issues while identifying concerns that were classified higher in relevance and impact on business results (p. 12). Holzinger (2005) asserts that usability should not be regarded solely as an indicator of interface excellence, but rather as a strategic element that affects user adoption, efficiency, and overall business performance (p. 72).

This viewpoint is especially important in dashboard usability, as connecting usability with business objectives can greatly influence organizational success. Dashboards are frequently implemented to augment operational efficiency, facilitate data availability, and refine decision-making. If a dashboard does not correspond with an organization's strategic objectives—either by displaying irrelevant indicators or demanding excessive cognitive effort—its adoption may be impeded, diminishing its overall efficiency. Incorporating both user needs and corporate objectives in usability evaluations facilitates the development of dashboards that deliver actionable insights while avoiding additional complexity for users.

Despite progress in usability research and assessment, considerable problems persist. A persistent issue revolves around the degree to which usability may be effectively quantified. Jokela et al. (2003) dispute the ISO definition of usability, contending that it is vague and inadequately addresses the complexities of usability in intricate, real-world scenarios (p. 53). Kaipio (2011) asserts that usability in healthcare information systems is significantly context-dependent and cannot be sufficiently evaluated using generic usability criteria alone (p. 34).

The challenge of measuring usability highlights the importance of qualitative feedback in dashboard deployment. Although conventional usability scores serve as a valuable baseline, they do not consistently find all the intricacies of user interactions with dashboards across different contexts. Trying to gather user feedback via multiple avenues guarantees that dashboards are enhanced according to actual usage patterns. This methodology is especially beneficial in sectors such as healthcare, where usability directly influences patient care and operational efficiency.

Usability is not a static characteristic but a multifaceted idea that must be comprehended in conjunction with users, tasks, and settings simultaneously. By doing so, one can embrace a more sophisticated methodology for system development, guaranteeing that usability is optimized for efficiency and effectiveness while also aligning with larger experiential, organizational, and cultural factors.

2.3 Customer value & Customer experience

Customer value is a crucial idea in marketing, corporate strategy, and innovation. It signifies the equilibrium between the advantages customers obtain and the expenses they incur while acquiring or utilizing a product or service (Smith & Colgate, 2007). The capacity to generate, assess, and improve customer value is essential for companies pursuing competitive advantage, enduring customer connections, and sustainable growth. Academics and professionals have created diverse frameworks to comprehend and quantify customer worth, each providing distinct perspectives on how companies might offer exceptional experiences to their clientele.

In laboratory settings, particularly regarding the design and performance of dashboards, comprehending consumer value is crucial. Dashboards function as essential instruments for researchers and technicians who depend on real-time data display, operational efficiency, and smooth connection with other laboratory systems. Utilizing organized customer value frameworks helps optimize laboratory dashboards to better user experience, improve decision-making, and ultimately boost productivity in scientific research and development.

Almquist, Senior, and Bloch (2016) defined thirty fundamental components split into four key domains: functional, emotional, life-changing, and societal impact, offering a logical approach for customer value. According to their research, businesses that excel in numerous aspects typically surpass competitors in revenue growth and customer loyalty. Drawing on Maslow's hierarchy of needs, their concept underlines that, even if more consumer involvement

leads from greater emotional and self-transcendent benefits, basic practical advantages like time savings and cost reduction are crucial. Smith and Colgate (2007) created a helpful paradigm breaking consumer value into four categories: functional or instrumental value, experience, or hedonic value, symbolic or expressive value, and cost or sacrifice value. This scientific technique guarantees that their value propositions satisfy a variety of consumer expectations, therefore helping businesses to evaluate and enhance them.

Implementing these findings in laboratory dashboards can maximize functional value by utilizing clear, intuitive interfaces that minimize cognitive load and increase efficiency. The enhancement of experiential value can be achieved by creating visually appealing and user-friendly dashboards, whilst the reinforcement of symbolic value can be accomplished by constructing systems that correspond with the prestige and credibility of advanced laboratory settings. Mitigating cost or sacrifice value entails minimizing the learning curve, facilitating smooth integration with laboratory apparatus, and decreasing the time needed to analyse intricate data.

Customer value is not intrinsically incorporated in products; rather, it is generated through the customer's utilization of a product or service (Grönroos, 2007). Comprehending these processes is essential for companies seeking to improve their value proposition. Kauppinen et al. (2009) emphasize the necessity of transitioning from a feature-driven development model to a value-driven one, wherein companies systematically assess customer utilization of their products to synchronize functionalities with actual requirements. This transition necessitates an outside-in methodology, wherein enterprises include client feedback, co-creation, and interdisciplinary viewpoints into their initiatives. A comprehensive understanding of consumer behaviour enables firms to transcend the presumption that feature augmentation enhances value, redirecting attention to how solutions fulfil customer demands and experiences.

For laboratory dashboards, this entails shifting from a design approach centred only on technology capabilities to one that prioritizes user workflows, the distinct challenges encountered by laboratory experts, and the essential metrics that must be presented in real-time. A customer-centric dashboard would enable scientists to swiftly detect data anomalies, efficiently monitor experiments, and reduce reporting errors, ultimately improving research quality and laboratory efficiency.

Requirements engineering is essential for aligning software and product development with consumer value expectations. Conventional methods of requirements engineering have predominantly concentrated on delineating and executing technical specifications; however, contemporary strategies use

creativity, co-creation, and iterative customer involvement to optimize value (Creative RE and Customer Value Evaluation, 2019). The Creative RE and Customer Value Evaluation report (2019) underscores the necessity for systematic methodologies that integrate structured processes with the adaptability to respond to evolving requirements. Nambisan (2009) examines how virtual customer environments facilitate co-innovation by enabling enterprises to utilize collective intelligence and user-generated concepts for ongoing enhancement. By offering channels for user engagement in product conception, testing, and feedback, companies can better match their innovation initiatives with market expectations.

Utilizing virtual environments for laboratory dashboards, where end-users—scientists, lab workers, and data analysts—may offer ongoing feedback on usability and functionality, can yield systems that better fit with actual research requirements. Involving end-users in co-creation processes enables dashboards to develop dynamically, integrating novel visualization methods, automated reporting, and AI-generated insights that facilitate advanced inquiry and experimentation.

Flint, Larsson, and Gammelgaard (2008) underscore that insights into consumer value are crucial for supply chain learning and innovation. They contend that supply chain managers ought not only simply respond to demand but instead foresee changing client preferences to create more valuable solutions. This necessitates a proactive strategy wherein data-informed decision-making, inter-organizational cooperation, and agile adaptation guarantee that enterprises stay attuned to evolving consumer demands. Companies that invest in comprehending client value more profoundly might achieve difference by anticipating requirements instead of only reacting to them.

In laboratory environments, this entails creating dashboards that display real-time data, anticipate equipment maintenance requirements, recommend process enhancements, and incorporate predictive analytics to forecast trends in experimental results. An effective laboratory dashboard must not only display historical and current data but also assist researchers in predicting and alleviating potential dangers proactively.

Assessing and appraising client value necessitates both qualitative and quantitative evaluations. The prevalent formula—customer value = perceived advantages minus perceived sacrifices—serves as a fundamental metric; however, evaluating concealed demands necessitates more profound engagement strategies (Creative RE and Customer Value Evaluation, 2019). Ethnographic research, focus groups, and iterative prototyping provide insights that surpass conventional customer satisfaction surveys. The Net Promoter Score (NPS) and analogous metrics assess a firm's value delivery in comparison to

competitors; nonetheless, they require the integration of ongoing learning systems to enhance and optimize client offerings (Almquist et al., 2016).

Laboratory dashboards should employ effective evaluation methods, including user testing in real research settings, heatmaps to monitor user interactions with dashboard components, and feedback loops to pinpoint areas for ongoing enhancement. Evaluating success via actual laboratory productivity improvements, mistake reduction metrics, and user satisfaction guarantees that dashboards align with the dynamic requirements of scientific research.

Consumers have moved from being passive recipients to co-creators of value as digital platforms explode. As companies use virtual environments, open-source platforms, and online communities to include consumers in product design, testing, and support, IT-enabled co-innovation has grown to be a key component in corporate success (Nambisan, 2009). Corporations such as Amazon and Apple have effectively assimilated these methodologies by perpetually refining client input and enhancing their value offerings via digital ecosystems. By cultivating continuous engagement through tailored services, integrated digital experiences, and flexible business models, companies can establish enduring relationships with customers who perceive themselves as actively participating in the brand's development. (Nambisan, 2009)

For laboratory dashboards, this entails offering customized interfaces that allow users to alter layouts, choose pertinent key performance indicators for their research, and incorporate third-party data sources. A flexible dashboard customized to user requirements improves usability and promotes long-term adoption and efficiency in laboratory settings.

Creating, measuring, and enhancing customer value is crucial for companies operating in competitive and dynamic marketplaces. By utilizing established frameworks, involving customers in co-creation, and matching product development with actual demands, firms can attain enhanced performance and customer loyalty. Future study ought to investigate the convergence of AI-driven personalization, real-time customer feedback mechanisms, and the ethical implications of value generation in the digital age. Businesses that prioritize a comprehensive grasp of customer value and its complexities will be optimally positioned to excel in their sectors.

In the laboratory sector, those who develop dashboards with an acute awareness of customer value will enable researchers to work more efficiently, make more accurate decisions, and ultimately advance scientific discovery at an accelerated pace.

2.4 Application Domain - LIMS

A Laboratory Information Management System (LIMS) is a complete software tool used to guarantee regulatory compliance, control data on laboratory operations, and simplify laboratory processes. In contemporary labs where massive data volumes must be effectively processed, arranged, and accessed, the system is vital (Mahaffey, 1990). LIMS, or automated systems for managing analytical procedures, related data, and laboratory samples. It guarantees traceability and data integrity while streamlining processes to cut errors and lower hand-off effort (Tagger, n.d.). LIMS, acting as a centralized platform, combines users, tools, and laboratory operations into a coherent framework to improve lab efficiency (Mahaffey, 1990).

Several important characteristics of a well-designed LIMS should guarantee its performance in laboratory environments. Cramer (2016) claims that a basic feature of LIMS capability is the capacity to enable the quick implementation of customized and thorough processes. This function helps laboratories to properly create, change, and run procedures, so ensuring that laboratory operations are simplified, and data management is handled. Furthermore, the architecture of the system must be naturally flexible to meet various demands for data tracking. This flexibility lets laboratories personalize the system for different data kinds, including test findings, experimental circumstances, and sample information, thereby giving a whole picture of laboratory activities, and supporting data-driven decision-making.

Apart from its adaptability, a LIMS must include built-in characteristics enabling its application in controlled surroundings. These features could cover audit trails, user identification, and electronic signatures, thereby ensuring that laboratory data is safely and precisely maintained while nevertheless conforming with industry standards and quality assurance criteria (Cramer, 2016). Moreover, a good LIMS should provide smooth integration between analytical tools, laboratory equipment, and enterprise resource planning (ERP) systems. The solution encourages openness and easy information flow across several platforms by letting effective data import and export, thereby helping laboratories to keep a comprehensive attitude to data management.

LIMS serves mostly to improve laboratory efficiency, guarantee data accuracy, and enable regulatory compliance. Achieving these goals depends much on automation since LIMS automates sample tracking, data entry, and result reporting thus less reliance on human operations. Increased operational efficiency and less human mistake are benefits of this automation (Tagger, n.d.).

Furthermore, guaranteed by a well-run LIMS is structured and safe data management, which offers real-time access to laboratory data—necessary for efficient decision-making and simplified reporting systems (Prasad & Bodhe, 2012). Another basic use of LIMS is compliance with industrial standards such Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP). Maintaining audit trails, data integrity, and producing required compliance paperwork, the system guarantees regulatory adherence (Mahaffey, 1990).

LIMS greatly helps laboratory quality control and assurance going beyond compliance. The system improves result accuracy and dependability by including automated instrument calibrating tracking and real-time data validation (Mahaffey, 1990). Furthermore, facilitating effective data interchange and reducing redundancy is the capacity to interface with several laboratory tools and business systems, such ERP and Customer Relationship Management (CRM) software (Prasad & Bodhe, 2012). Appropriate for many laboratory environments, including research, clinical, pharmaceutical, and environmental testing laboratories, LIMS is also made to be scalable and flexible (Prasad & Bodhe, 2012).

By means of a strong framework for automating processes, enhancing data integrity, and guaranteeing industry standards compliance, LIMS has transformed laboratory management. LIMS greatly increases operational efficiency and scientific advancement by simplifying laboratory procedures and improving data access (Tagger, n.d.). Moreover, its capacity to interact with a variety of laboratory tools and business systems guarantees that labs may keep ambitious standards of data management while satisfying changing operational needs and regulatory requirements (Mahaffey, 1990). Modern laboratory environments cannot function without LIMS since it not only maximizes laboratory performance but also strengthens data dependability and process transparency.

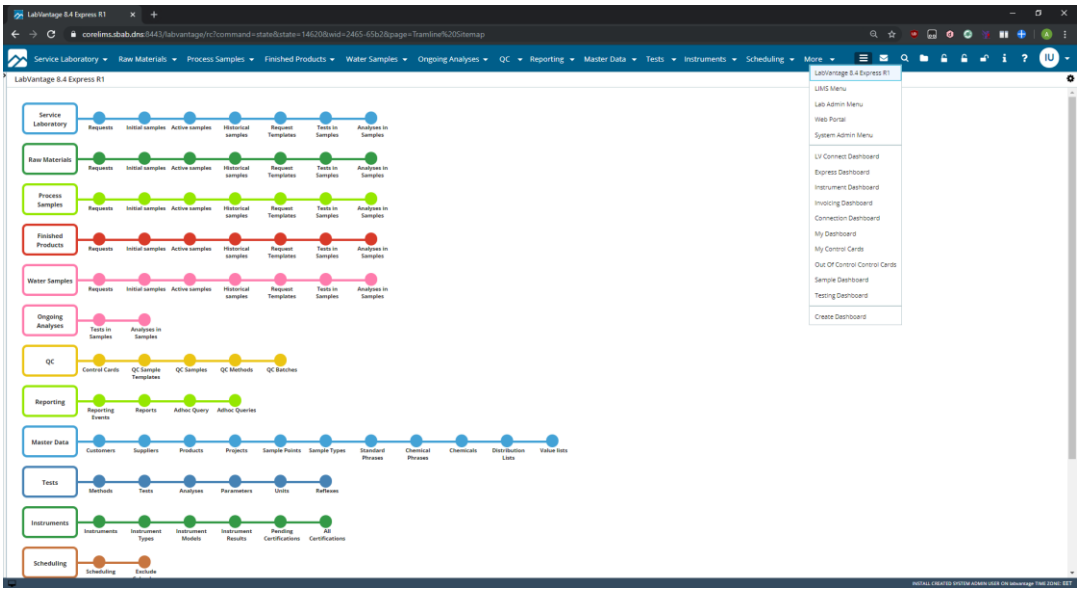

Figure 1 LabVantage Main tramline view from the product of the company.

2.5 Dashboard

By offering a clear, real-time perspective of vital information, dashboards mostly seek to improve data-driven decision-making. Performance monitoring is one of their most important roles since it helps companies and businesses to track important indicators and evaluate their advancement toward strategic goals (Buttigieg et al., 2017). Dashboards help to assist empirical evidence-based rather than intuitive decision-making processes by combining many data sources (Cotgreave, 2016). Dashboards enable doctors in clinical environments, for instance, monitor patient vitals and instantly spot health hazards (Badgeley et al., 2016). In commercial and industrial settings, they help leaders to evaluate operational effectiveness and modify their plans of action.

Dashboards' capacity to improve productivity and efficiency adds still another important advantage. Simplifying processes helps companies to better utilize resources since it lowers the time needed to collect, analyse, and interpret data (Khairat et al., 2018). By acting as a consistent reference point for several stakeholders, professionally designed dashboards increase cooperation and communication (Elias & Bezerianos, 2012). Data that is easily available and clearly shown helps departments inside a company to coordinate their efforts toward common goals and align their aims. Moreover, dashboards give real-time analysis and alerts, therefore alerting users of significant changes in trends or anomalies and offering quick updates on key indicators. In sectors like healthcare and finance, where quick answers to developing problems are vital, this ability is especially important (Roberts, 2012).

Dashboards can be arranged according to particular use scenarios. Whereas operational dashboards concentrate on real-time monitoring of daily activities, strategic dashboards give executives high-level performance measures and trends. While tactical dashboards help users evaluate departmental goals and make data-driven changes, analytical dashboards enable in-depth data analysis allowing users to drill down into specifics for pattern discovery and forecasting (Buttigieg et al., 2017). Despite these variations, every dashboard has as its shared objective increasing access to pertinent data and encouraging wise decision-making.

The design of a dashboard determines its effectiveness mostly. A good dashboard must be easy to use, unambiguous, and effective in data presentation. The choice of suitable visual elements is among the most key factors of dashboard design. Various kinds of data call for different visualization techniques; line charts are best for showing trends over time, bar charts enable comparisons across categorical data, and heat maps help show density or intensity (Few, 2006). Ensuring the usability of a dashboard also depends critically on clarity and simplicity. While too many ornamental features could create distractions and lower efficacy, using suitable colours, fonts, and contrast improves visibility (TUN DM Online, 2004). With important performance indicators clearly shown and more details made available through interactive drill-down tools, the logical presentation of information enhances usability even more (Stephen, 2010).

Interactivity and customization are also fundamental components of effective dashboards. Users should have the ability to filter, drill down, and explore data in ways that suit their specific needs. Interactive dashboards enable deeper analysis and personalized experiences, enhancing their utility for a wide range of users (Elias & Bezerianos, 2012). Additionally, ensuring that data is accurate and updated in real time is essential for maintaining the credibility and reliability of dashboards. A dashboard that fails to provide timely and precise information diminishes its effectiveness and may lead to poor decision-making (Cotgreave, 2016).

Many dashboards have design problems that compromise their efficacy, notwithstanding their many benefits. Information overload—excessive material provided without priority—is a typical problem whereby people find it challenging to derive useful insights. Likewise, a lack of context could lead to misinterpretation, particularly in cases when data points lack suitable labels, annotations, or explanations. Another difficulty is effective data integration since dashboards must perfectly combine several data sources without discrepancies. Furthermore, poor responsiveness could restrict access since

dashboards should be made to run best on several platforms, including desktop computers, tablets, and mobile phones.

The discipline of dashboard design changes as technology develops. Dashboards are progressively including artificial intelligence and machine learning to provide predictive analytics and AI-driven insights, so enabling users to forecast trends and make proactive decisions (Khairat et al., 2018). The emergence of speech and gesture-based interfaces points to a change in future user interaction with dashboards, therefore enabling hands-free data exploration. Furthermore, promising are augmented reality dashboards, which offer immersive, three-dimensional representations of intricate datasets improving analytical capacity (Roberts, 2012).

Dashboards play an integral role in modern data visualization by allowing users to monitor performance, make informed decisions, and streamline operations. Their effectiveness depends on well-thought-out design principles that prioritize clarity, usability, and real-time functionality. While challenges such as information overload and inefficient integration persist, innovations in artificial intelligence and interactivity continue to redefine the future of dashboard technology. By adhering to best practices in dashboard design and functionality, organizations can maximize the benefits of dashboards as powerful tools that drive productivity, collaboration, and data-driven decision-making across various domains.

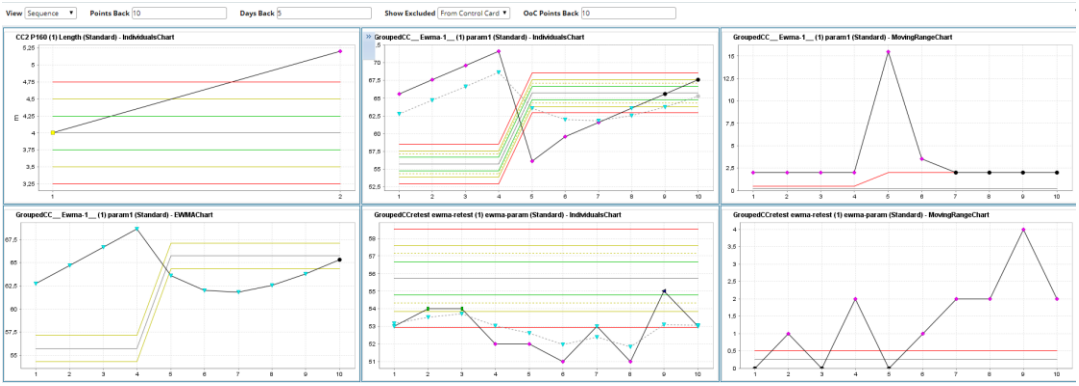

Figure 2 Example dashboard 2 of different charts from LabVantage.

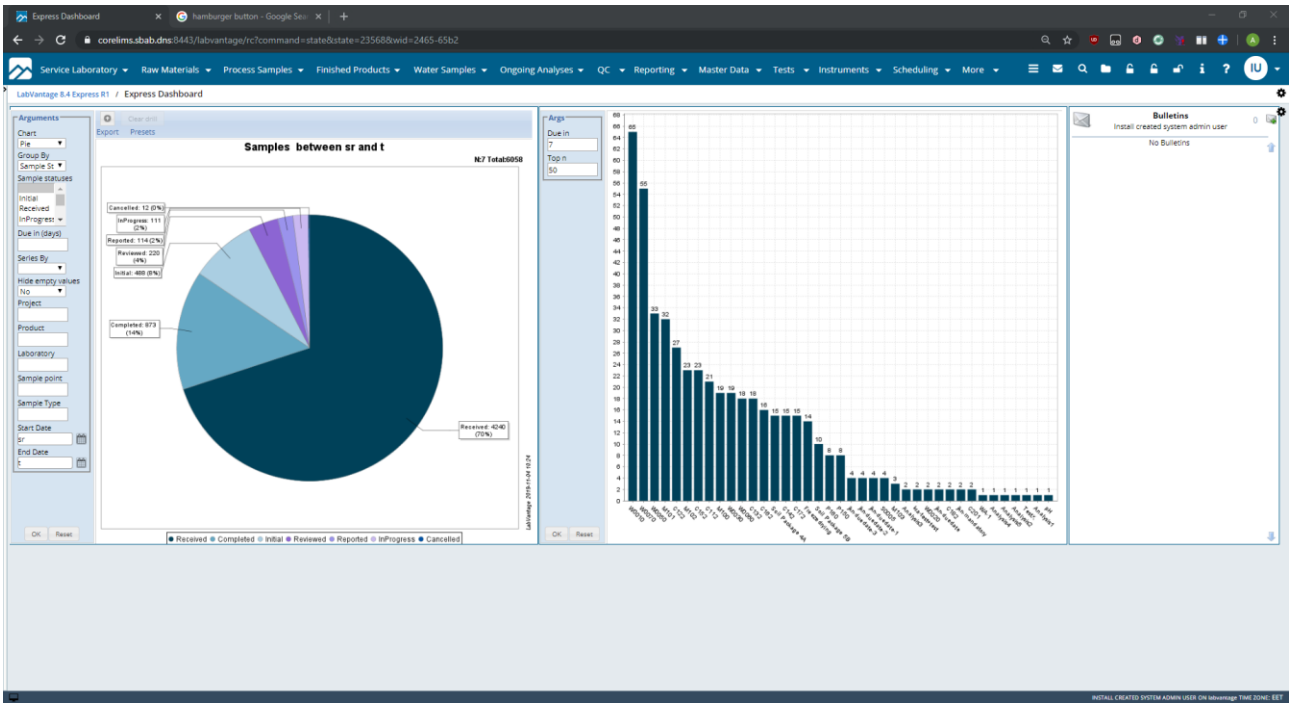

Figure 3 shows what a typical dashboard looks like. In this dashboard there are two charts and a bulletin object. Each of these objects or charts are called gizmos. To be able to alter these a user would have to go into admin mode.

2.6 Company Presentation

The company this thesis is done for is Whitelake Software Point Oy, WSP, which is a mid-sized LIMS company. They are the leading actor on the market in Northern Europe with offices in multiple countries and the headquarters situated in Espoo. The company has during its 25+ years provided over 500 laboratories with LIMS solutions in almost all industries including healthcare, research and analytical services. The company provides services for the whole lifespan of the product which includes delivery, support, training, and consulting. The employees in the company are naturally specialized in IT but there is also a comprehensive laboratory knowledge to better understand and work with customers.

The main LIMS solutions WSP provides are LabVantage Enterprise and LabVantage Express. These products fit the needs of QA/QC laboratories, gives possibilities to do analytical testing and also enables R&D laboratories in multiple fields and disciplines. Furthermore, LabVantage Medical Suite is another product that is developed for healthcare laboratories. With it you get functionalities to handle all medical needs like Microbiology, Pathology and Blood banking as an example. All these products have a lot to offer already in their default format but if there are some special needs then additional

components and modules can be added to extend the functionality available for the customer.

The project tendering process is essential to WSP's operations, facilitating efficient project procurement and acting as the initial point of client engagement with the LIMS product and its dashboard. The process commences when a corporation issues a public tender, prompting WSP to engage. The company thereafter provides written responses that address the fundamental requirements. These fundamental requirements usually require the dashboard functionality to be able to move forward in the process. If chosen to move forward, subsequent actions will include demos, both virtual and in-person, to exhibit the product's functionalities. Following the successful acquisition of the tender, an implementation project commences to incorporate the system into the client's workflow.

While the dashboard is introduced already during the tendering process it is usually not at the forefront during implementation due to other urgent system requirements from the customer. Therefore, the dashboard can potentially be configured later on in the process depending on the customers resources and prioritization for their process needs.

2.7 LabVantage LIMS and Dashboard

The product in centre for this study is the LabVantage Enterprise which is a widely used LIMS that offers numerous functionalities for managing laboratory data. The main page of the product can be seen in Figure 1. One of the core features of the LabVantage Enterprise is the dashboard, which consolidates information into a single screen. However, to understand the unique characteristics of the dashboard, it is crucial to examine other areas of the LIMS that perform potentially similar tasks.

The LabVantage LIMS is built on a simple framework, consisting of larger menus known as "tramlines" which have tram stops or nodes. This is shown in Figure 4 below. The tramlines provide an easy overview of the functionalities that can be initiated. The tramlines are designed to be used from left to right, enabling users to manipulate objects through their lifecycle. For instance, when a laboratory receives a sample that requires testing, it is created and received. This sample can then be accessed from the Receive tram stop. Metadata is then added, and test data is inserted while the sample is in progress, and it can be accessed from the Manage node. Once the sample is complete, it is archived and visible in the Archived node. In brief, the tramline represents the visualization of an object's lifecycle.

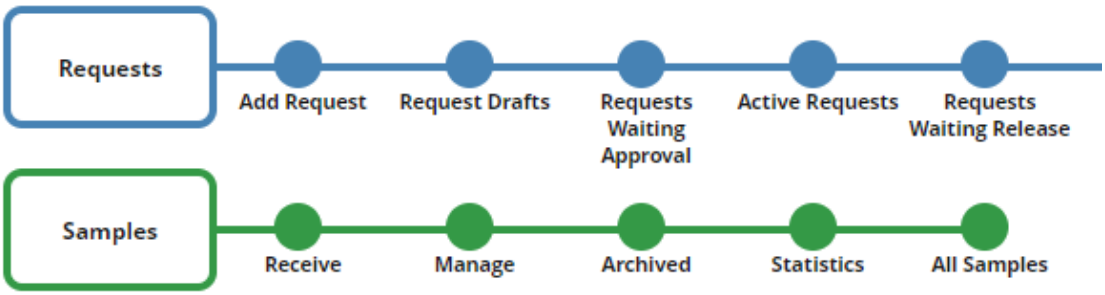

Figure 4 An example of two tramlines and their tram stops in LabVantage.

Most nodes in the LabVantage LIMS, when clicked upon, direct the user to a listpage. The listpage, as seen in Figure 5, is essentially a table with rows representing the objects managed under the node and tramline, while the columns contain different data attached to the object. Listpages consist of multiple features that a dashboard can also include, such as providing an overview of all objects under the node. Additionally, they offer customizable columns, enabling users to determine the information displayed and in what order. Users can also filter and group the objects shown, thereby streamlining the data, and providing an efficient means of navigation.

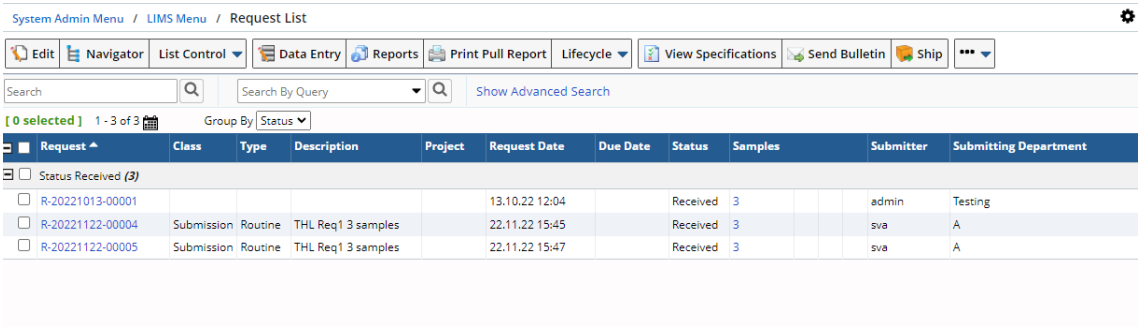

Figure 5 A listpage in the LIMS.

The ability to filter and query to find particular objects or data attributes is one of the most important aspects of the listpage.
The listpage offers two main ways to search and filter for specific objects. The first way is by utilizing predefined filters and queries that allow users to search for the desired object using specific conditions. These filters are highly configurable and dynamic, allowing users to tailor their search to meet their specific needs. The predefined filters and queries also enable users to save their search criteria for future use.

The second method for finding specific objects in the LIMS is through the use of the "ad-hoc search" functionality. This functionality enables users to search the entire table in a manner of their choosing. The ad-hoc search feature is not limited to predefined search criteria and allows users to search for

any potential data attached to the object. This capability is limited only by the user's knowledge and expertise in navigating the software.

In summary, the listpage is an essential feature of the LabVantage Enterprise that provides users with the ability to search and filter for specific objects or characteristics using both predefined filters and ad-hoc search functionality. They bring quite many of the same qualities that the Dashboard possesses in data visualization.

Finally, the dashboard module itself is based on a so-called Gizmo-driven framework to display discrete collections of information on a single page. LabVantage comes with preconfigured dashboards that can act as templates for the customers to see what the dashboard can do and possibly configure them to use with their data. Due to the high customization factor of the software and the customers differing process the preconfigured dashboard tends to lose value as they rely on the standard configuration and use of the system customers may choose to not align with.

Some examples of the dashboard have already been shown in Figure 2 and Figure 3. One graph in a dashboard is one gizmo and essentially the dashboard is built up from multiple dashboard that can have different types. Without having to explain all possibilities the researcher will below show one preconfigured dashboard and explain what it consists of.

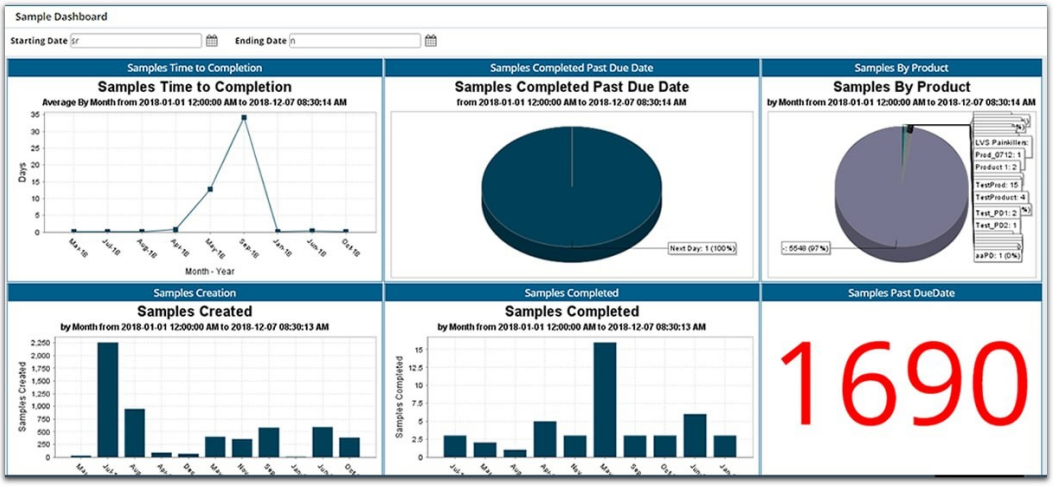

Figure 6 The preconfigured Sample dashboard in LabVantage.

The dashboard as shown in Figure 6 shows the Sample dashboard that consists of seven different gizmos. The first gizmo is the one where the date range is specified. This gizmo would then control the other gizmos to alter their dataset dynamically based on the input values. Then there are five chart

gizmos which can show charts in different formats as seen in earlier Figures, especially Figure 2, 3 and 6. And to complete the dashboard there is also a meter gizmo to show the number of samples past the due date in this instance.

The dashboards are configurable with the correct access rights in the system but are otherwise locked to both placements, look and colours. Therefore, it requires some effort to make changes to the dashboard and its gizmos if a changes or update is needed. Also, if the dataset that is configured to show in a chart needs modification it will require a modification on the gizmo itself. It cannot usually be configured through the user interface. To be able to modify it like that it will require additional gizmos to handle the new parameters to be configurable or a different gizmo altogether that can show data in a more configurable and complex way.

Figure 7 and Figure 8 shows additional preconfigured dashboard with some extra types of gizmos in them to showcase what the dashboard module can achieve.

Figure 7 The Connection dashboard from LabVantage.

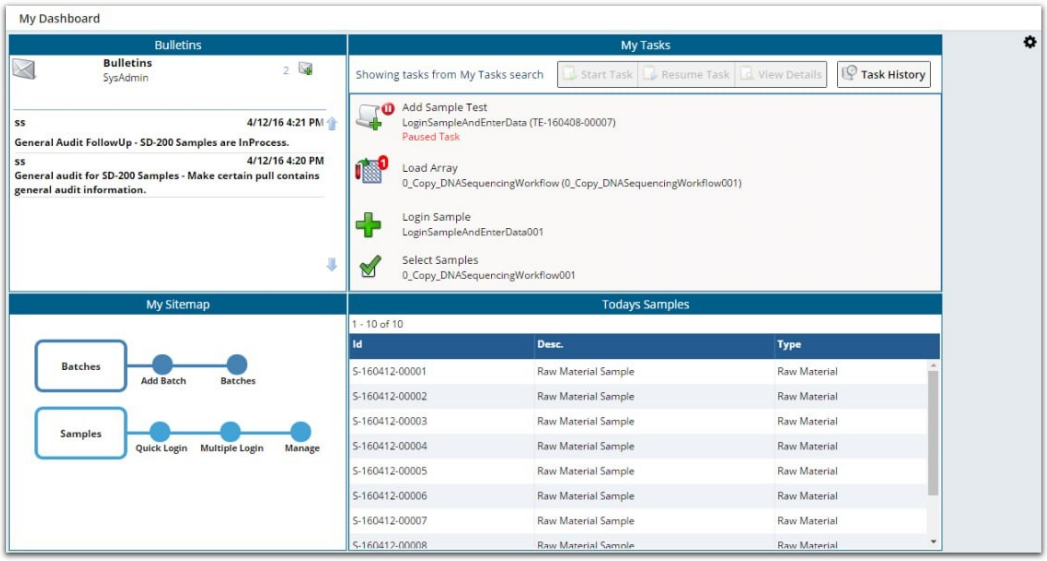

Figure 8 The "My Dashboard" from LabVantage

3 Research design and methodology

This section explains the methodology of the thesis. Firstly, the objective of the thesis will be restated. The research approach and its methodological decisions are explained comprehensively for and then advocated for. Further on, the data collection methods will be explained. Finally, the ways the data is analysed will be presented and specified and what considerations were taken.

3.1 Research Method

The thesis was conducted to extract findings that could help the company and organization improve the product and increase its usage. Therefore, the thesis used a primarily deductive approach by using an applied methodology that was also iterative to be able to adapt to the findings appropriately. Answers to the research questions were found through a direct approach to achieve the most accurate and comprehensive answers to provide to the company.
The thesis process started with a preliminary literature review after the scope and research questions had been initially defined. From this initial literature review the semi-structured interview format was defined and developed which is presented in chapter 3.3

3.2 Literature Review

For this thesis, the researcher has chosen to find suitable methods in approaching this kind of research subject, and then based on the models found, create a suitable model specifically for this thesis.
The first model the researcher used as an outline for my own model is based on the literature review of user-centred design: The human-centred design process is depicted in figure 3. (ISO 9421-210, 2010)

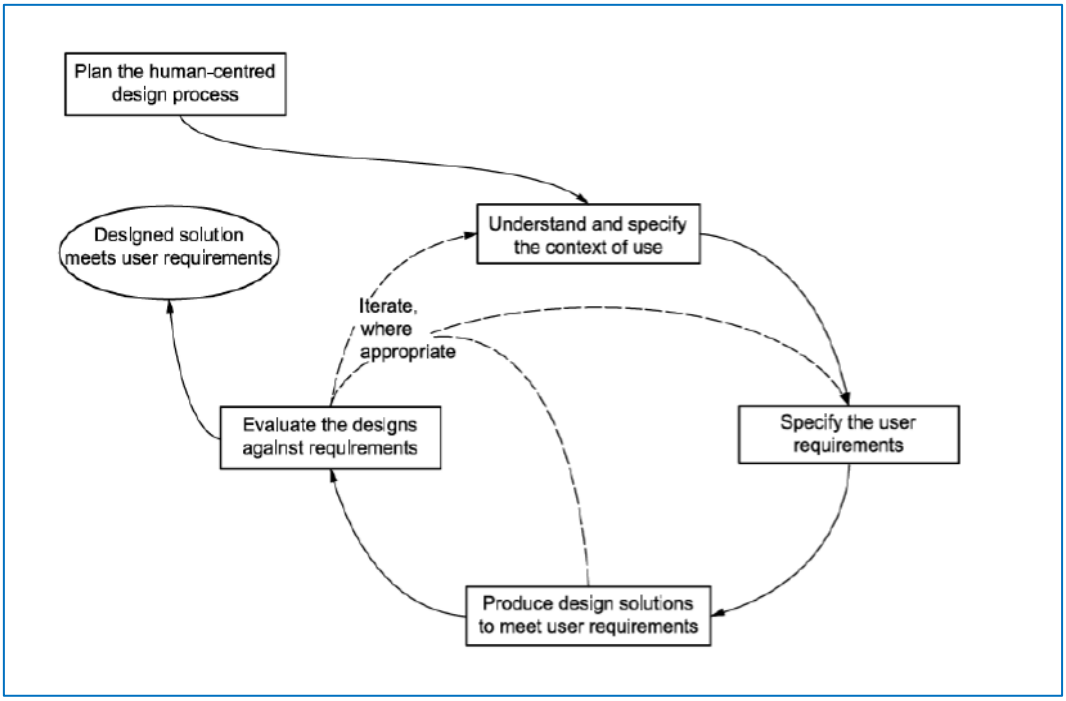

Figure 9 The human-centred design process.

As can be seen from Figure 9 above, the process has four main phases that are used in an iterative fashion. This model is very suitable for this kind of thesis as there are multiple types of users and they have differences in their needs and requirements for the dashboard module. Additionally, this model gives the possibility to go back for more literature and theory to help with later interviews depending on what the initial findings are during the data collection phase. Finally, the model also contains a validation phase which ensures that the solutions to the identified challenges are tested to see which ones are viable to implement and which ones should be further reiterated. (ISO 9421-210)

The second model the researcher found very suitable for the thesis is the requirements engineering process as the goal indirectly for the thesis was to find out requirements for the dashboard module to be able to develop it. The process is depicted in figure 10:

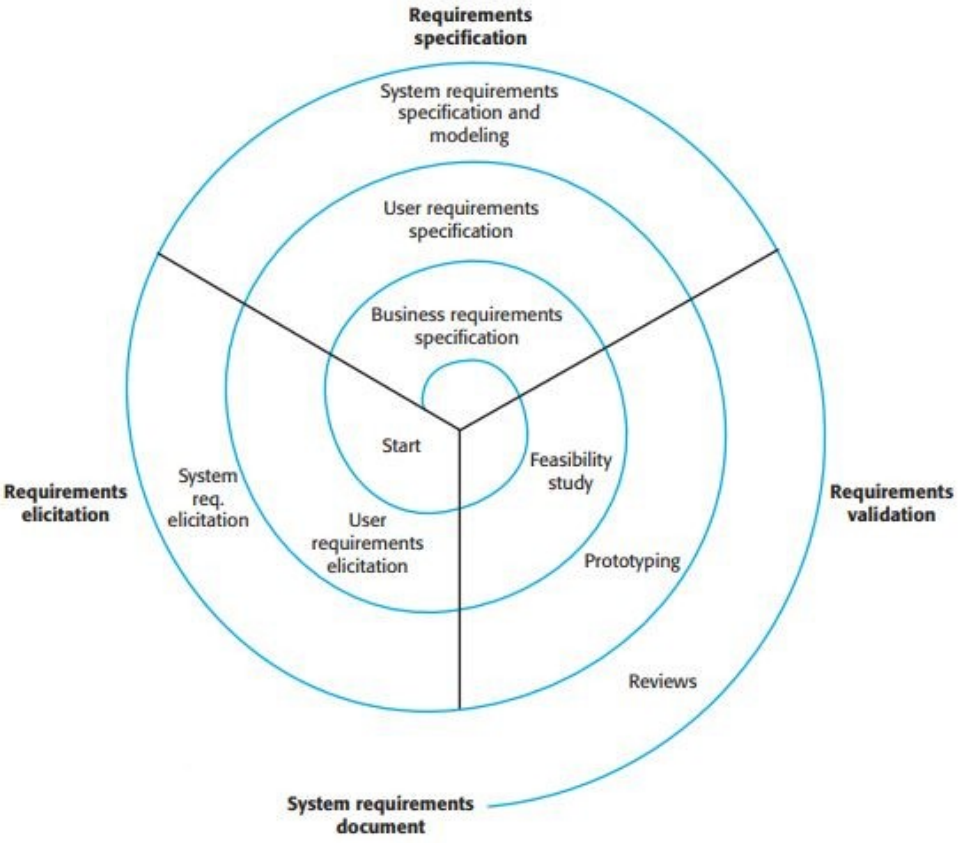

Figure 10 Requirement Engineering process.

The requirement engineering process is also iterative as seen in the figure. The model enables different approaches depending on the level of detail needed for developing a system. The number of iterations in the spiral as well as using all steps is completely up to how well requirements are elicited. (Sommerville, 2016)

When comparing the two models it is easy to see that they have many similarities. They both focus in the beginning of each iteration to understanding users and the current system. The following step is to specify the requirements and then validate them. The validation step is the most differing one as the design process uses more focus on creating design solutions compared to the requirement process having prototypes just as an option.

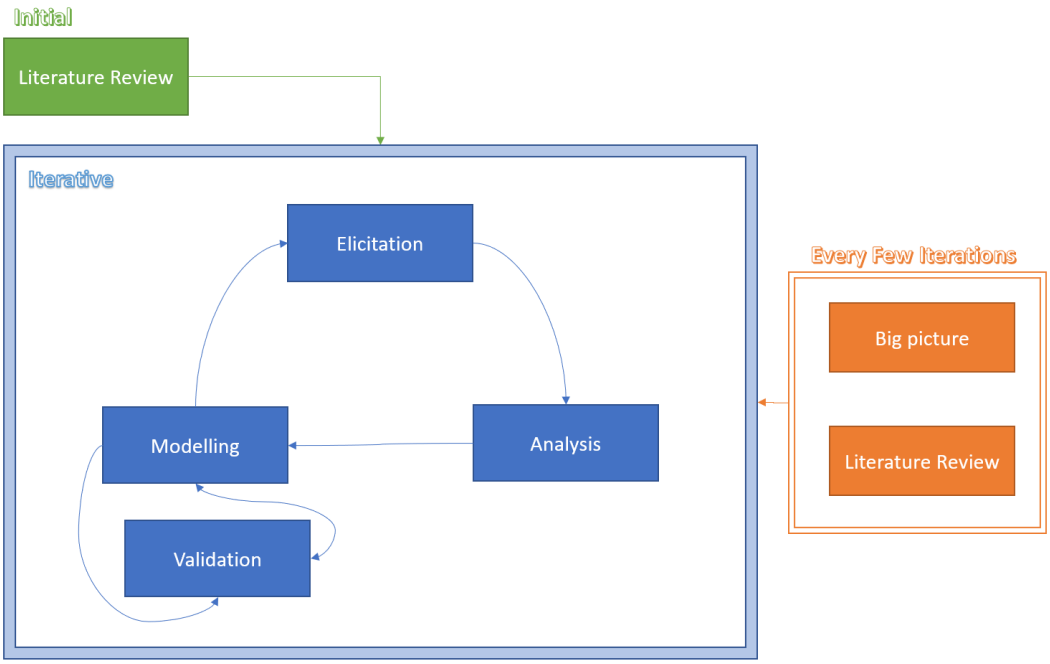

Figure 11 The thesis process created by the researcher.

In Figure 11 above is the thesis process that the researcher will be using during the work. It is an iterative process that tries to blend the human-centred process and requirements engineering process together. This model places an initial heavy focus on a literature review to learn about the subjects required for performing the thesis. After this the process becomes iterative with a small section done only every few iterations. The main iteration contains Elicitation which is finding out new requirements or functionalities that are needed in the dashboard module. After this follows an Analysis stage which focuses on combing through the gathered data and understanding it on a deeper level. The third stage puts a heavy focus on creating mock-ups/prototypes of the requirements found in the Elicitation and Analysis stage. This is then supposed to be validated and then refined before once again starting the Elicitation stage. The steps not done every iteration is doing additional literature review based on what the findings are as they might not be what I expect. Furthermore, it gives a possibility to take a step back from the process and understand the bigger picture on what important findings is and what it irrelevant for this thesis.

3.3 Semi-structured interviews

The data collection process for this thesis involved conducting interviews with both internal and external stakeholders. To ensure consistency and accuracy of the data collected, the interviews were primarily conducted in

person, except for one internal interview which was done through Teams. The questions asked were consistent throughout each interview round, but the questions were tailored to fit the individual interviewee's role and responsibilities. Therefore, the basis of each interview remained the same with the possibility to gain as much information from the interviewee's individual experiences.

Semi-structured interviews are a great tool to find out more indirect values an interviewee might have instead of using, for example surveys with more strict answers. The interviewing method is excellent for asking structured questions for data collection while still not limiting the discussions that are created around the questions (DiCicco-Bloom, B. & Crabtree,2006). Furthermore, by using this form of interview the discussions will bring enough data for saturation to happen, which means that data collection is sufficient to form conclusive themes and results. Finally, having an open discussion theme beyond the questions asked could emerge which would point to previously unknown problems. (Eriksson & Kovalainen, 2008)

The questions were open-ended in nature, which allowed for a wide range of responses and perspectives to be captured. It was anticipated that the responses from the internal stakeholders would focus more on technical details, while the external stakeholders would be more concerned with end-user satisfaction and business goals. Despite these differences, the main themes that emerged from the interviews were consistent across all parties. (Lewis, Saunders, & Thornhill, 2019, pp. 434-444)

To ensure that the data collected was as comprehensive as possible, all interviews were recorded, either through phone or computer audio, with notes taken during the interview to supplement any areas where the recording quality was less than optimal. The combination of audio recordings and notes helped to provide a complete and accurate picture of the responses given by each interviewee.

It is worth noting that the interviews were conducted during customer visits beyond the scope of the thesis, which allowed for a more natural setting and a greater depth of insight into the perspectives of the interviewees. However, the focus of the questions remained with an emphasis on understanding how the dashboard could be improved to create more value for the end-user while maintaining a manageable implementation process. (Lewis, Saunders, & Thornhill, 2019, pp. 434-444)

The data was collected in three distinct stages. All data was conducted in semi-structured interviews with the difference that the final interviews for the purpose of idea validation utilized mock-ups. The first set of interviews

were conducted during early June of 2019 and the interviewees were internal to the company. The following set of interviews were conducted during the end of June of 2019 and all the interviewees were customers. Finally, a set of interviews were held in the middle of August of 2019 for the purpose of validation in which the interviewees were once again internal. All the interviews were held after the initial literature review had been completed during the spring April-June 2019.

All the interviews had their audio recorded for transcribing and analysis purposes. The interviews lasted from 45-120 minutes and all interviewees were briefed on the aim of the interviews. The language used in the interviews is based on the expected flow of the interview. Therefore, the interviews were conducted in mainly English and Finnish with one interview in Swedish. In the beginning of every interview the main concepts and themes were presented before starting with the questions.

The interviewees represented either developer, admin, or manager roles. These roles enabled data collection from a multitude of angles to be able to analyse the data later comprehensively. Furthermore, there were expectations with the interviewees chosen that they possessed the correct skills, tasks, and information regarding the aims of the thesis.
A table of the conducted interviews and the interviewee with dates is presented in table 1.

Subject	Role(s)	Date
S1	Project Manager/ Developer	7.6.2019
S2	Developer	12.6.2019
S3	Project Manager	13.6.2019
S4	Project Manager	17.6.2019
S5	Admin	24.6.2019
S6	Admin	25.6.2019
S7	Project Manager/Admin	26.6.2019
S8	Project Manager	27.6.2019

Table 1 The table shows the interviewees their roles and when they were interviewed.

Interviewee background	Discussion about the interviewee's position and responsibilities as well as experience with the dashboard
Interaction	Themed questions angled to find out the interviewee's interaction with the system and how the dashboard currently is being utilized.
Usability	Questions themed to find out the current situation with the "user experience" of the dashboard
Customer value	Discussion about what functionalities bring value to the interviewee and which ones are lacklustre.
Change development	Questions mainly for the interviewees in developer roles about what changes they have implemented and their overall viewpoint on the development process of the dashboard
Demo session	An interactive part where the interviewee shows how they accomplish things in the dashboard

Knowledge	The interviewee's viewpoint on how they have learned the system and how they wish to gather information about the dashboard

Table 2 Interview themes for the semi structured interviews

3.3.1 Internal Interviews

These interviews represented the first stage of research aimed at understanding the perspectives of developers and project managers within WSP regarding the dashboard. The primary goal was to explore their thoughts on the dashboard's functionality, effectiveness, and role within the organization. Additionally, the interviews sought to uncover insights into how the dashboard was utilized in both internal operations and external customer interactions, particularly its role in sales and client engagement.

Another critical aspect of the internal interviews was identifying the needs and expectations of developers in terms of dashboard improvements. This involved gathering feedback on technical limitations, usability challenges, and potential enhancements that could make the dashboard more effective from a development standpoint. The insights obtained from these discussions provided a clearer understanding of the technical constraints and the specific features that developers believed would enhance both internal workflows and customer experience.

Given that the internal interviews were conducted with individuals directly involved in the development and maintenance of the dashboard, the focus was inherently more technical compared to the customer interviews. The discussions delved into aspects such as system architecture, customization options, performance issues, and the feasibility of implementing new features. This technical emphasis ensured that the feedback gathered could directly inform future development strategies and contribute to optimizing the dashboard's functionality.

By prioritizing a technical lens in these internal discussions, the research established a solid foundation for subsequent customer interviews. The findings from this stage provided valuable context for understanding how the dashboard could be improved not only for end-users but also for those responsible for its ongoing development and maintenance.

3.3.2 Customer Interviews & Selection of interviewees

Following the initial round of internal interviews, customer interviews were conducted to gain an external perspective on the dashboard's usability, functionality, and customer value. The interviewees were primarily individuals in managerial or administrative roles, as they were responsible for overseeing the dashboard's implementation or development, managing workflows, and ensuring that it remained an effective tool within their respective organizations. Their positions allowed them to provide insight into both strategic and day to day aspects of dashboard utilization.

The main objective of these customer interviews was to build upon the findings from the first internal interview by assessing how the dashboard was perceived and used by external stakeholders. This included gathering feedback on its strengths, finding the interviewees pain points, and understanding how well it integrated into their daily work processes or how much value they could extract from the module. Additionally, the interviews tried to capture their expectations and desired features they felt they were missing, and any other gaps that might exist when compared to other tools they relied on for data visualization, monitoring, and reporting.

To ensure an exhaustive analysis, a conscious effort was made in selecting customers who actively used the dashboard module within a production environment. This was essential to make sure that the feedback was based on real-world application rather than theoretical or too limited use. By finding customers who had more experience with the system, the interviews could uncover more meaningful findings, for example which features were most valuable, which aspects needed improvement, and how the dashboard compared to alternative solutions in the market.

Furthermore, there was an effort to diversify the customers chosen as a second main consideration. Measures were taken to try to include customers from as different industries and operational contexts as possible to try to capture a broader range of findings. Given that some industries may have extremely specific workflows, reporting needs, and compliance requirements, this approach would help in identifying a wider spectrum of potential enhancements for the dashboard. By incorporating perspectives from multiple fields in the industry, the research aimed to ensure that any proposed improvements would address the needs of a diverse user base, making the dashboard more adaptable and effective across different business environments.

In addition to discussing the dashboard's technical and functional aspects, the interviews also covered topics like the interaction between WSP and its customers. This included evaluating the level of support provided, the ease

of onboarding and training to start using the dashboard module. Understanding these dynamics was also important for identifying not only improvements directly connected to the dashboard but also potential enhancements in the company's customer engagement, support, and training initiatives that could improve overall user satisfaction and adoption rates of the module.

By structuring the customer interviews in this way, the researcher was able to gather a well-rounded set of insights, bridging internal development perspectives with real-world user experiences. These findings played a key role in shaping recommendations for improving the dashboard, ensuring that future enhancements aligned with both technical feasibility and customer expectations.

3.3.3 Contextual Inquiry / Demo session

All interviews had an interactive section where the researcher used existing templates or the customers' own dashboards to gain valuable information. This included on how they use it currently and what it excels at and also how it could be improved. This section was valuable as it was hands on, and one could get direct feedback on what challenges the interviewees had. Also, by observing how they used it and challenged that behaviour, valuable insights could also be found. Finally, by using the existing templates it was possible to explain what the dashboards could do beyond what the customers potentially were aware of and also in the internal interviews look at where the limitations were.

The interactive segment of the interview was a segment in which the researcher made use of the pre-existing templates in the LIMS system or if possible, the interviewees own dashboards. This consequently offered a broad platform for analysing usage patterns, strengths in the current dashboards, and opportunities for improvement. This method aligns with the fundamental principles of Contextual Inquiry, a method for gathering qualitative information that emphasizes the observation and interaction with users in their actual environments. (Holtzblatt & Beyer, 2015) By including templates into the conversations, the researcher quickly employed the artifact walkthrough approach, an established technique in Contextual Inquiry, to reconstruct how users interacted with dashboards in their workflows (Raven & Flanders, 1996).

The value gained through this hands-on interaction approach cannot be overstated. Contextual Inquiry is rooted in the belief that data gathering must occur within the user's actual work setting, allowing researchers to observe the

subtle, often unconscious ways users engage with the system (Holtzblatt & Beyer, 2015). During these demo sessions, the researcher was not merely a passive observer but also an active participant, trying to understand the interviewee in how dashboards facilitate their work, where they potentially struggle, and what expectations they might hold for improved functionality within the module. This methodology ensures that findings are deeply embedded in users' everyday experiences.

Additionally, observing the interviewees interactions with the dashboards allowed the researcher to uncover latent needs i.e. challenges that users might not explicitly articulate or voice at all but that become apparent through their usage of the system. This approach follows the main principles of Contextual Design, where user interactions are studied to reveal unspoken needs and opportunities for design improvements (Holtzblatt & Beyer, 2015). For example, difficulties in locating specific key metrics essential to their processes or difficulties with the navigation could become clear only through direct observation rather than the interviewees self-reporting.

Furthermore, by using the existing templates, the researcher was not only able to assess how the dashboards were currently used but also able to demonstrate potential functionalities that the interviewees might not have previously considered and therefore not at all aware about. This adheres to the concept that design must not only react to existing behaviours but also guide and influence future usage (Cockton, 2006). Through this process, internal teams could also identify system limitations by testing edge cases or scenarios that might not have been previously recognized.

The addition of these interactive sessions underscores the importance of engaging users through contextual and participatory methods. Instead of relying solely on surveys or structured interviews, which may limit users to predefined responses, this hands-on engagement allows for deeper insights, leading to more meaningful design improvements. This iterative and immersive approach ultimately ensures that the resulting dashboard enhancements are aligned with actual user needs, fostering a more intuitive and effective system.

3.3.4 Validation Interviews

There were two interviews/sessions held after all other interviews had been held and a summary analysis had been performed. These were held with two of the internal interviewees that had been interviewed at first. They were chosen due to their experience with the product. The aim with these interviews was to confirm/dispute the results this thesis had come to through a

presentation consisting of claims and mock-up designs of solutions/ideas that had been presented in the previous interviews. They acted as help when the results gathered were analysed in a thematic analysis.

3.4 Thematic Analysis

By employing an emergent theme analysis, the researcher allowed patterns to develop organically instead of applying preconceived categories. This method guaranteed that the study stayed firmly based on the facts instead of being limited by theoretical models (Taylor-Powell & Renner, 2003, p. 3).

Both manual and computerized approaches were applied in order to spot emerging themes. The researcher systematically categorized the data to refine the themes and their potential subcategories (Taylor-Powell & Renner, 2003, p. 4). Frequency counts included a quantitative component that gave a disciplined way to evaluate thematic prominence without substituting qualitative interpretation (Taylor-Powell & Renner, 2003, p. 5).

Qualitative analysis software enhanced efficiency, but manual interpretation remained essential for contextual nuances. The combined use of qualitative coding and quantitative pattern identification resulted in a structured yet nuanced analysis (Taylor-Powell & Renner, 2003, p. 8). The themes that were identified are presented in section 4 as the headers for the different subsection in the section. They are ordered in from the most occurring themes to smaller themes only brought up by a lesser amount of the interviewees.

3.5 Validity, reliability, and considerations

This thesis focuses on a laboratory dashboard, while addressing usability and customer value questions. Semi-structured interviews were applied to improve the validity by guaranteeing in-depth investigation and uniformity across respondents. There could have been several elements affecting internal validity. While response bias may have caused participants to hide critical opinions, the choice of participants already using the dashboard may have distorted results toward experienced users. Furthermore, the researcher's knowledge of the system might have affected replies subtly by asking leading questions.

Regarding validity outside of this study, the findings most apply to laboratories utilizing Laboratory Information Management Systems (LIMS), although they could be applicable to other companies using comparable data visualization dashboards. Still, variations in industry standards, dashboard

acceptance rates, and regional regulatory constraints could restrict generalizability.

To try to raise the reliability of the thesis findings, the researcher used multiple approaches. Every interview was recorded verbatim to maintain accuracy. Furthermore, a uniform interview structure guaranteed comparability between the interviewees. Minimizing subjectivity, comments were methodically categorized using thematic analysis into recurrent topics. To confirm results versus initial insights, a validation step including internal stakeholders was conducted. Although qualitative research by nature involves some subjectivity, cooperative analysis helps to guarantee consistent interpretation.

One should admit several prejudices and constraints. As said before, the researcher's own experience with dashboard construction could cause a possible bias in interpreting data and posing leading questions. Furthermore, insights from non-users were excluded by participant selection limited to consumers and internal personals already familiar and using the dashboard.

Ethical integrity was maintained by several means as well. Before taking part in the trial, participants signed consent and were instructed on study goals. Anonymizing the answers guarantees confidentiality. For this project, securely kept recorded interviews and transcripts were used exclusively.

4 Results and Analysis

4.1 Interview analysis

This chapter presents a deep exploration of the findings derived from the eight main interviews conducted for this study. The researcher employs a thematic analysis approach to find recurring patterns and themes, offering rich insights into the challenges, advantages and perceptions associated with dashboard usage in laboratory environments. The chapter systematically examines these themes to provide a nuanced understanding of how dashboards are utilized, the obstacles faced, and their potential for optimization. Each theme is discussed in detail, supported by evidence from the interviews. After having presented the themes found from the interviews the findings are then matched with the literature review and further analysed before conclusions are drawn in section 5. All interviewees are presented as their subject number only.

4.2 Dashboard Limitations and Underutilization

The prominent recurring theme across almost all (7/8) interviews was the underutilization of dashboards. Despite their potential to provide real-time insights and improve operational efficiency, dashboards act as peripheral tools in many organizations. Participants highlighted a multitude of reasons for this, including limited functionality, lack of user training, lack of advanced feature training and competition from external business intelligence (BI) tools.

For instance, S2 reported that dashboards were primarily used for error monitoring and system maintenance notifications, with little use for more advanced features such as workload tracking or user-specific insights or economic insights. Similarly, S7 noted that *"We use dashboards in weekly meetings, but many of the graphs are irrelevant, so we don't use them outside those sessions."*. Dashboards that are mainly employed during weekly meetings to visualize sample progress and workload distribution is valuable but, their relevance is hindered by the inclusion of irrelevant graphs and the limited adoption of more interactive features. Therefore, the daily use was extremely limited.

The underutilization of dashboards, for example with quality monitoring was attributed to inadequate training. Most users were not equipped with the skills or knowledge to leverage advanced features, such as configuring Statistical Process Control (SPC) charts or analysing Corrective And Preventive

Action (CAPA) metrics. Moreover, the static nature of current dashboards limited their interactivity, reducing user engagement and trust in the tool's capabilities.

Participants also expressed a lack of confidence in dashboard data accuracy, which further discouraged adoption. S8 for example revealed that "*I often export the data manually because I don't trust the dashboard to provide accurate figures*". Therefore, the dashboards were often bypassed in favour of manual data exports to external tools, where users felt they had greater control over the output and could trace from where the data originated from. This trend underscores a gap between the capabilities of dashboards and user trust in their outputs.

4.3 Customization Needs for User-Specific Dashboards

The necessity for customizable dashboards was another significant finding (7/8). Interviewees consistently emphasized the importance of tailoring dashboards to meet the diverse needs of distinct roles, such as lab workers, managers, and technicians. However, the lack of intuitive customization tools emerged as a major barrier to achieving this.

For example, S1 stressed the value of role-specific dashboards, proposing that lab workers benefit from task-focused interfaces that display daily priorities and workload distribution with the following statement: *"Having a 'My Dashboard' feature would allow each user to set up a personalized view, instead of relying on static layouts."*. Similarly, S3 suggested implementing a "My Dashboard" view, enabling users to create personalized layouts tailored to their responsibilities. However, in most cases, the users still relied quite heavily on developers to configure their dashboards, which limited their ability to adapt tools to their evolving needs.

The rigid structure of current dashboards was particularly problematic in organizations, where laboratories with diverse operational models required significant customization S6 mentioned. Interviewees expressed frustration with the reliance on SQL queries and developer intervention for even minor adjustments. This lack of flexibility restricted the usability of dashboards and reduced their perceived value. S8 similarly expressed the desire for dashboards that allowed for seamless, user-driven adjustments without requiring technical expertise. This was also highlighted by S3 who said that *"Right now, all modifications must go through IT, which delays simple changes that could improve our efficiency."*

4.4 Technical and Visual Challenges

Technical and visual challenges emerged as significant barriers to the effective use of dashboards in laboratory environments from many of the interviewees (6/8). These challenges often hindered user engagement, restricted scalability, and reduced overall functionality. Interviewees frequently highlighted issues with data scalability, noting that as datasets grew larger, visual elements on dashboards became cluttered and unreadable. For example, S7 stated the following: *"The current graphs are hard to read, and overlapping labels make them almost useless for larger datasets."* S2 described similarly how overlapping x-axis labels and poorly scaled graphs rendered some visualizations ineffective, particularly when analysing large datasets over extended periods. In one instance, S6 showed how attempts to visualize multi-year trends led to unintelligible outputs, forcing users to external tools for clarity.

Many dashboards were described as static and lacking interactivity, with users unable to tailor the visualizations to their own process specific needs. S4 stated that *"If we could drill down into the data and interact with graphs dynamically, it would improve usability significantly."*. This emphasized the importance of interactive features like drill-down capabilities and dynamic resizing of charts to enhance usability. Similarly, S3 noted that the absence of basic customization options, such as adjusting colour schemes or prioritizing metrics, left users feeling constrained and unable to adapt dashboards to their evolving workflows.

Several participants also pointed out that the visualization tools integrated into dashboards were outdated and insufficient for modern laboratory needs. Charts and graphs were frequently described as overly simplistic, with little variety beyond basic bar and pie charts. S1 and S6 expressed frustration with the lack of advanced visualization options, such as histograms or sparklines, which could provide more granular insights. For instance, S7 suggested incorporating throughput time charts as a basic option to track the duration from sample receipt to completion, offering a clearer view of operational efficiency.

Performance issues compounded these challenges, especially for laboratories managing large volumes of data. Dashboards often struggled to manage extensive datasets, with prolonged loading times and occasional freezes. Any such performance can also affect the entire system if the dashboards were to be of frequent use. S6 described how generating reports on multi-year datasets could cause significant delays, disrupting workflows and diminishing trust in the system. S8 also recounted instances where attempting to summarize thousands of samples overwhelmed the dashboard, forcing users to turn to external tools to be able to get results.

In addition to technical limitations, poor layout design and inefficient use of screen space were recurring criticisms. S3 observed that small chart sizes and wasted white space made it difficult to interpret key metrics quickly by saying that *"Charts should be scalable and resize dynamically to avoid wasted screen space."*. S7 highlighted the challenges of navigating such layouts during lab meetings. The inability to resize or reconfigure dashboards to emphasize critical metrics further limited their practicality for daily use as a configured dashboard is locked and cannot be configured on the go.

These findings all underscore the need for substantial improvements in the design, how dynamic the charts are and the scalability of dashboards to meet the more complex and evolving needs of laboratory environments.

4.5 Quality Monitoring and Process Control

Dashboards were widely recognized as essential tools for quality monitoring and process control, offering laboratories a centralized platform to oversee operational performance and compliance. Despite their potential, many (5/8) interviewees expressed that current implementations often fell short of expectations, particularly in their ability to deliver actionable insights and facilitate proactive quality management.

The ability to monitor error rates in real-time was cited as a critical feature for ensuring system reliability and data accuracy. For example, S2 said that *"We track error rates using dashboards, but more advanced features like trend analysis are missing."*
Even though the dashboards were used to track data transfer errors between offices and external organizations was deemed valuable, participants highlighted significant limitations in the visualization tools available. Current dashboards lacked advanced features, such as detailed trend charts, which are crucial for identifying patterns and anomalies over time. Without these capabilities, users found it challenging to gain a comprehensive understanding of the underlying issues, hindering their ability to implement long-term corrective actions.

For quality assurance to be effective, granular insights into specific failures are essential. However, existing dashboards often provided only aggregated data, leaving users to rely on manual investigations to uncover actionable insights. This inefficiency not only consumed valuable time but also increased the risk of oversight, particularly in laboratories handling high volumes of samples.

Statistical Process Control (SPC) models were identified as a critical addition to enhance quality monitoring especially by S3 saying *"Integrating SPC models and CAPA tracking would make dashboards more valuable for quality control."*. Integrating SPC charts into dashboards would allow for real-time visualization of performance metrics, such as deviations from control limits. This capability would enable laboratories to detect emerging issues promptly, reducing the likelihood of recurring problems. A dashboard displaying SPC metrics for quality control samples could highlight trends in deviations, allowing managers to implement pre-emptive adjustments before they escalate into quality lapses.

Corrective and Preventive Actions (CAPA) systems are integral to sustaining high-quality standards, yet their integration with dashboards remains underdeveloped. By linking CAPA systems to dashboards, users could access real-time metrics on unresolved incidents, categorized issues, and recurring problems. Visualizing CAPA data would help managers identify patterns, prioritize interventions, and evaluate the effectiveness of corrective measures over time. For example, a dashboard could display a breakdown of incidents by category, enabling users to allocate resources effectively to address the most pressing concerns.

4.6 Predictive and Resource Planning Features

Five out of eight (5/8) participants regularly underlined the value of predictive and resource planning tools in dashboards since they may transform laboratory management by simplifying processes and thereby preventing inefficiencies. These features were seen to be essential for controlling workloads, allocating resources, and guaranteeing operational continuity.

Using past data, S6 explained the need of dashboards able to forecast job completion times and workload peaks. Visualizing these trends and patterns will help laboratory managers to proactively distribute resources to avoid congestion during times of great demand. Such dashboards, for instance, can show expected processing durations together with forecast sample inflow for the next week, therefore enabling managers to plan staffing or scheduling changes based on possible workload increases. A key component of laboratory efficiency was seen as being this capacity to predict and reduce workload issues.

S1 underscored the following *"A dashboard that displays real-time capacity usage would be a game changer."*. This would increase the value of dashboards that monitor and display resource utilization rates. By presenting real-time and historical data on operational capacity, such dashboards would enable managers to assess whether their resources were being fully utilized

or underutilized. For instance, a laboratory running below capacity might reassign tasks or consolidate operations to optimize productivity, while one nearing full capacity could adjust workloads to prevent staff burnout or equipment overuse. These insights would help laboratories maintain an equilibrium between resource availability and demand, ultimately enhancing their overall efficiency.

S8 added that integrating maintenance schedules into dashboards would provide a comprehensive perspective on instrument availability and calibration requirements. This statement was corroborated by S3 who said that *"Including maintenance planning would prevent scheduling conflicts when instruments are unavailable."*. This integration would allow managers to align operations with maintenance schedules, ensuring critical instruments are not overbooked or unavailable during key workflows. For example, a dashboard showing upcoming calibration or downtime periods for essential equipment could enable managers to reschedule tasks requiring those instruments, minimizing disruptions and delays. Such visibility would be particularly useful for laboratories that rely on highly specialized instruments with limited availability.

Participants widely agreed that predictive analytics could elevate dashboards from static monitoring tools to dynamic strategic planning aids. Features like forecasting workloads, tracking resource utilization, and integrating maintenance schedules would transform dashboards into comprehensive management tools. This enhanced functionality would empower managers to make data-driven decisions, improve operational efficiency, and align resources with both current and future demands, ensuring laboratories remain agile and responsive in their operations.

4.7 Integration with External BI Tools

The integration of dashboards with external Business Intelligence BI tools was a recurring theme throughout the interviews (5/8). Interviewees frequently relied on BI tools for advanced analytics, as dashboards were often perceived as inadequate for complex data exploration. However, the dashboard's main advantage is of course that it is based on the live data compared to the external BI tools which could be infrequently updated and therefore not provide the correct insights needed for the current situation.

S2 reported using BI tools for financial reporting, while dashboards were limited to operational overviews. S4 noted that dashboards lacked the depth required for detailed statistical analyses, prompting users to adopt external solutions. S6 proposed a hybrid model where BI tools were integrated into dashboards, combining the real-time functionality of dashboards with the

analytical power of BI tools. S6 also said that *"PowerBI is our main analysis tool. Dashboards work for a quick overview, but they can't replace proper BI tools."*. Interviewees agreed that this approach could bridge the gap between operational insights and advanced analytics as the more advanced tools from the BI software could now use the live data from the laboratory to provide powerful insights.

4.8 Training and Documentation Gaps

Training and documentation gaps emerged as a larger barrier to dashboard adoption by 5/8 of the interviewees. Participants consistently reported insufficient initial training and a lack of follow-up sessions to address advanced features. S8 stated that *"Most of what I know about dashboards, I learned through trial and error."*[1]

S2 further highlighted that many users often relied on a learning by doing approach to master dashboard functionalities due to inadequate formal training. S7 emphasized the need for refresher sessions to keep users informed about new features and updates by stating the following: "*We had initial training, but follow-ups are needed to cover more advanced features.*". S1 suggested that comprehensive documentation, including interactive tutorials and detailed manuals, could empower users to explore dashboards more effectively. Interviewees agreed that structured, ongoing training was essential for maximizing the utility of dashboards.

The absence of integrated communication and notification tools within dashboards was identified as a missed opportunity to streamline workflows. Participants proposed features such as task alerts, bulletins, and real-time notifications to enhance operational efficiency. These are somewhat available in the product itself but their integration with dashboards is very limited.
S7 envisioned a notification system to alert technicians about high-priority tasks or equipment issues. Similarly, S3 suggested using dashboards as information channels to provide updates on pending tasks and system changes. These features were seen as crucial for reducing reliance on external communication tools like for example email and making task prioritization easier.

4.9 Geographic Data Visualization

Geographic data visualization was highlighted as a valuable feature to be added to the dashboards. 2/8 interviewees suggested incorporating mapping tools into dashboards to track sample locations or customer distributions,

[1] Det mesta jag har lärt mig om Dashboards, har jag lärt mig genom att pröva mig fram.

enhancing operational transparency and providing a graphical overview of the operations.

S2 described a mapping interface used to display sample collection points, while S6 said that *"We use geographic data to track customer locations, but it's not well integrated into our dashboards."*.
Therefore, using geographic data to optimize laboratory services could be beneficial. While geographic data visualization is available in the product it is not easily integrated with current dashboards rendering them less valuable.

4.10 Financial Reporting and Metrics

Finally, financial reporting and metrics emerged from 2/8 interviews as a key area for development. Participants expressed interest in dashboards that tracked costs, revenue, and resource efficiency.

S6 described dashboards that estimated revenue from unfinished work, while S4 stated that "*Financial reporting is one of the main reasons we still rely on external BI tools.*". This highlighted the potential for linking financial metrics with LIMS and the dashboards. Such features were seen as valuable for administrative users, providing insights that could inform decision-making and financial planning.

5 Discussion

In this fifth section the researcher will return to answer the research questions that was stated in the beginning of the thesis. Beyond that the researcher will also try to discuss the results that came from the analysis and how and if they correlate with the literature review. Finally, the researcher will try to draw some conclusions and give some suggestions for the company this study was made for as well as what future research should be if that is needed to further improve the product.

5.1 Answers to the research questions

RQ1: How are users experiencing using the dashboard?

The researcher found that the dashboard module in laboratory settings is largely underutilized due to usability challenges, limited customization options, and insufficient training seen mainly in Chapter 4.2. End-users often must rely on external Business Intelligence (BI) tools, such as PowerBI and Qlik, because the dashboards lack advanced analytics and interactive features as stated in Chapter 4.7. This reliance limits the role of dashboards to basic operational overviews, such as sample tracking and monitoring system errors, rather than supporting strategic decision-making and quality control as can be seen from Chapter 4.5.

The major usability issue identified is the lack of customization as already mentioned earlier, which forces users to depend on developers for modifications, creating inefficiencies as the lead time for change can grow rather long as seen as in Chapter 4.3. Furthermore, Chapter 4.4 highlights performance issues, including slow response times and difficulties handling large datasets, as a second issue that would hinder dashboard adoption. Additionally, from Chapter 4.2, users expressed concerns over the data accuracy and trust of where the data came from, leading some to bypass dashboards entirely in favour of manual data exports to external tools to be able to reliably process it.

RQ2: What is the value of the dashboard for users? Current and future?

The dashboard is now working mainly as a monitoring instrument for overseeing sample status and workload allocation. However, its complete potential remains unexploited owing to limitations in interaction and predictive insights as presented in Chapter 4.2. Chapter 4.6 highlighted that a considerable number of users perceive the dashboard as lacking sufficient real-time

capabilities, hence diminishing its effectiveness for supporting laboratory activities.

Users contend that dashboards could provide substantially more value in the future with the implementation of many essential features. A commonly cited enhancement from Chapter 4.3 is the necessity for more interactivity, specifically via drill-down functionalities and refined graph scaling, facilitating more profound data interpretation. Furthermore, Chapter 4.6 stated that including predictive analytics for workload assessment and resource allocation would enable laboratories to foresee workload surges and constraints, facilitating improved scheduling and operational efficiency.

A further potential enhancement involves expanding the dashboard's functionalities in quality monitoring and process control efficiency. Chapter 4.5 presents that the integration of the products other capabilities like Statistical Process Control (SPC) models and Corrective and Preventive Actions (CAPA) tracking will facilitate a more methodical method for ensuring compliance and operational. Users demonstrated a significant interest in communication and notification functionalities, including task alerts and real-time updates, to diminish dependence on external communication tools such as email and to enhance internal task coordination as shown in Chapter 4.8.

Furthermore, numerous users in Chapter 4.10 emphasized the necessity for dashboards to include financial reporting tools, allowing them to monitor expenses, resource allocation, and revenue forecasts from within the system. Geographic data visualization was seen in Chapter 4.9 as a critical area for enhancement, as mapping sample collection locations and monitoring contamination trends would yield significant insights into laboratory operations. Currently, dashboards are predominantly utilized for operational tracking; however, users highlighted in Chapter 4.7 that a more seamless integration with BI tools, such as PowerBI and Qlik, would greatly enhance their analytical depth and relevance for strategic decision-making.

RQ3: What is required to improve the dashboard to meet the identified user requirements?

To increase usability and optimize value, several essential enhancements were found. A primary necessity is enhanced customisation and personalization. Users underscored the necessity of creating role-specific dashboards customized to the distinct requirements of laboratory personnel, supervisors, and technicians. The implementation of a "My Dashboard" feature would enable users to customize their data presentation and retrieve pertinent information more effectively as explained in Chapter 4.3. Moreover, in Chapter

4.3 it was also concluded that facilitating non-developer modification would empower users to modify layouts and set data presentations independently of technical assistance, hence enhancing flexibility and accessibility.

Enhancements in usability and design were deemed essential. Numerous users observed as in Chapter 4.4 that enhancements are required in graph scaling and display clarity, especially when managing extensive datasets. The incorporation of drill-down functionalities from Chapter 4.3 would enable users to analyse data trends more efficiently, offering a more intuitive and insightful experience. Furthermore, dashboards must provide real-time updates from findings in Chapter 4.6 to guarantee that users may depend on them for dynamic monitoring and decision-making, instead of resorting to external technologies for more immediate data insights.

The necessity for enhanced training and documentation was a consistent issue presented in Chapter 4.8. A multitude of customers indicated inadequate instructions for proper dashboard utilization, resulting in diminished confidence in its features. Offering interactive tutorials, training videos, and a Frequently Asked Questions section (FAQs) would facilitate the closure of this knowledge gap and promote increased system adoption. The implementation of template dashboards, intended to assist inexperienced users in swiftly establishing and personalizing dashboards to meet their individual requirements, was recognized as a crucial element in Chapter 4.8 enhancing the onboarding experience.

In addition to usability and training, users emphasized the necessity for enhanced integration with external technologies. The integration of predictive analytics would allow the dashboard to more precisely assess workloads and resource needs, assisting managers in optimizing laboratory operations more efficiently as shown in Chapter 4.6. Enhanced integration with BI tools like PowerBI and Qlik was deemed crucial in Chapter 4.7 for enabling dashboards to augment, rather than rival, current analytical systems. Geographic data visualization capabilities, including the tracking of sample locations and the monitoring of contamination patterns, were identified in Chapter 4.9 as significant improvements that would augment the strategic value of the dashboard. The implementation of communication tools, such as task notifications and system bulletins as presented in Chapter 4.8, would enhance workflow efficiency, and diminish the necessity for external coordination.

5.2 Reflections on results in contrast to literature

The results of this study, obtained from semi-structured interviews and thematic analysis, correspond strongly with the theoretical framework outlined in the literature review. The study's principal issues, such as dashboard

constraints, customisation requirements, usability challenges, and the significance of training, are firmly rooted in known ideas of usability, user-centred design (UCD), and customer value.

The literature analysis highlights that user-centred design (UCD) is essential for guaranteeing usability and efficiency in digital interfaces (ISO 9241-210, 2019). The research findings corroborate this, as numerous users indicated difficulties in creating dashboards to satisfy their requirements due to inflexible structures and insufficient straightforward customization options. The usability aspect of the research, which emphasizes problems such as suboptimal visualization, insufficient data scalability, and absence of interactive elements, clearly aligns with the literature's discourse on effective User-Centred Design principles (Preece, Rogers, & Sharp, 2002).
A notable discovery in the study was the absence of initial and continuous training, leading to the underutilization of dashboards. This corroborates the literature's claim that usability encompasses not only interface design but also the necessity for users to comprehend and interact effectively with the system (Nielsen, 1994). According to research, usability testing and heuristic evaluations may enhance the dashboards to more effectively meet users' requirements (Hartson, Andre, & Williges, 2003).

Customer value, as delineated in the literature, comprises functional, experiential, and symbolic elements (Smith & Colgate, 2007). The results provided in this study substantiate this framework by demonstrating that although dashboards offer functional benefits in monitoring sample statuses and system notifications, their complete potential is hindered by usability issues. The absence of personalization and scalability constrains the experiential value for consumers, diminishing overall happiness (Almquist, Senior, & Bloch, 2016).

Furthermore, as noted in literature, dashboards must correspond with customer workflows and facilitate strategic decision-making (Grönroos, 2007). The survey findings indicate that customers depend on external Business Intelligence (BI) solutions like PowerBI and Qlik for comprehensive analytics, implying that dashboards inadequately fulfil their strategic requirements. This corresponds with studies supporting dashboards that incorporate predictive analytics and interactive data exploration to augment consumer value (Kauppinen et al., 2009).

A significant theoretical discourse in literature pertains to the necessity of training and knowledge retention for optimizing the efficacy of digital instruments (Holzinger, 2005). The findings in this study indicate that insufficient training leads to the underutilization of dashboards. This immediately corroborates the literature's assertion that usability must transcend interface

design to include training tactics that empower users to proficiently traverse and utilize dashboards (Hornbaek & Frøkjær, 2009).
The literature indicates that iterative training, interactive tutorials, and thorough documentation improve user engagement and long-term memory (ISO 9241-210, 2019). The findings presented here indicate that users would gain from organized training sessions and improved documentation to address knowledge deficiencies and promote dashboard utilization.

Predictive analytics and resource planning are crucial for enhancing laboratory operations, as presented in literature (Creative RE and Customer Value Evaluation, 2019). Findings presented here indicate that customers need dashboards that predict workload increases, track resource usage, and incorporate maintenance schedules to improve operational efficiency. These findings align with the literature's focus on predictive tools that enhance decision-making and workflow management (Flint, Larsson, & Gammelgaard, 2008).

The literature review examines the synergistic function of dashboards and BI tools, contending that dashboards deliver real-time insights, whereas BI tools furnish more profound analytical capabilities (Nambisan, 2009). The interview findings validate this distinction, as customers often utilize PowerBI and Qlik for intricate data analysis while employing dashboards for operational monitoring. This substantiates the assertion that forthcoming dashboard development ought to prioritize enhanced integration with BI tools instead of striving to supplant them (Almquist et al., 2016).

The study results significantly align with the literature review, reaffirming essential theoretical ideas such as user-centred design, usability, customer value, and predictive analytics. The necessity for enhanced training, superior customisation, and effortless interaction with BI tools corresponds with current research on dashboard optimization. Future enhancements must focus on these elements to transform dashboards from rudimentary monitoring instruments into sophisticated, user-centric decision-support systems.

5.3 Applicability

The research detailed in Improving the Value of a Laboratory System dashboard through User-Centred Approach provides significant insights into usability problems, modification requirements, and training deficiencies related to laboratory dashboards. The study concentrates on the LabVantage LIMS dashboard of Whitelake Software Point Oy; however, its conclusions are applicable outside this specific scenario. Numerous reported issues—such as restricted interaction, inadequate training, and limitations in

managing extensive datasets—are prevalent obstacles in dashboard systems across diverse industries.

A primary finding from the research is the considerable underutilization of dashboards, frequently attributed to insufficient user training and awareness. This problem is not exclusive to LabVantage LIMS; rather, it is a prevalent concern faced by organizations that depend on dashboards for workflow management, monitoring, and data-driven decision-making. In the absence of adequate onboarding and continuous support, users often turn to external tools like PowerBI or Qlik for sophisticated analytics, thereby diminishing the perceived value of the integrated dashboard system.

The study underscores the necessity for improved customization options. The users' inability to customize dashboards for their individual roles without developer assistance results in inefficiencies and irritation. This difficulty is prevalent in various businesses where dashboards are anticipated to deliver both comprehensive operational summaries and detailed, task-oriented information. Implementing features like personalized dashboards, role-specific displays, and user-friendly configuration tools may greatly enhance user adoption and engagement.

Furthermore, the research underscores extensive usability issues, especially in relation to dashboard design and data presentation. Users often had challenges in analysing extensive datasets due to inadequate scalability, ambiguous labelling, and restricted graph customisation. These difficulties highlight the necessity of implementing a user-centred design methodology to guarantee that dashboards are both functional and intuitively accessible to various user demographics.

Although the study is conducted in a limited setting with only one product for one company, its conclusions are pertinent to various enterprises aiming to enhance their dashboard systems. Organizations dependent on real-time data visualization, process monitoring, or predictive analytics may experience enhancements in usability, integration, and training. The suggestions offered—such as incorporating predictive analytics, augmenting real-time data visibility, and expanding BI tool compatibility—conform to best practices relevant across various industries.

In conclusion, although the findings of this study are specific to the LabVantage LIMS dashboard, they are universally applicable to other contexts where dashboards are essential for operational efficiency and decision-making. Organizations aiming to enhance dashboard usability and user engagement can implement these findings by refining training methodologies,

augmenting customization options, and advancing data visualization approaches to more effectively address user requirements.

5.4 Recommendations to the company

The main suggestions for the company can be placed in three main categories. There are the features that should help the dashboard functions to have a higher usability and customer value from both a customer perspective as well as a developer perspective. The second category which might be the biggest, is knowledge or training which simply put is how easy it is to understand what the dashboard can do and how easy things might be to implement. Finally, the last category is marketing which concerns how the module is presented and sold to customers and how easily a customer will perceive value in the module.

5.4.1 Features

There are many new features that can and probably should be implemented in the dashboard module to increase customer value and usability. Many of these the researcher also wants to categorize as quality of life improvements to bring the dashboard module up to par to comparable products or competitors, so it is easier to identify the value of the module.

The main examples the researcher want to recommend to the company would be the management of the graphs in a multitude of ways like scaling, colours, and axis management, as well as having the possibility to drill-down from them into the data better. These are all lacking somewhat right now or are in a state where it requires a larger amount of effort from both the customer and developer to implement these things. Beyond that the suggestion would be to look at the possibilities to integrate other internal module functionality in new types of graphs or even external tools to be able to streamline processes without leaving LIMS.

5.4.2 Training and Knowledge

This might be the most important finding in this thesis regarding the module and has implications towards the rest of the software and how it is managed and improved. As found earlier, experience with the dashboard module was a limiting factor for many of the interviewees. They stated that training had been inexistent or very brief. As the product is very complex and since the dashboard module is but one part of it, it is understanding that the customers might have had to prioritise more important processes to implement first.

The recommendation for the company on how to alleviate this issue was with new training material that could easily be consumed like video material and concrete examples of dashboard implementations and more specific functionalities. Also, a catalogue of templates and use cases would help both the developer and customer to find out what is the potential of the dashboard module and what the actual needs are when trying to implement it.

A secondary issue that makes this issue more complex is that WSP are running multiple versions of the software in parallel as customers do not always stay on the lates version. The market WSP operates in is however quite slow due to regulations and the need for stability which means that customers, especially big ones, are slow to update to later versions creating the demand for this support for multiple versions. This means that the dashboard module can be implemented differently in older versions compared to new versions which can create issues when building the dashboards, but also potentially be a limiting factor if some features are removed or added in an updated version.

5.4.3 Marketing

As explained in the chapter about the company, WSP, goes through a tendering process to acquire a new customer. During this phase, the dashboard module is almost always a requested feature. Therefore, to get further in the tendering process WSP have to fulfil the requirements the customer asks for i.e. a dashboard module, even if the company might not have all the requirements fulfilled directly. There might be some features that need an iterative process. After this initial phase of fulfilling requirements, the company can receive the opportunity to showcase the dashboard module for a customer. However, even if this might be the first contact for the customer with the dashboard module it is still up to the customers discretion if they want to focus on it or on other more pressing matters for their laboratory processes. If a project is successfully sold to a customer there will usually be a training package or introduction package given to the customer so they can achieve a proficiency in the product. During this training, the dashboard module will be showcased again and talked about more in-depth but beyond this it is still up to the customer to decide what they want to focus on to be able to get their acquired system into production.

What this essentially means is that the dashboard module is not fully at the forefront during an implementation phase. This can then lead to a situation where the dashboard is harder to get it implemented if the customer, due to resource issues and not fully knowing what the dashboards can do.

The analysis and validation interview have suggested that this issue might be resolved partly if the training and knowledge recommendation is implemented. Other solutions require a look at WSP overarching processes and a better way to structure on how to sell in this module to alleviate the underutilization problem found in the results. Therefore the recommendation here is too produce a better process for when to introduce functionality to customers so they are not overwhelmed by the complexity in the product and try to find ways to have a streamlined process on what the company offers with the product from the sales and tendering process to the implementation phase and even after sales.

5.5 Limitations of the research and future research

The inherent limitation in the data collection process for dashboard improvements is rooted in the fact that the module has not been widely adopted across all company customers. The insights gathered are therefore limited to a subset of users who have already made the decision to implement the dashboard. This presents a potential bias: while the data reflects real-world usage, it does not account for perspectives from those who either opted not to use the module or lacked the necessary resources to integrate it into their workflows.

The exclusion of non-users from the study raises concerns regarding the broader applicability of findings. It is possible that organizations that have chosen not to use the dashboard could provide valuable feedback regarding barriers to adoption, whether due to usability concerns, lack of perceived value, or resource constraints. However, an alternative perspective suggests that focusing on active users ensures that the findings are highly relevant to the immediate target audience. These insights are grounded in actual experience, rather than hypothetical opinions, which could help prioritize meaningful enhancements.

Another key limitation stems from the influence of internal team members—developers, project managers, and consultants—on the assessment process. While their technical expertise provides crucial insights into system constraints and development needs, their perceptions of what end-users require may not always align with actual user needs. As the system's primary stakeholders, end-users (e.g., laboratory technicians and managers) are the ultimate decision-makers regarding whether the dashboard provides sufficient value to justify integration into daily operations. While internal teams have valuable experience in supporting customers, their perspectives are filtered through the lens of system design and troubleshooting rather than hands-on daily usage.

That said, internal interviews are particularly valuable in understanding technical aspects, system constraints, and potential improvements from an engineering perspective. Many usability concerns—such as the need for customizable dashboards, improved visualization options, and better real-time data handling—may not be fully articulated by end-users, but they are well understood by developers who observe recurring issues across multiple implementations.

A critical aspect of the findings is the gap between users with technical expertise and those with limited technical skills. Customers often do not have access to the same development tools or in-depth system knowledge as internal teams. This creates an additional barrier in terms of configuring dashboards or modifying them to better suit their needs. Many laboratory professionals lack extensive IT training, meaning that dashboard usability needs to prioritize intuitive design, pre-configured templates, and reduced reliance on developer intervention.

One strength of the study was the broad range of laboratory settings covered in the research, from large-scale industrial operations to smaller laboratory setups. This diversity allowed for an extensive range of use cases to be examined, offering insights into how different organizations interact with the dashboard. However, there is still an opportunity to expand the research further by conducting additional interviews within the same organizations or across similar industry segments. This would help solidify recurring patterns and further validate the findings.

Given these constraints, subsequent studies should contemplate the following:

1. Engaging Non-Adopters: Analysing the reasons behind certain clients' failure to utilize the dashboard may yield information into unmet demands or perceived deficiencies.
2. Direct End-User Studies: Executing further usability assessments with end-user laboratory personnel may reveal more challenges in navigation, accessibility, and customisation that can be improved upon.
3. Comparative Analysis: Assessing competitor dashboards or alternative solutions may yield standards for prioritizing changes or where there is a niche of functionalities where the dashboard module can excel.
4. Longer analysis of existing dashboard: Monitoring the development and evolution of dashboard usage over time inside businesses may enhance tactics for boosting engagement and utility.

6 Conclusions

This thesis examined the usability, value, and opportunities for enhancement of the laboratory system dashboard inside the LabVantage LIMS product. A user-centred approach revealed that although the dashboard possesses operational potential, its current implementation is underutilized due to usability limitations, restricted flexibility, and inadequate training.

The first research question investigated users' experiences with the dashboard. Although some deemed it beneficial for monitoring sample progress and workloads, many favoured external business intelligence tools like PowerBI and Qlik for more comprehensive analysis and drill down. Insufficient interactivity, rigid structure, limited data visualization, and sluggish performance, when datasets were large, were identified as the primary usability issues. Users demonstrated a lack of faith in data accuracy, prompting them to depend on manual exports to other products instead of the dashboard for their decision-making.

The second research question examined the existing and future value of the dashboard. Currently, it functions mostly as a monitoring instrument rather than an analytical resource. Future enhancements may increase its function in operational efficiency, quality assessment, and predictive workload analysis. By incorporating more sophisticated capabilities, the dashboard could transform into a strategic instrument that facilitates decision-making throughout laboratories.

The third research question concentrated on essential enhancements to fulfil user requirements. Improving customisation is a primary objective, enabling users to modify dashboards independently of developer support. Enhancing the data visualization, optimizing the efficiency for extensive datasets, and integrating business intelligence tools would significantly improve the usability in the dashboard module. The lack of training must be rectified through systematic actions and hands-on lessons with the customers to optimize user engagement.

This thesis provides a versatile analysis of dashboard usability, in context to what has been conducted in the company before; yet further research is recommended. Implementing user testing with sophisticated features, conducting comparative assessments of other dashboard systems, and engaging non-users may provide valuable insights for future development.

In conclusion, resolving the current usability issues, increasing the customization possibilities, and improving integration with external tools as well as internal modules and components are crucial for converting the dashboard

from a passive monitoring instrument into a vital element of laboratory administration within LabVantage. These enhancements will then hopefully promote adoption, valuable workflows, and increase the data-driven decision-making, guaranteeing that the dashboard satisfies both operational and strategic requirements within laboratory settings.

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Figures

Tables

Appendix 1 – Interview Agenda

The agenda is a summary of questions asked during all interviews and acts as guidelines during the actual interview. Not all questions were asked to all interviewees. Furthermore, it should be highlighted that these questions acted as a template only and therefore the actual question asked might differ based on what the ongoing interview revealed.

Introduction

1. Do you have any questions about the interview process before we begin?
2. Can you tell me about your professional background?
3. Your current role and responsibilities?
4. Experience working with laboratory information systems and dashboards.

Interaction and Usability

5. How frequently do you use the dashboard in your daily tasks?
6. Can you describe a typical workflow where you interact with the dashboard?
7. How confident are you in using the dashboard effectively?
8. Do you find the interface intuitive?
9. Are there any features that feel difficult or cumbersome to use?
10. What are the most common tasks you perform using the dashboard?
11. What do you find most useful about the dashboard?
12. What aspects of the dashboard do you find frustrating or lacking?
13. Have you encountered any performance issues, such as slow response times or difficulty handling large datasets?
14. Have you received formal training on how to use the dashboard, or have you learned through experience?
15. Do you feel that additional training or documentation would improve your ability to use the dashboard?
16. Does the dashboard allow you to tailor views or customize data presentation to meet your needs?
17. If customization is available, how easy is it to configure the dashboard to your preferences?
18. Do you feel limited by the current customization options?
19. What specific features or improvements would make the dashboard more useful for your role?

20. Would a personalized "My Dashboard" feature be beneficial for your workflow?

Customer Value

21. How does the dashboard contribute to achieving your work objectives?
22. Are there specific features that bring the most value to your daily operations?
23. Are there any missing features that would enhance your experience? Can you provide examples?
24. If these features were available, how would they change your workflow or efficiency?
25. Would you be willing to invest in additional dashboard functionalities if they improved your workflow?
26. How does the dashboard compare to other tools you use (e.g., PowerBI, Qlik, Excel)?
27. Would you recommend this dashboard to other professionals in your field? Why or why not?
28. Quality Monitoring and Process Control
29. Do you use the dashboard for quality control or process monitoring?
30. Does the dashboard help you track and prevent errors or deviations in lab processes?
31. Would the integration of other modules (e.g. Statistical Process Control (SPC)) improve its usefulness?
32. Predictive and Resource Planning Features
33. Does the dashboard help with workload planning and resource allocation?
34. Would you benefit from predictive analytics, such as workload estimation or instrument availability tracking?
35. How do you currently manage workload peaks and scheduling? Could the dashboard assist in this?

Developer and Implementation Challenges

36. From a developer's perspective, how easy is it to implement customer-requested changes?
37. What are the most usual challenges when modifying or improving the dashboard?
38. Are there specific changes that are particularly difficult or impossible to achieve?
39. Are there technical limitations in terms of data integration, visualization, or system performance?
40. Do customers require training, or are they able to use the dashboard intuitively?

41. What are the most commonly requested features or support inquiries regarding the dashboard?

Demo Session

42. Can you walk me through your most common interactions with the dashboard?
43. Can you demonstrate any workflows or tasks you find particularly easy or difficult?
44. Let's review some templates or existing configurations—do they meet your needs?
45. Are there alternative layouts or visualization formats that would improve usability?

Other additional questions used in some interviews depending on the discussion.

46. Do you think dashboards should have built-in notifications for pending tasks, sample delays, or system updates?
47. Would real-time notifications improve your ability to manage laboratory tasks efficiently?
48. Would integrating external BI tools (such as PowerBI or Qlik) with the dashboard add value?
49. Would financial reporting features, such as cost tracking and revenue projections, be useful in your work?
50. How do you currently track financial metrics related to lab operations?
51. Would integrating location-based data (e.g., sample collection mapping, contamination trend tracking) be valuable for your lab?
52. Have you used mapping tools in other BI or analytics platforms? How do they compare?

Final Thoughts

53. What are the biggest improvements you would like to see in the dashboard?
54. Is there anything else you'd like to share about your experience with the dashboard?