

Exploring requirements, new features, and design for a laboratory management tool developed by Meocon GmbH: the Q_alizer

Bachelor Thesis in Computer Science
submitted

by

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Abstract

Quality control in the pharmaceutical industry serves the purpose that only high-quality and safe drugs reach the market. This highly complex process needs to be monitored and planned carefully. Therefore, Meocon GmbH, a management consulting boutique for the pharmaceutical industry created the Q_alizer, an intelligent tool that analyses and visualizes the sample flow processes in quality control organizations and helps to uncover weaknesses. Since Q_alizer is in its early stages, no requirements engineering had taken place so far to check if all of the users' needs are fulfilled. Therefore, this thesis explores Q_alizer users' needs and Meocon's vision of the further development of the tool. A new prototype with new functionalities for KPI insights, planning, distributing and forecasting and a new design has been developed in Figma focusing on the outcomings of the requirements engineering. In evaluation, users were very impressed by the new features and new design but also made suggestions for further improvement.

Zusammenfassung

Die Qualitätskontrolle in der pharmazeutischen Industrie dient dem Zweck, dass nur hochwertige und sichere Medikamente auf den Markt kommen. Dieser hochkomplexe Prozess muss sorgfältig überwacht und geplant werden. Deshalb hat die Meocon GmbH, eine Unternehmensberatungsboutique für die pharmazeutische Industrie, mit dem Q_alizer ein intelligentes Werkzeug entwickelt, das die Probenflussprozesse in Qualitätskontrollorganisationen analysiert, visualisiert und hilft, Schwachstellen aufzudecken. Da sich der Q_alizer noch im Anfangsstadium befindet, hat bisher kein Requirements Engineering stattgefunden, um zu überprüfen, ob alle Bedürfnisse der Anwender erfüllt werden. Daher untersucht diese Arbeit die Bedürfnisse der Q_alizer-Benutzer und die Vision von Meocon für die weitere Entwicklung des Tools. Es wurde ein neuer Prototyp mit neuen Funktionalitäten für die KPI Erkenntnisse, Planung, Verteilung und Prognose sowie ein neues Design in Figma entwickelt, das sich an den Ergebnissen des Requirements Engineering orientiert. Bei der Auswertung waren die Benutzer von den neuen Funktionen und dem neuen Design sehr beeindruckt, machten aber auch Vorschläge für weitere Verbesserungen.

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Chapter 1

Introduction

The pharmaceutical industry is one of the most important fields of the Swiss economy, adding more than 25% of Swiss industrial created value, a 5.1 times higher productivity than overall economy, 46'800 employees and 36.0 billion Swiss francs nominal gross value added in the year 2018 [4]. Not only is the pharma industry an important part of the Swiss economy, it has also made a huge contribution to human health by developing drugs and treatments to fight humans most feared illnesses like cancer, heart conditions and many more. In the last two years, when COVID19 circulated around the world and killed a lot of people pharma became even more important in the battle to find a vaccine to end this global pandemic.

When a pharma company produces a drug in their production plants, the quality of the drug has to be ensured at all time. This ensured that only high quality drugs are put on the market. This assurance is supposed to be done from Quality Assurance (QA) units. During the production process, samples will be taken continuously from production to measure the quality of the drug. This is where Quality Control (QC) comes into play. They analyze the samples from production on different indicators. This process of quality control is complex, since often you only have a couple of hours to complete the analyses because a lot of drug ingredients are instabil. Further labor leaders have to keep track of all different projects, the belonging samples and their hold time, the analyses which have to be done, deviation reports that have to be written, and much more. All this makes the planning and monitoring around the lab very difficult. In the past planning and monitoring is done without any help from software except excel sheets.

To support lab leader of QC labs, lean lab managers and QA staff in their daily work, Meocon GmbH, a management consulting boutique specialized on lean lab projects, created a web based dashboard called Q_alizer over the past few years. This dashboard shows different key metrics of a laboratory such as all the work in progress, the throughput rate, input and output amount of samples and tests, and advanced analytics like ABC-XYZ analyses. The dashboard is currently designed in an excel manner with lots of tables and graphs. Because of the huge amount of information presented in the Q_alizer, users find it difficult in the past to filter out the information they really need. Further, the users need to interpret the data shown in the tables and graphs in order to gain insights and take the appropriate actions. This process is time-consuming and error-prone. Additionally, Q_alizer is in it's early stages and therefore knowledge about what feature users are missing is lacking.

Therefore, this thesis is focused on making the Q_alizer more user-friendly, by exploring new

functionalities users may be missing and by making the data visualization more understandable and lowering the data interpretation step for the users by presenting insights directly. As a first part, requirements engineering will take place. The main goals are to find out which information users of the dashboard really need in order to complete their daily work and to compare it to the information that is already presented in the Q_alizer. Further, problems users experienced with the Q_alizer in the past and unclear behavior of the Q_alizer should be discovered. Also, the vision from Meocon for the further development of the tool is incorporated. In a second part, a new design Mock-up for the Q_alizer will be created with a software called Figma. The design includes the needs and wishes gained in the requirements engineering part. At last, an evaluation of the new prototype will take place.

1.1 Main Contribution

The main contributions of this thesis are:

- Requirements Analysis to get acknowledgment on what information lab leaders need to perform their daily work.
- Requirements Analysis to get acknowledgment on what behavior of the Q_alizer is desired by users and which behaviour needs improvement.
- Requirement Analysis to collect Meocon's vision in how further developing the tool.
- A new prototype for the Q_alizer that is tailored for users needs and presents the desired information in an useful and understandable way and includes new functionalities.
- Through fitting information visualization, the data interpretation step is lowered and therefore, insights gained with the Q_alizer are less error prone and less time consuming.
- The new design provides insight and possible actions directly to users, and therefore lowers the amount of work for Meocons consultants in a massive way and makes the Q_alizer a standalone tool.
- The new prototype has many new functionalities users missed in the tool and thus making the tool more useful for users.
- All of the above mentioned points lower the barrier between the Q_alizer and the users and therefore improves Q_alizers usability and usefulness.

Chapter 2

Background

2.1 Quality Assurance and Quality Control in the pharmaceutical industry

The production of therapeutic products is a highly regulated process and is in Switzerland contained in the Federal Act on Medicinal Products and Medical Devices. The purpose of this act is to ensure that only high-quality, safe, and effective therapeutic products reach the market[9]. Further, drug production is regulated by the food and drug administration (FDA) and they defined manufacturing regulations, which are widely accepted and followed by pharmaceutical industries. This standard is called current good manufacturing practice (cGMP). To guarantee the high quality of a drug, each drug producing process has to be under surveillance of QA. The production of a drug in a pharma company happens in their production plants. The production is done in batches and samples are taken continuously from the production to get a momentum caption of the state of the drug. For a batch to be released, all quality measurements need to be in defined specifications. specifications that have been defined before by QA. For these quality measurements, the quality control units are responsible. They analyze all samples from production and evaluate the results. If a result is not in the specification, they inform production units and take adequate steps to further process. This process of quality control is complex because hundreds of different samples can arrive every day. All containing multiple analyses and different specifications. Further, samples have a specified hold time - the time in which a valid result needs to be obtained - which may be 3 hours, 24 hours, 3 days or more. This is due to the instability of different ingredients of a pharmaceutical product. All these facts make the organization and planning process of a QC laboratory rather complex. QC lab managers need to have an overview about which samples are currently in the lab, which analyses have to be done in which time, which processes and projects are currently produced in which producing plants, how well do their resources fit the needs and many more. They also need to distribute the work to employees in a meaningful way and manage the distribution of work and prioritize some samples before others[5]. In these processes, a lot of mistakes can happen. For example, a sample can be forgotten and overdue his hold time, which leads in the worst case to the loss of a batch or to a deviation report. A loss of a batch means a loss of many weeks of production and quality control work, which of course involves a loss of thousands or millions of Swiss francs. Further, the drug produced in this batch can not be distributed to patients, since the quality measurements are not fulfilled. Even when deviation reports are less serious, they can lead to significant reputation damage of that company, since the number of deviation reports written has to be published for

customers. For pharma companies it is therefore essential, not to lose any production batches and have as less as possible deviation reports. This means, a pharma company must ensure to minimize error happening. To avoid such errors to happen, good planning and monitoring of a lab is necessary. Before the development of the Q_alizer, pharma companies working with Meocon GmbH did not have any software to help them in the process of planning and monitoring their laboratories expect excel sheets.

2.2 Meocon GmbH

"Meocon GmbH is a management consulting boutique, focused on Strategy Development and Deployment, Business Transformation, Business Process Improvement, Operational Excellence, and Change Management mainly in Life Science and Health Care industries" [6]. It was founded by Fabio Oro in the year 2019. Since then, they have worked with various pharma companies around the globe and helped them solve business problems. One project of Meocon GmbH is the Q_alizer, which is presented in the following section.

2.3 Q_alizer - from data to insights to actions

"Q_alizer is an intelligent technology that analyzes and visualizes your sample flow and paper flow processes in your quality organization. I uncovers weaknesses and makes it more transparent, predictable and more effective. QC Lab/QA staff will receive a lean way to plan, predict, improve and report the current and future state of the organization, resulting in increased productivity and reduced maintenance." (Meocon, 2020). In QC labs, the Q_alizers takes following tasks:



Figure 2.1: Q_alizer for QC labs (Fabio Oro, 2020)

Q_alizer is a web-based dashboard deployed to the Google Cloud Platform. The cloud architecture ensures automatic scale-ability and low costs. The back-end is a containerized flask application implemented in python. The front-end is implemented in Angular. Upon opening

the Q_alizer, users can choose a data set which they want to look at. Once selected the data set, they are forwarded to Q_alizer's main page which is called "all graphs". On every page of the Q_alizer, users can apply various filters like test methods, analysis SOP's, projects, time frames, analysis groups, sample status and many more.

2.3.1 All graphs

- Input/Output (I/O) graphs: These graphs serve the purpose to show the user how many samples/tests arrive weekly and how many samples/tests are finished weekly. Further, users can see trends in which weeks more samples arrive or how the performance of how many samples are finished by the lab is rising/falling.
 - QC reception: showing the weekly number of samples/tests received by the laboratory
 - Authorized: showing the weekly number of samples/test authorized by the laboratory
 - Release: showing the weekly number of samples/test released by the laboratory
- Work in progress (WIP) graphs: The WIP describes how many unfinished work currently in the lab is. It is always desirable for a laboratory, to keep the WIP as small as possible. If the WIP rises, this is a sign that the performance of the lab is not sufficient for the work that arrives.
 - WIP development by status: showing the weekly work in progress by sample/test status divided into development statuses in pooling/in analysis and to be released
 - Current WIP distribution (Analysis SOP): showing the distribution of number of samples/test per analysis SOP and their statuses
 - Current WIP distribution (project): showing the distribution of number of samples/tests per project and their statuses
 - Current WIP distribution (method): showing the distribution of number of samples/tests per analysis method and their statuses
 - Total WIP distribution: showing the total WIP of number of samples/tests and the Sample Backlog
- Trough put time (TpT): The TpT is the time a sample/test takes from arrived status to released status. The lower the TpT is, the better. If the TpT tends to rise, this is also a sign that the performance of the laboratory is not sufficient for the amount of work that arrives.
 - In pooling/in analysis: showing the weekly throughput rate of samples/tests with status in pooling/in analysis
 - To be released: showing the weekly throughput rate of samples/tests with status to be released
 - Total: showing the total throughput rate of samples/tests in all statuses
- Performance: In this section, users can gain insights on how many % of released samples were released on time. The higher the On time performance, the better. If the on time performance is low, this is a clear indicator that the laboratory is not performing well enough.

- On-time performance: showing the weekly % off on-time performance of released samples.
- Weekdays: In this section, users can see on which days which work is done. The goal is to distribute the work consistent over all weekdays.
 - QC reception: showing how many samples/tests arrive on which weekdays in the lab
 - Authorized: showing how many samples/tests have been authorized on which weekdays in the lab
 - Release: showing how many samples/tests have been released on which weekdays in the lab

2.3.2 Advanced Analytics

For performing the advanced analytic, the first aggregation level can be done on test level or sample level. Further, a sub-aggregation can be done on Analysis SOP, method or project level. The section advanced analytic has two main analyses. First, there is a ABC-XYZ analysis, where the chosen sub-aggregation gets categorized in samples/methods/analysis SOP's that arrive steadily, in patches or seldom. On a secondly axis, the chosen sub-aggregation gets categorized by the volume that arrives. Therefore, users can gain insight on which aggregations are daily incomes and don't need to be planned extra and which aggregations need more attention.

2.3.3 Simulation

In this section, users can perform a WIP simulation by typing in numbers for total received samples/tests and their maximal capacity. Out of these numbers, a sample WIP is calculated and showed in a graph. This is especially useful to see if current resources will be enough in the future or not.

2.3.4 Labflow Analyzer

In this section, users select a time period in days, for example, 21 days and then a graph is produced where the users can see how long it took for a sample to change its status from released to QC reception to authorized. The line for each sample is colored in green, red, or orange. Where red stands for sample took longer than the chosen time period, green stands for a sample completed within the selected time period and orange stands for sample not completed yet.

2.3.5 Planner

This section is demanded for planning. Users can see all open samples/tests and prioritize them if they are urgent or neglect them if they are not urgent. After this step, users can see all samples/tests they have to analyze and they are grouped together on analysis devices. Further, free spaces on the device are shown and a user can assign samples to the free spaces. This assures optimal usage of resources. They can also export the plan of the week and distribute it to employees.

Chapter 3

Requirements Engineering

To get insights about the experience users made with the Q_alizer so far and what information is missing for them to perform their daily work, interviews with industry representatives took place. Interviewees were four people, from two different international pharma companies working together with Meocon GmbH. Additionally, meeting with members of Meocon GmbH took place in order to gain knowledge about their vision of further development of the Q_alizer.

3.1 Interview Protocol

Hello and welcome to today's interview. My name is Lynn, a bachelor's student in software systems at the University of Zurich. I also have a background in the pharma industry as I absolved an apprenticeship as a laboratory assistant in biology at Lonza and I continued working there in a QC Microbiology lab during my bachelor's semester holidays. In my bachelor's thesis, I am trying to improve the Q_alizer and therefore I would like to ask you some questions about your experience with the Q_alizer.

- But first, I would like to know something about you and your daily work. Can you please tell me something about you, your background and also a little bit about your position in your company and what your tasks involve?
- On a normal day, tell me about how you use Q_alizer in your daily tasks? How does it help you perform your tasks?
- What is your overall experience with the Q_alizer and why?
- Please tell me about the features of the Q_alizer you use most? In which cases do you use it?
- Which insights do you gain with this feature and how does it help you to perform your daily work?
- Are there other features you use often? What do you use them for? What are the insights?
- Did you experience any problems while using the Q_alizer? Which ones and when did they occur?
 - Can you tell me about a recent example when this problem raised?

- How did you deal with/resolve this problem?
- Does the Q_alizer offer features that you did not understand and what was unclear?
- What do you think about the planning feature of the Q_alizer, did you already use it?
- What do you think of the start page of the Q_alizer? Do you find it convenient?
- If you explain the Q_alizer to one of your team members, how do you do this at the moment?
 - Would it be useful for you to have a manual that explains the Q_alizer and its features that you can give to your team members?
 - Would you prefer this in a text or video format?
- Did you miss explanations in parts of the Q_alizer and where would this be?
- Can you think of information that would be useful for your work that is not presented in the Q_alizer? What would it be? We are coming to the end of the interview. I would like to thank you for taking the time to talk with me about the Q_alizer and your experience with it. It was very interesting to hear your point of view, and this will help me a lot in improving the Q_alizer. My next step of the thesis is to create a new design mock-up of the Q_alizer and I would like to ask you if you are interested in testing the new design once it is finished and have a short talk with me about the new design?

3.2 Interview Data

3.2.1 Interview Company A

Interviewees were two women working for company A¹, one of them being a lean lab project manager and the other being a global lean lab manager. They both mostly use the Q_alizer and especially its tables for creating monthly KPI reports, since they are important for lean lab management.

The features mostly used by them are the WiP, TpT and number of batches released in time. Further, they love the feature with the ABC-XYZ Analysis, because it gives them insights about which samples are the most important in their lab. Overall, they like the final version of the Q_alizer.

They would love to use the Q_alizer more for planning, but they have a problem with the planning feature since not all sample data is imported correctly in the Q_alizer. They import data in the Q_alizer by uploading an excel file to the share point, which is then hourly ingested into the Q_alizer. They use this way of importing data since they do not have a database in their company where all samples and the associated data is stored. They experienced significant mismatches in the number of samples on the excel sheet and the number of samples in the Q_alizer, the difference has dimensions above 100 samples. The missing samples are sometimes shown in the inconsistent data tab from the Q_alizer and sometimes not. They find this behavior very confusing and this leads them not to trust the data in the Q_alizer. They assume that the reason for this data ingestion issue to be not matching time stamp formats. Another issue is, that sometimes time stamp 3 comes after time stamp 4 in the Q_alizer, which is impossible since an analysis can't be finished before it has started. For them to use the planning tool, two things have to happen. First, the data ingestion issue has to be fixed, and second, more information on

¹Pharmaceutical company wished to stay anonymous

available machines needs to be in the Q_alizer. For example, they want to see if their resources (especially analysis machines) are enough for analysis future samples or not.

Further, they would love to have data about full time employees (FTE) currently working in the lab, since this is an important KPI for their monthly report. At the moment, the data is ingested hourly, but they would like to have a button where they can start the data ingestion at any point in time. They would like to have the opportunity, to export the ABC-XYZ Analysis in an table format, which shows which samples are in which category. Further, they want to overlap all graphs in the I/O feature and they would love to determine which of these four graphs to overlap. For example, they want to overlap the QC Reception graph and the Released graph and see it together in one graph. They are used to have overlapping graphs.

They find the name of the ageing table feature misleading. And they want to have the possibility to change the starting point of the Y-axes of all graphs (which is already implemented in Q_alizer but it was not clear to them that the axes are clickable and adjustable). Further, they find the coding scheme of Q_alizers graphs unintuitive and inconsistent. They suggest to use always the same color to show the same sample types.

They want to have an extra feature called Sequence analyser, which was introduced to them by Meocon, included in the Q_alizer.

The Q_alizer was explained to them by Fabio Oro and they explain the tool to their employees by opening the tool and go through the features. They find the Q_alizer mostly self-explaining and if they don't understand what a feature is for, they read the Cookbook. A guide that has been created by Fabio Oro. They use this guide more and more often and find it very supporting.

Both interviewees are interested in testing and giving feedback on the newly created Q_alizer prototype.

3.2.2 Interview Company A second

Interviewee were one men working for an international company A², he is an improvement and support leader in QC and has in the past worked in QA.

The features he uses most are the WiP, TpT and the advanced analytics. He uses the graphs especially for his weekly meeting on lab performance. Overall, he loves the final version of the Q_alizer and is very satisfied with it.

During using the Q_alizer he experienced following problems: In the ABC-XYZ table of the advanced analytics feature, the Y-axis is "None" and the filter for "sample type" is not working correctly. When all sample types are selected, everything works fine but once selecting only one or some of the sample types, wrong data is shown in a sense that only very few data points are shown in the table, which can't be true according to his data. In the on time performance graph, the sample type filter is also not working. Once selected a sample type, no data is shown in the on time performance chart. On the WiP graph, the Y-axis is "None". Further, when exporting the total WiP graph as image, the title of the graph is missing. The zoom button is not working on all different graphs, nothing happens when he clicks on it.

Overall, he does not like the way of filtering. If you press deselect all, you additionally have to click outside of the filters for the page to refresh and the filters do be deselected. This additional click and refreshing is unnecessary and time consuming for him.

When you click on the different columns of a graph, then an additional table opens where you can see which samples are actually in that bar of the graph. He would also like to have filters here. Further, on some graphs, this additional tables don't show up.

He ingests the data same as the people of the first interview, by uploading an excel file to the share point. This means that he has to copy the data from their intern excel file once a week

²Pharmaceutical company wished to stay anonymous

to the excel file on meocon's share point. He would love to omit this step by linking the data ingestion module directly to their intern share point with the excel sheet. Further, he would like to have a higher rate of data ingestion. At the moment, this is only done once a week, but he would like to have this done at least once a day.

When he explains the Q_alizer to his employees, he opens the tool and goes through the features. He would like to have an user guide for the features of the Q_alizer and additionally a short training (about 30 mins) with the meocon team to get explained the advanced features like advanced analytics and ageing tables.

He did use the Q_alizer only for monitoring so far, no planning activities were involved. This is due to the lean lab team at his site to be very new, but he plans to use the planning tool in the near future.

For him, every needed KPIs are already presented in the Q_alizer and he is not missing any information. Also, he did not experience data ingestion problems like the interviewees from the first interview.

Overall, he really like the simplicity and excel manner of the Q_alizer. He like things to keep simple. He has used other tools in the past, which were much too complicated. Also his employees are very used to this excel manner of presenting and filtering data and this makes it easy for them to understand the Q_alizer quickly. He could imagine having an additional start page of the Q_alizer, where the most important KPIs are shown. This KIP's, mostly the WiP, should be shown separately for each sample type (Raw Material, In Process Samples, Endfill samples and Stability Samples) with the monthly filter set to yes. And he would like to see week to week performance on the start page.

The interviewee is interested in testing and giving feedback on the newly created Q_alizer prototype.

3.2.3 Interview Company B

Interviewee were one men working for Company B³. He was lab leader from a biochemical laboratory for over ten years and now got a new position in lean lab management.

He used the Q_alizer only for three weeks until the time of the interview. He used it primarily to get insights and understanding about the state a laboratory is in. The most interesting features for him are the Input/Output KPIs and the WiP and TpT. It is important to him to find the weaknesses of a laboratory. He did not use the planning feature of the Q_alizer yet.

Overall, he likes the Q_alizer very much and is impressed by the insights he can gain with this tool. Further, he likes that he has now a way to show to the upper management, if the resources they currently have are enough to manage the current workload. If the resources are not enough, the KPIs presented in the Q_alizer are a good way to show the management that a lab needs more employees or material resources.

He did not experience any problems with the Q_alizer but to use the Q_alizer with greater depth, they had to fill out additional fields in their sample database (LIMS). This created extra work. By now, they try to fill out this fields continuously.

He would love to have also their performance shown in the Q_alizer (number of tests per person and day/week). Further, he would like to have the possibility to input a goal for different KPIs into the dashboard. For example, if he wants to have his WiP between 30 and 50, then the dashboard should show two lines by 30 and 50 in the WiP graph. It would be beneficial to him, to see what has changed compared to last week/last month. For example, the WiP has grown by 5% since last month. According to him, project managers are mostly interested in the future. For example, if three new projects come in in 3 months, he must know if the resources of a lab

³Pharmaceutical company wished to stay anonymous

are enough to stem this additional amount of work. He wants to see in advanced, how his WiP will change in these forecast scenarios. This would make planning of human and non-human resources a lot easier. Further, he wants to see which samples/tests cause a WiP increase at a glimpse, without having to apply a number of different filters before. It is important, to find the weaknesses of a laboratory, such that they can be omitted.

The interviewee is interested in testing and giving feedback on the newly created Q_alizer design mock-up.

3.3 Interview Analysis and Insights

In all three interviews, the users were pretty satisfied with the Q_alizer and its features. They are impressed by the possibilities and insights Q_alizer offers. In general, Q_alizer matches users needs, but there are some extensions wished by users. In the following, we will have a closer look at which aspects match users needs and which do not.

3.3.1 How Q_alizer fits users needs

The target user group of this tool are lean lab managers and lab managers. Both try to improve the productivity of a lab. To have an overview about the performance of a laboratory, they need to have knowledge about different KPIs and to get these KPIs, they are using the Q_alizer. They mentioned that following features are especially beneficial to them:

- The WiP shows, if the amount of work that is currently in a lab is increasing, decreasing or stays consistant. For a laboratory to be productive, the WiP has to stay small. If the WiP increases over a big timespan, then more and more unfinished work is accumulated and this increases the workload and the multitasking and thus lowers the productivity. Hence, it is important for a lab manager to know how high the WiP of a laboratory is and this need is satisfied with Q_alizers WiP graphs.
- The TpT shows the average time, in which a sample changes its status from arrived in the laboratory until it's release. This is important because it shows how fast a laboratory is working. If the TpT increases, this again points to problems in the laboratory. This is important for lab managers to know and this need is satisfied by Q_alizer's TpT graphs.
- Samples in a laboratory have a different hold time - the time in which a sample has to be analyzed and released. It is important for laboratories to not overdue this hold time, since often the production is dependent on the result of the analyses and can not continue with the next production step until the results are released. Hence, a lab manager need to know how many of it's received samples are released in time. This need is fulfilled with Q_alizer's performance feature.
- Further, users need to create weekly or monthly reports in their companies, to discuss and show to other employees the performance of a laboratory. For this, Q_alizer offers the feature to export all graphs into jpg files, these images can be easily included in the reports. This saves users a lot of time and is very appreciated by them.
- It is important for lab leaders to know, which samples deserve the most attention. If a sample type only arrives once a month or once a year, it is not that important to optimize it's analyses. But if a sample type arrives daily in big execution, it makes sense to optimize the processes of exactly this sample type. This will have much more impact on the

productivity of a laboratory than optimizing samples that arrive sporadically. Therefore, lab leaders have great interest in which sample types are their important ones. This need is covered by Q_alizer's ABC-XYZ analysis, which users love.

Coming to the design of the Q_alizers, users report that they find it most parts of it very intuitive and that they did not need any explanations on how to navigate through the tool. They especially like the simplicity and the excel similar manner, in which the tool is designed. They are used to excel and therefore it is easy for them to adapt their knowledge to use the Q_alizer.

In general, Q_alizer does a good job in giving users insights of the state of the art of a laboratory by showing them different metrics. Users are impressed by the ease different metrics are shown and they like to have all these metrics in one place, ready at all time without having to perform the data analysis by their selves.

3.3.2 How Q_alizer does not fit users needs

Talking about features, user explicitly named following features that they would like to have in the Q_alizer:

- an KPI for productivity, which they measure in number of tests performed per day and person
- a button where the data ingestion can be triggered whenever they want
- the possibility to overlay different Input/Output graphs
- the possibility to set goals for KPIs and to have them shown in the graphs as lines
- an KPI for FTE (full time employees)
- an additional filtering feature in the tab that opens when you click on data bars in the graphs (instead of the search feature)
- the possibility to export the ABC-XYZ analysis in a table format
- the sequence analyser tool included in the Q_alizer

Further, they reported that they would like to use the Q_alizer not only for monitoring the actual state of a lab, but more for forecasting. They especially want to know how their KPIs will change in the future and if their resources are enough to stem the workload coming. Which is not yet fully realized in the Q_alizer.

Users find it difficult, to get all the insights from the data that the tool offers. They have heard from Meocon, that by intelligent filtering, more insights can be generated. This insights can for example be which sample types are responsible for WiP increase, which tests are arriving the most and how high the variability of the laboratory is. Users would like to have a training for this purpose.

Additionally, users mentioned that they want to use to Q_alizer for planning and distributing work among lab employees.

Speaking about the design, users reported following issues/desires to improvement:

- more color consistency through the dashboard - data representing the same group of things should also be displayed in the same color
- clickable parts of the dashboard should also be recognizable as such

3.3.3 Bug list

The interviewees did also report several little bugs that should be fixed. Thus, the following bug list will be handed over to the developers of Q_Alizer such that they can include them in their back log and fix them as soon as possible. Since bug-fixing is not part of this thesis, they will not be further addressed.

- data ingestion timestamp problem from company A
- in the ABC-XYZ analysis, the Y-axis is labeled as none
- in the ABC-XYZ analysis, the filter "sample-type" seems to work not correctly. As soon as only some sample types are selected, only very few data is shown
- in on-time performance, the filter "sample-type" is not working correctly
- on the WiP graph, the Y-axis is labeled as none
- when the total WiP graph is exported, the title is missing
- the zoom button in the right corner of the graphs does nothing

3.4 Meocon's vision

Meocons vision is "from data to insights to actions" and they want to develop the Q_alizer in a direction, from which it is a standalone tool and does only need a very few amount of assistance from Meocons employees. At the moment, the dashboard is mainly a tool that collects, analyzed and presents data. To get insights from this data, Meocons consultants need to carry out weekly or montly meetings with the users to explain them the insights which can be derived from this data visualisations. In a future scenario, the tool should be able to present the insights directly to the users, thus omitting the data interpretation step for the users and also saving time for Meocons consultants. For example, instead of showing the WiP and the possibility to filter the data in order to know which samples are responsible for the WiP increase, the tool should directly display to the users which sample groups are responsible for the increase. At the moment, Meocons consultants also need to suggest different actions that should take place according to the data to the users. They observed, that these necessary actions are mostly the same in many different labs in different countries. In future, the tool should also tell the users, which actions they have to take in order to improve their KPIs and thus the productivity of the laboratory. Hence, the goal is to lower the consulting part of Meocon through the Q_Alizer. In addition, the tool should also have more features for planning and distribution the work in a lab to the different employees. Despite of actual missing data to implement all this visions, the new design of the Q_alizer should not be constraint by this missing data. The new prototype should be focused on this vision and provide a direction, in which the Q_alizer should develop in the next years.

3.5 Conclusion

In recapitulation of all the requirements engineering, the new design will be focused on implementing Meocon's vision of furhter developing the tool combined with users wishes of new functionalities. Insights shall directly be presented to users and thus lowering the data interpretation step for users. With that, also the need from users to have training for intelligent filtering in order to gain insights will be omitted. Further, the new prototype will also focus on

presenting possible actions to take for users. An additional feature for planning and distributing work in a lab to the employees will be included as well as a functionality to forecast the key performance indicators. Further, the design will implement visualisation principles in choosing colors that are consistent through the whole tool and do focus on presenting the data and not distract from the important parts.

Chapter 4

Related Work

4.1 Related Theory

4.1.1 Human-Computer Interaction Process

Human-Computer interaction is a multidisciplinary research field interested in the interaction between humans and digital systems. This research field touches upon computer science, psychology, sociology and design and places humans in the focus of research.

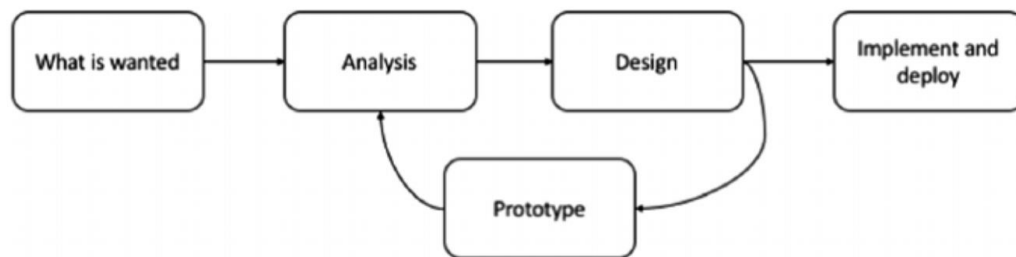


Figure 4.1: The HCI design process (Dix et al., 2004)

In the human-computer interaction process, the first step is called "what is wanted". This step focuses on exploring user's need and their habits in their natural environment, where they would use such a tool. A suggested tool is interviewing the users but can also be recording user's behaviour or observing the users when they are performing their daily tasks. In the next phase "analysis", researchers try to analyze the findings from the first step and formulate the main desires and problems users faced. These first two steps are essential to start the third step "design". In the design phase, researchers create a first design of how the application could and should look like. Once the initial design is mature enough and progresses towards the ideal solution, researchers can then start with the fourth step "prototype". In this step, a prototype is being created. This can be a paper or software prototype, where both have it's strengths and weaknesses. A paper prototype is fastly created and cheap but does not provide a deep interaction level. A software prototype on the other hand, takes more time to be created but also provides a deeper level of possible interaction. Once the prototype is finished, another analysis phase takes

place, also often referred as evaluation. In this phase, the goal is to explore to what extent the prototype is fulfilling users' need and if the design is logical and easy understandable for users. If it turns out, that not all of the defined goals are reached, again a design and prototyping phase starts with a following analysis phase. This circle continues until designers and users are satisfied with the prototype. Then the last phase, "implementation and deploy" can start, where the prototype is actually implemented in software, deployed and provided to users [1].

4.1.2 Dashboard Design

Dashboards are all around us and provide us with information to make decisions even when we do not recognize them as dashboards. For example the dashboard in the car shows us how fast the car is going, the RPM, how much gas is left, warning symbols and many more. This helps us understand the car and take actions based on data, for example if we recognize that we are driving too fast and put our foot on the brake. This example shows what dashboards are made for: dynamic displaying information to help people make decisions.

Since dashboards help people to make decisions, it is really important that they fulfill key aspects, otherwise they can lead people into the wrong direction and causing them to make bad decisions. For a dashboard to be great, it has to be:

- **Accurate:** the data and insights shown by the dashboard have to be accurate, otherwise users will not use it to make decisions. This means that the data quality has to be ensured, otherwise wrong data will be displayed which leads users to take wrong decisions. Further, all the data has to be shown and not only a non-updated part of it. This is why it is important, to show the users when the last data update has taken place.
- **Clear:** The data must be presented clearly with no distractions. This includes fonts, colors, context and layout. Fonts should never be decorative but fulfill a clear purpose. For example describing a chart with chart titles and axes labels. Therefore, sans serif fonts such as Arial, Helvetica or Verdana should be used. Also the font size has to be big enough such that the user can clearly read all the information. Colors in the dashboard should be easy on the eyes and be chosen consistently over the whole dashboard. Further, they need to contrast the background enough to see it clearly. Every part of the dashboard should be put in context, this means that charts should come with title, categorical labels and axis description. Since in most countries people read from left to right and top to bottom, the layout should be chosen such that the most important information is on the top left and the least important information is on the bottom right.
- **Empowering:** A dashboard should help people to make decisions and empower them. This means that the dashboard should be viewed regularly by users. If this is not the case, then the dashboard clearly misses its purpose and seems to be not useful to them.
- **Succinct:** While it is easy to put hundreds of interesting graphs on a dashboard, a good dashboard should only show the information that is really needed in a succinct way. Also it should be possible to view different data visualizations simultaneously, because scrolling prevents users from being able to compare these visualizations.

If a dashboard fulfills these four points, it's on a good way to be a great, useful dashboard [3].

4.1.3 Importance of good information visualization

Information visualization is a way of showing data in a graphical way to make it easier for viewers to understand the abstract connections of the underlying data. For a human scanning through thousands of datapoints is a hard task and it is also nearly impossible to see the underlying connection the data has. But once this data is visualized in a good way, it becomes much easier for humans to perceive information and interpret this data. But the task of information visualization is everything else than an easy task to do and doing information visualization in a wrong way can cause serious damages as various events in the past have shown. One such example is the so called challenger disaster. In 1986 the spacecraft Challenger exploded shortly after its take-off because of failure in O-ring seals. An investigation that took place after the disaster found out, that the cold ambient temperature caused the O-ring seals to fail. NASA engineers had tested O-ring seals with different temperatures before the accident and analyzed the data. The data visualization they used is presented in graph 4.1 [12].

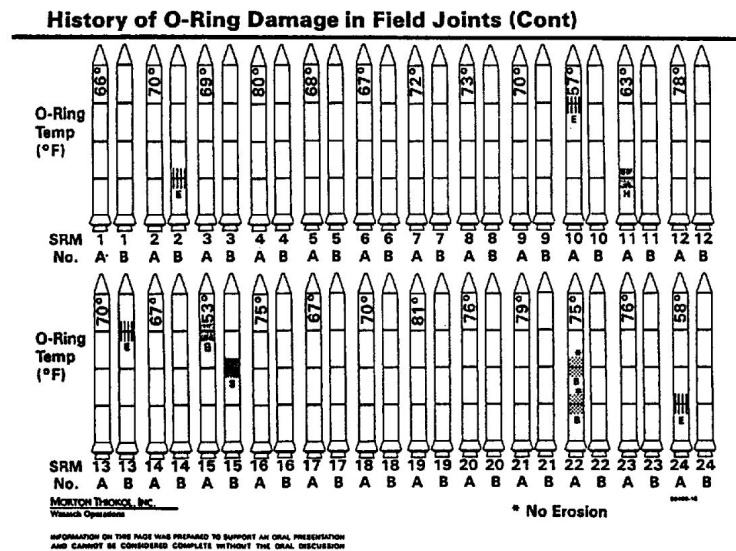


Figure 4.2: NASA's Visualization of O-Ring Damage in Field Joints (NASA, 1986)

Edward Tufte, an american statistician and professor emeritus of political science, statistics and computer science at Yale university published a book called Visual and Statistical Thinking: Displays of evidence for making decisions. In this books, he claims that the cause of the challenger accident was bad information visualization. In the visualization 4.2, the data is arranged by launch date instead of by the temperature, which is the critical factor. This made it impossible for the decision makers to see that weather below 66 degrees fahrenheit has high risk of O-ring failure. The temperature at launch was even way below this 66 degrees fahrenheit and was also never tested before. Tufte claims, that this bad information visualization led to a miscommunication between team members of NASA and finally to the explosion of the challenger and the death of all 7 board members. Would the data have been visualized in a better way, this tragedy could have been prevented [11]. This example shows the importance of right information visualization. Also nowadays, many examples of bad information visualization are produced and published every day. Since the data dealt with in the pharmaceutical industry is also crucial and

connected to human health and therefore needs to be visualized in a correct way, this chapter focuses on good and bad information visualization.

4.1.4 Data graphics theory

Lets start with the graph about the O-ring damage presented on image 4.1. The data was ordered by launch date instead of outside temperature at launch, which caused the decision makers not to be aware of the danger awaiting their astronauts when launching with such low temperatures. This shows that an accurate ordering of the data is crucial in information visualization. Further, the rockets displayed on the visualization are redundant and do not represent any data, this is referred as chart chunk and should be avoided at all costs because this draws the viewer's attention not to the sense and substance of the data and leads to distraction. In good information visualization only the data is inked and the non-data parts of the visualization remains uninked as much as possible. This makes the design much clearer and focuses attention to the data itself [10]. As Tufte summarized in his book, following principles are the most important in good information visualization:

- *Above all else show the data.*
- *Maximize the data-ink ratio.*
- *Erase non-data-ink.*
- *Erase redundant data-ink.*
- *Revise and edit.*

(Tufte, 2007, S.105)

4.2 Similar projects and tools

4.2.1 Laboratory Information Management Systems (LIMS)

Laboratory Information Management Systems (LIMS) have been developed and widely used by laboratories over the past twenty years. LIMS have the goal to map laboratory workflow processes. It collects data from various analysis devices and combines it with user input. Often, samples are registered in these LIMS systems by users and their status is updated whenever it enters a new processing step. This guarantees sample and result tracking which is required from the FDA to permit a drug to enter the market. It is important to know which samples have been taken from which production step at which time and what the results of the following analytics were to ensure the high quality of a drug. Monitoring and documenting these processes is exactly what LIMS are developed for [8].

Even if LIMS do a great job in these low-level monitoring of a laboratory flow, they do not allow to perform high-level analytics like showing the average time a certain processing step takes over a whole project or how many samples are unfinished within a project given a current time and many more. Q_alizer, therefore, aims to build upon such LIMS systems and allow high-level analytics upon the data collected by LIMS.

4.2.2 Dashboard Activities Tracker for a QC Laboratory

A prototype dashboard for activity tracking in a QC laboratory has been developed by the University of Puerto Rico using the DMACV (define, measure, analyze, design verify) methodology. The goal of the prototype was to increase the visibility of testing processes at a QC laboratory and thus improve resources utilization in terms of human resources and equipment. This prototype, for example, shows how long on average the lab needs for the steps testing request, sample arrival, testing process, results reporting, and results notification. By splitting up the sample testing process into these categories, the prototype allows deeper insights into the laboratory testing flow and helps uncover weaknesses. The showed that the sample's transportation uses a lot of time and this fact could be improved by reallocating the QC laboratory near the production plants. This would also reduce the human costs for transportation since no humans would be needed to transport the samples from one building to another. Further, they showed that using a dashboard that shows the activities and workload from QC lab processes allows more efficient resource allocation and utilization and lets users better react to unplanned testing events[7]. This prototype is in a sense similar to Q_alizer since both offer high-level analyses of

the data of QC laboratories' sample flow. However, Q_alizer aims to do much more than that by including many different advanced analytics tools.

Chapter 5

New Prototype

In this chapter, the prototype with new functionalities and new design is described. The Figma prototype can be accessed under the following link: [Prototype](#)

5.1 Overview page

This is the overview page of the Q_alizer. It is the start page that is immediately opened after opening the application. It serves the purpose of giving the users the most important information at a glance.

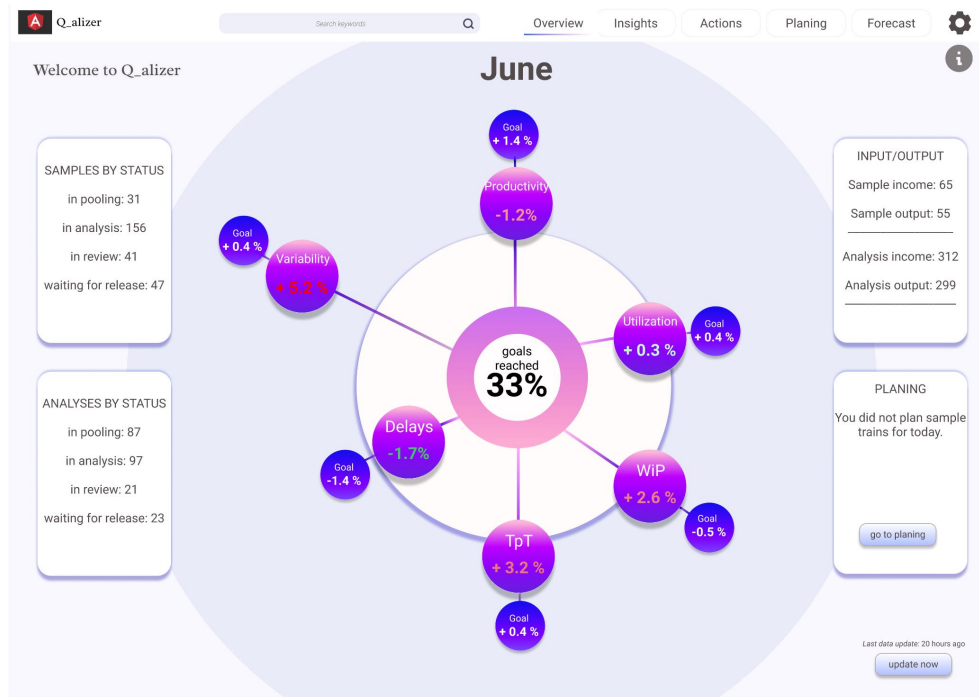


Figure 5.1: Q_alizer's Overview page

The left side shows the number of samples and number of analyses that are currently in the laboratory, sorted by sample status. This shows the user a current caption of the work that is currently sitting in the lab. The sorting by status is chosen, because the user can directly see in which parts the most work is accumulated. E.g. If there are many samples in pooling, this means that there are many samples that have to be analysed and this means that most of the work has to be done by laboratory technicians. On the contrary, if there are many samples waiting for release, most work is sitting by the scientists.

The graph on the middle shows the important KPIs of the laboratory which are tracked by Q_alizer. Every month, lean lab managers set goals for the next months for all of these KPIs. E.g. the lean lab manager decides, that they want to decrease the Work in progress by 0.5 % in June compared to the month before. The outer small bubbles exactly shows these goals that have been set for June. The big bubbles in the middle show the different KPIs and the change they have compared to the month before. E.g. the WiP has increased by 2.6 %. The longer the distance between the innerest circle and the big bubbles, the worse the result. E.g. Variability has increased by 5.2% which is a big change in the bad direction, hence the Variability bubble is far away from the innerest circle. The innerest circle shows you how many of your montly goals you are currently reaching. Imagine looking at the graph on the 24th of June, then you can interpret that you have only reached 33 % of your monthly goals yet. This graph serves the purpose that the users can see at a glance how their lab is currently performing and it gives the users the insights to directly intervene in parts of the laboratory where it is necessary. With this graph on the start page, the new Q_alizer is much more focused on setting and reaching KPI goals.

On the right side, the montly in- and output of the laboratory is shown. In optimum, the output is as big as or bigger than the input. This means that the lab finishes the work that enters the laboratory. The right bottom bar is dedicated to the planning of analyses. It shows the user if he has already planned the analyses for today, which is in this example not the case. The user can by clicking on the "go to planning" button directly go to the planning section of the Q_alizer. On the right bottom corner there is a button to update the data (ingest the data from database into Q_alier. This was until now done on hourly or daily basis by the data ingestion module of Q_alizer but it was a big wish of the users, that they can regulate and start the data ingestion by themselves.

Every page has an information button on the top right corner that gives the users information on how to interpret the graphs. On the navigation bar on the top of the page, users can navigate to other pages and also search for keywords in the search bar. Further, a user can also directly navigate to the insights pages of every KPI by clicking on the big KPI bubbles.

5.2 Insights

5.2.1 Productivity

On the Insights-Productivity page everything is dedicated to the monitoring of the Productivity KPI, which is defined as number of tasks finished per day and employee. The first part is dedicated to the current productivity the laboratory has. The graph can be filtered by many different groupings by clicking on the filter symbol at the top right corner of the graph.

The second part is dedicated to the productivity change in a selected timeframe. The change is by default grouped by the last seven days and by projects and analysis SOP. The grouping and timeframe can be changed by clicking on the filter symbol on the top right corner. This part serves the purpose to show the user at a glance in which specific areas the productivity has

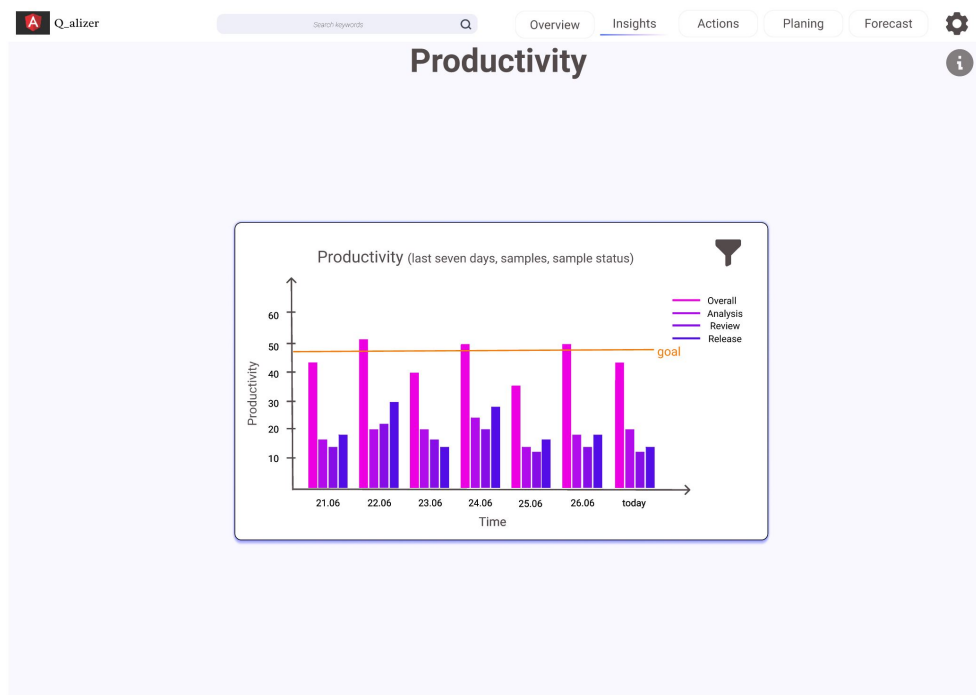


Figure 5.2: Q_alizer's Productivity page

changed. The user may get deeper knowledge about which projects are working good and which are not. Similar insights can be gained with all the other groupings.

The third part is dedicated to the productivity comparison between similar labs. Most of the pharma companies are international companies with many sides in different countries. It is not uncommon that there are labs in other sides that do very similar work to the laboratory of the user. This is why it is interesting to compare the productivity of similar labs to your lab. Maybe one of the other labs is much more productive in an explicit analysis and then it could be interesting to get in touch with them and look what they are doing better. This insights can then be adapted into the users lab and therefore increase this labs productivity. This feature was also wished by users in the interview.

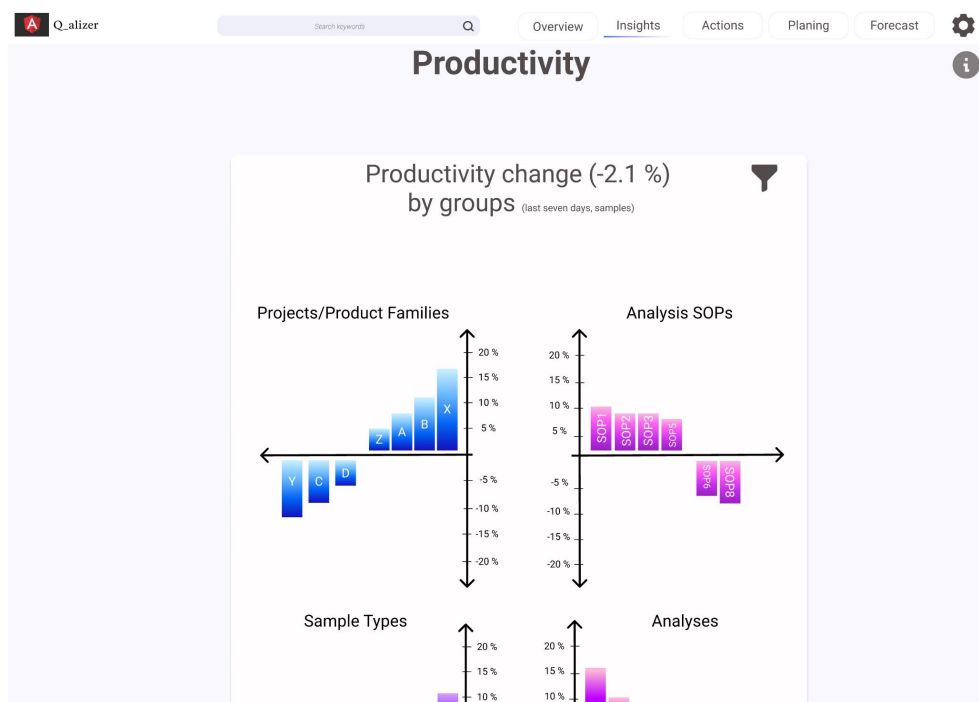


Figure 5.3: Q_alizer's Productivity page, second part

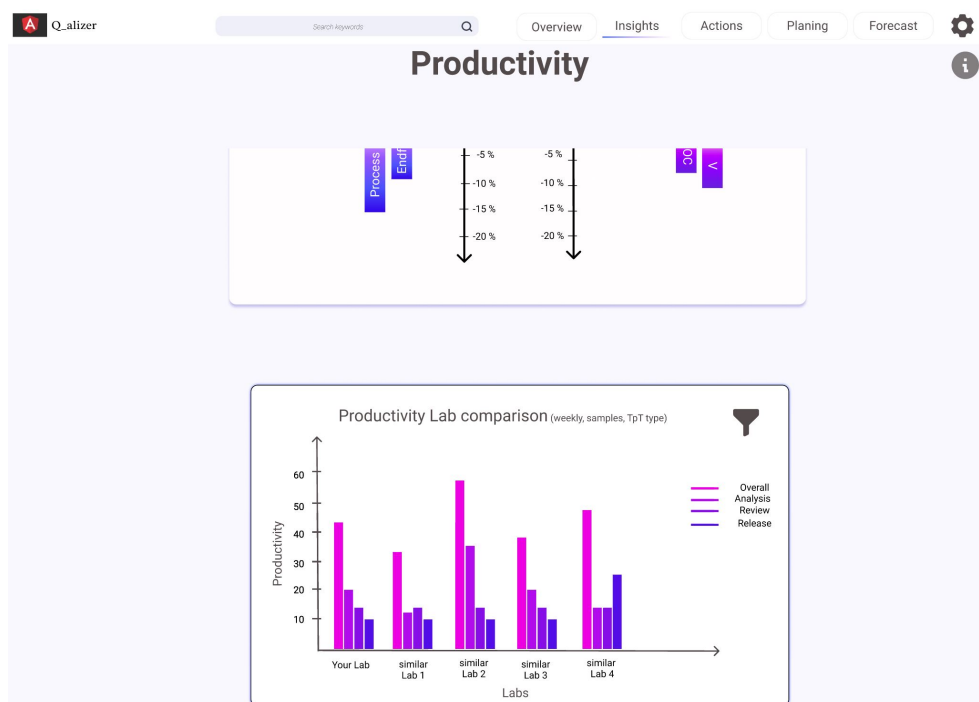


Figure 5.4: Q_alizer's Productivity page, third part

5.2.2 Work in Progress

The work in progress site is dedicated to insights all around the KPI Work in Progress. At the top, the current work in progress is shown. The first diagram shows the distribution of the current work in progress, grouped by default by projects, SOP's, Analyses and sample types. The groupings can be changed by the filter symbol on the top right. For users, it is especially useful to gain insights in which projects and which analyses they have accumulated a high work in progress. It could be the case, that the lab continuously increases his work in progress. In the old version of the Q-alizer, they could not find out in which parts the work in progress was growing. But in this version, the user can directly see where the problems are laying. It could be, that only one analysis is not working well and that there is a lot of work in progress getting accumulated. A lab leader can then directly look at the process of this analysis and try to improve it.

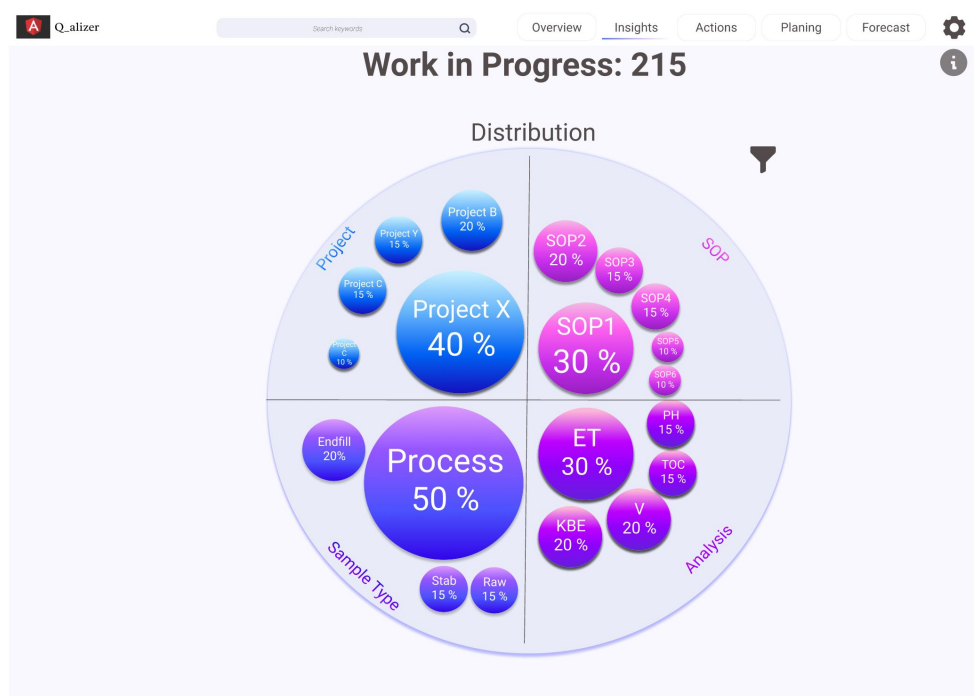


Figure 5.5: Q-alizer's Work in Progress page - Distribution

The second part is dedicated to the WiP change in a selected timeframe and by different groupings. In this section, users can directly see where and how their WiP changed. This can be useful to detect weaknesses early and then take the right actions that the work in progress in these fields does not continue to rise.

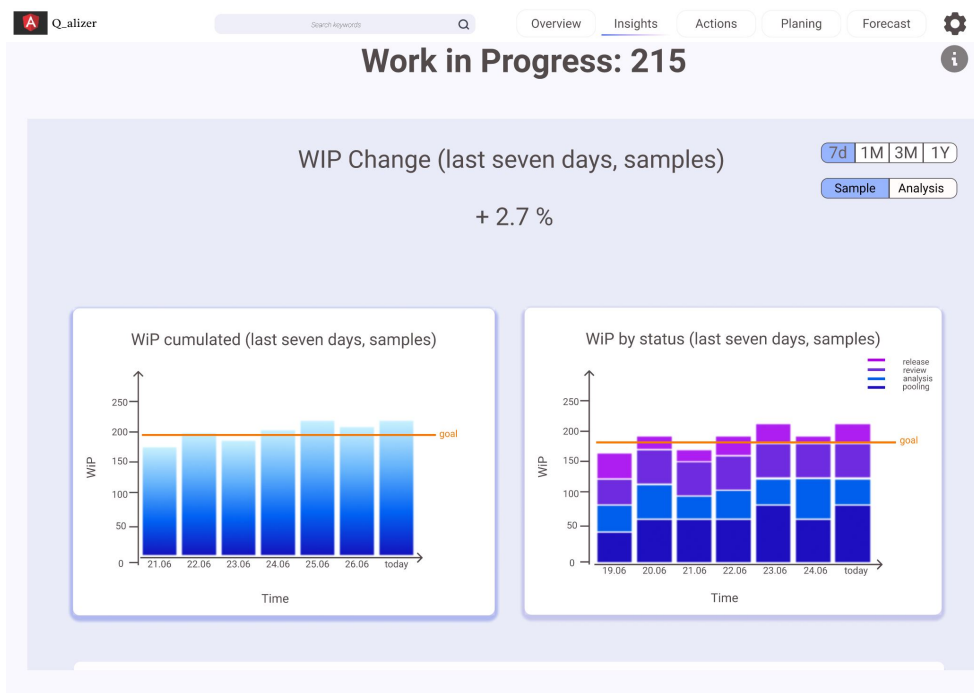


Figure 5.6: Q_alizer's Work in Progress page - Change

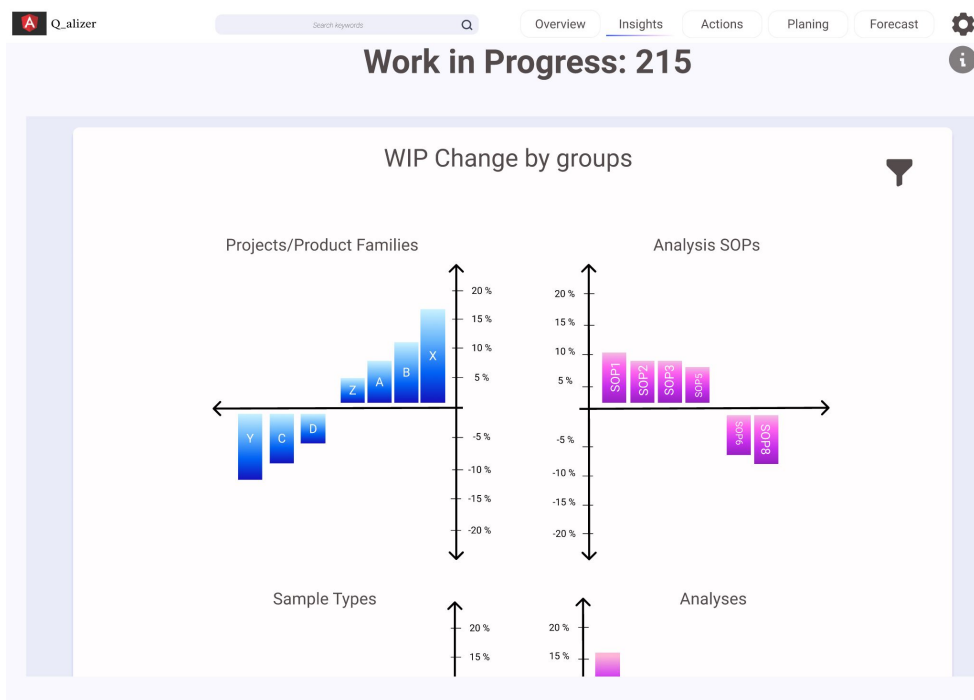


Figure 5.7: Q_alizer's Work in Progress page - Change (1)

5.2.3 Throughput time

This page is about the throughput time of a laboratory. The average time, the lab needs to process a task, for example a sample. This page has the same structure as the productivity page. First, the graph that shows the throughput time with the possibility of different groupings and timeframes. The goal is to show the user, where his labs throughput time is high and where it is low. Then, the throughput time change by different groupings and at last the throughput time comparison with similar labs is shown. The development over time can also be very interesting. If the throughput time rises over time in a specific project or analysis, then it is important to search the reason in the lab and ensure, that the throughput time is decreasing again.



Figure 5.8: Q_alizer's Throughput time page

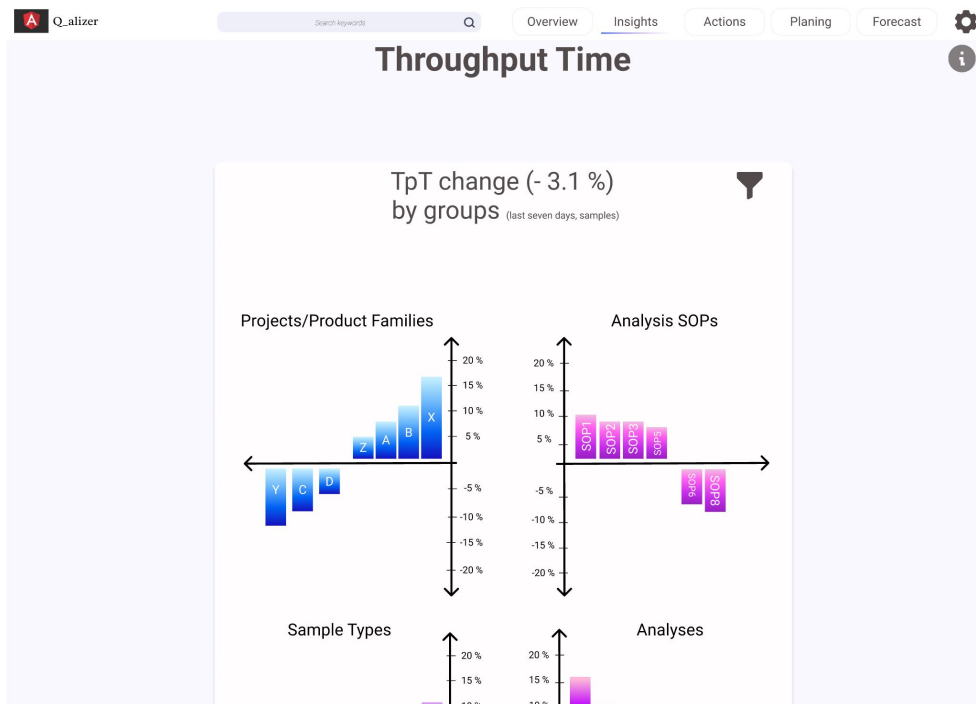


Figure 5.9: Q_alizer's Throughput time - Change

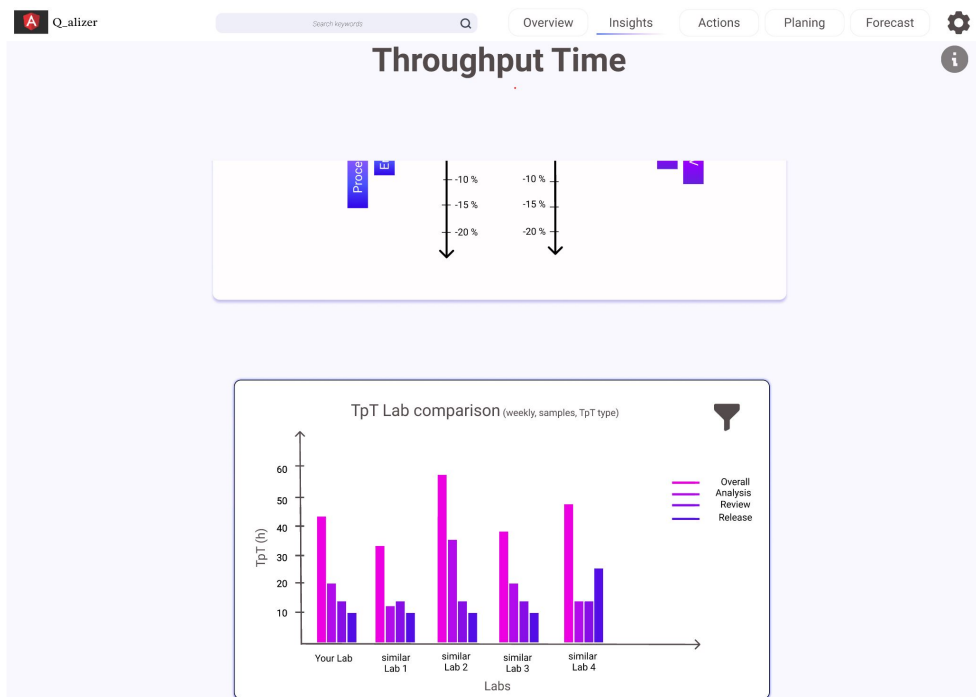


Figure 5.10: Q_alizer's Throughput time page - Lab Comparison

5.2.4 Input/Output

This insight page is dedicated to the in- and output. Input are all samples and analyses that a lab receives and output are all samples and analyses that a lab finishes. In an optimal scenario, the output is as big as or even bigger than the input. The graph on this page shows the user the in and output and also the ratio. The graph can be grouped by many different parameters. For example by sample status, projects, analyses and more. It helps the users to gain insights in which groups the lab has more in than output. This is important to find weak spots of a lab.

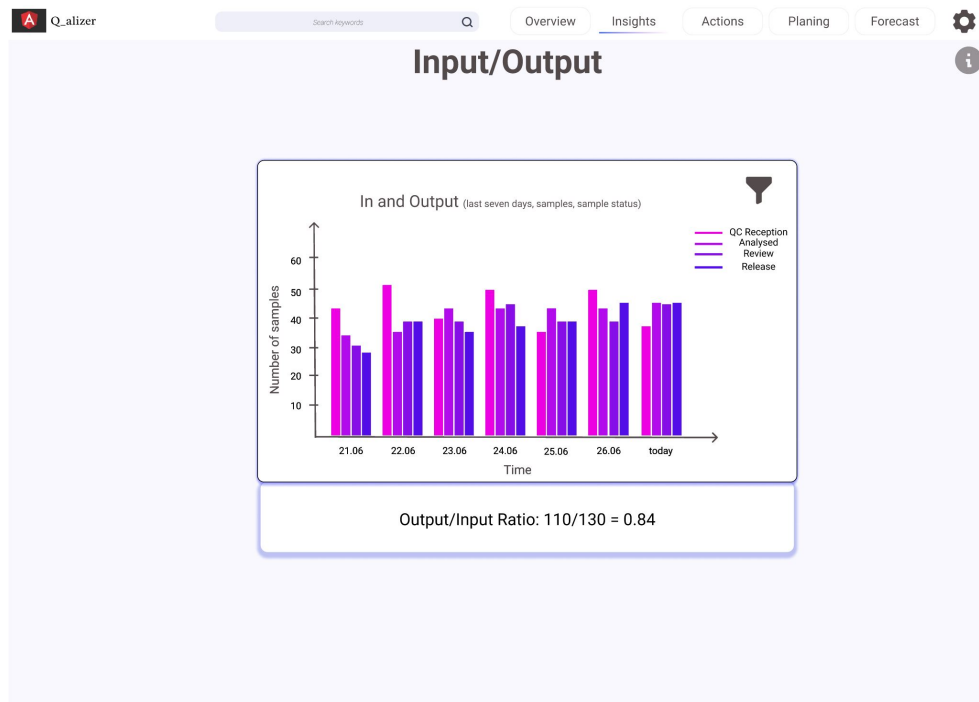


Figure 5.11: Q_alizer's In- and Output page

5.2.5 Delays

Many samples in laboratories have due dates, which should not be exceeded. By exceeding due dates, one may risk entire batches and lose a lot of money. But it is not that easy to have an overview on how many delays a laboratory had. The delays page of the Q_alizer fullfills exactly this purpose with a graph that shows how many samples have been finished in time and how many are delayed and the ratio of it. Further, the graph can be filtered to get insights about in which projects or samples or other groupings the most delays happen.

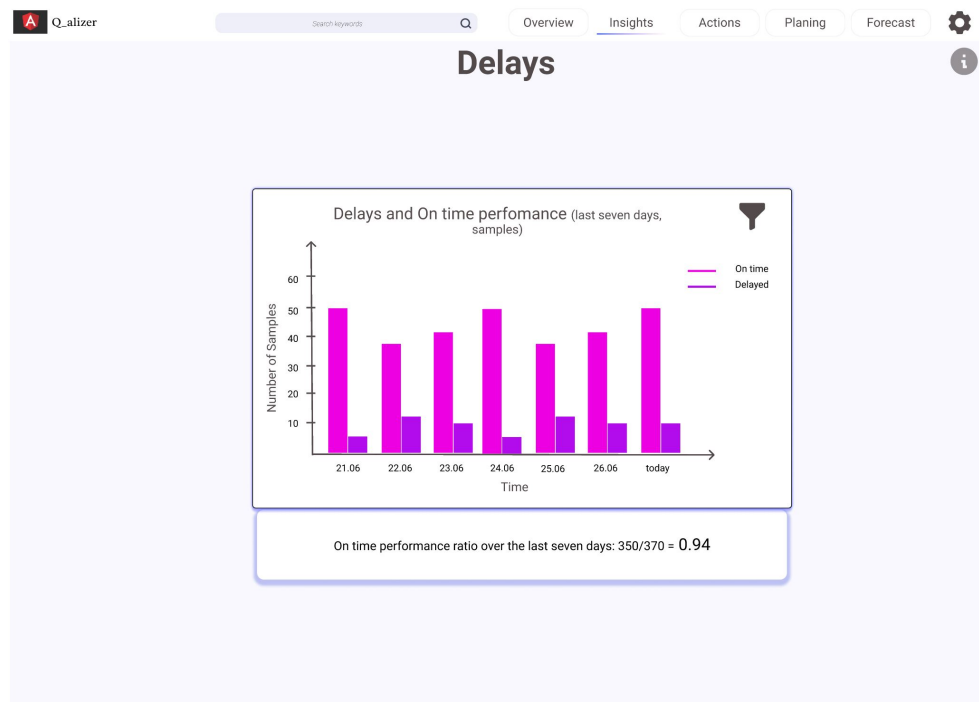


Figure 5.12: Q_alizer's Delays page

5.2.6 Impacts on Throughput time

Many of these KPIs discussed in the insights pages of the Q_alizer have influence on each other. Especially the utilization and the variability can influence the throughput time. The higher the utilization and the higher the variability, the higher is also the throughput time. In different levels of variability in combination with a special level of utilization one can reach a critical point. After this point, the throughput time does not increase at a normal pace, it can literally skyrocket. It is very important for a lab not to reach this point, but the problem is that lab leaders had no indicators that showed them that they could reach this point in the near future. Therefore, this page of the Q_alizer shows the KPIs Variability, Utilization and throughput time. Further, it shows a graph with the combination of all the three variables and their influence on each other. It can help the user to decide how he wants to decrease the throughput time in future. If they are already near the critical point, maybe some more employees need to be employed in near future in order to prevent the throughput time to skyrocket.

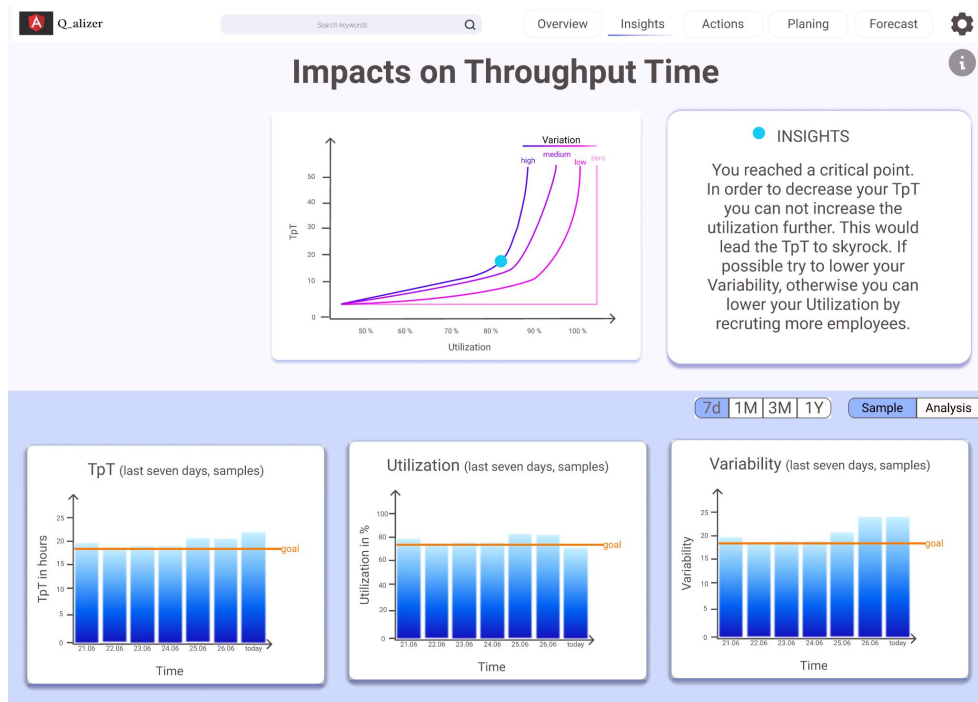


Figure 5.13: Q_alizer's Impacts page

5.3 Actions

Meocons plans to implement some machine learning algorithms and let them find patterns in the data that is ingested in the Q_alizer. Out of these patterns they want to recommend some actions, that lab leaders should take in order to increase the performance of the laboratory. For example could the algorithm detect that often endotoxin analyses are not finished in time. Further it could detect that by the time these analyses could not have been finished there were many free employees that would potentially have had time to do this work. At the same time the algorithm detects that all the endotoxin measurement devices were occupied at that time. Therefore the Q_alizer could recommend the lab leaders to buy another endotoxin device. For such action recommendations, this page is designed.

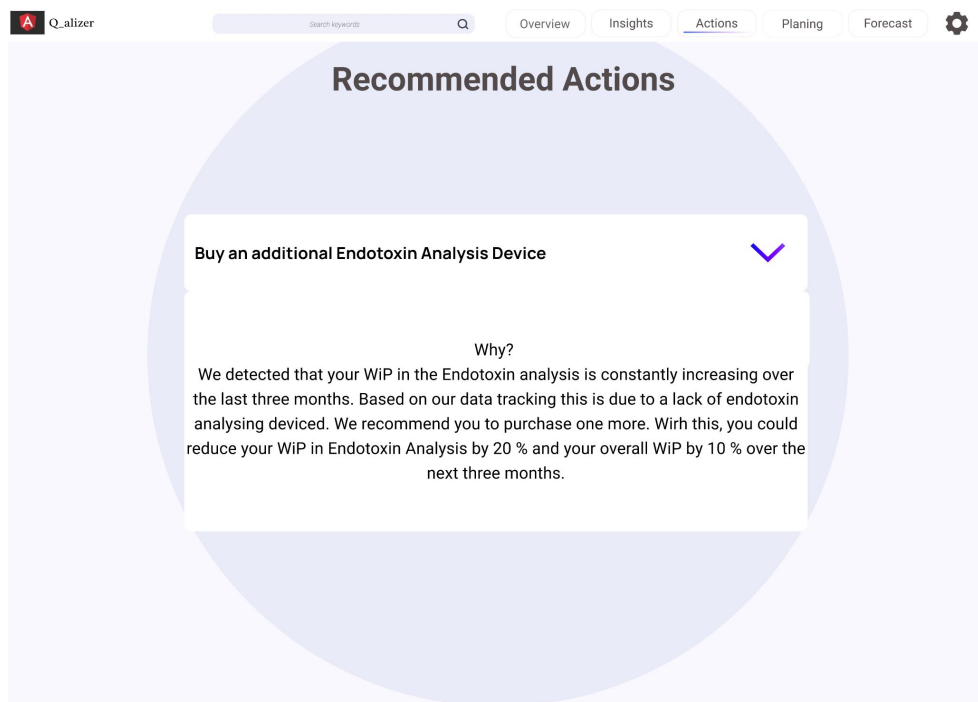


Figure 5.14: Q_alizer's Actions page

5.4 Planning

In this prototype, the planning feature of the old Q_alizer has been extended.

5.4.1 Samples

On the first page, all samples that are currently in the lab are shown ordered by due date - process time, such that the samples that have to be done first also are shown first. The user has the possibility to prioritize or skip samples. Prioritized samples are prioritized in the computation of the optimal sample trains and skipped samples will not be included. Sometimes, lab managers know that there is a problem in the production and therefore some samples don't have to be analysed at the moment. As soon as all prioritizing and skipping has been done, the user can click on compute optimal sample trains.

Q_alizer

Search keywords

Overview Insights Actions **Planing** Forecast

Your samples

Priotizite and Skip your samples


| Sample Id | Project | Batch Nr. | Analysis | Analysis SOP | Due date | Process time | Due date - process time | Prioritize | Skip |
|-----------|---------|-----------|-----------|--------------|-------------|--------------|-------------------------|------------------------|--------------------------|
| 1435168 | X | 3 | Endotoxin | DSF2284 | 30.06 11:00 | 120 min | 5h | <div><div></div></div> | <input type="checkbox"/> |
| 1435167 | Y | 1 | Bioburden | DSF2234 | 30.06 11:00 | 60 min | 6h | <div><div></div></div> | <input type="checkbox"/> |
| 143535 | X | 6 | TOC | DSF4564 | 30.06 10:30 | 30 min | 6 h | <div><div></div></div> | <input type="checkbox"/> |
| 143534 | Z | 1 | Endotoxin | DSF2284 | 30.06 12:00 | 120 min | 6h | <div><div></div></div> | <input type="checkbox"/> |
| 143465 | B | 4 | HPLC | DSF2647 | 30.06 13:00 | 120 min | 7h | <div><div></div></div> | <input type="checkbox"/> |

Compute optimal sample trains

Figure 5.15: Q_alizer's Samples page

5.4.2 Sample Trains

Once the user clicked on compute optimal sample trains, Q_alizer computes the optimal sample trains. Optimal sample trains are a collection of analyses and the samples that are analysed in these analyses. Q_alizer knows how many samples can be analyzed together in a specific analysis and makes trains containing these samples. Prioritized samples come first, and then the samples are allocated by due date - process time. Like this, samples that have to be done soon come first and less important samples are allocated to later sample trains. On this page the optimal sample trains are shown and the user has the possibility to remove samples from the trains, if he wants to. Once the user is satisfied by the sample trains, he can click on accept optimal sample trains.

 Q_alizer

Search keywords


Overview

Insights

Actions

Planing





Forecast



Optimal sample trains

Sample train 1: Endotoxin DSF2284

Train full 5/5

| Sample Id | Project | Batch Nr. | Analysis | Analysis SOP | Due date | Process time | Due date - process time | Prioritized | Remove sample from Train |
|-----------|---------|-----------|-----------|--------------|-------------|--------------|-------------------------|------------------------|--|
| 1435168 | X | 3 | Endotoxin | DSF2284 | 30.06 11:00 | 120 min | 5h | <div><div></div></div> |  |
| 1435165 | X | 3 | Endotoxin | DSF2284 | 30.06 12:00 | 120 min | 6h | <div><div></div></div> |  |
| 1435145 | X | 3 | Endotoxin | DSF2284 | 30.06 12:00 | 120 min | 6h | <div><div></div></div> |  |
| 1435166 | X | 3 | Endotoxin | DSF2284 | 30.06 14:00 | 120 min | 8h | <div><div></div></div> |  |

Sample train 2: TOC DSF4564

Train full 12/12

| Sample Id | Project | Batch Nr. | Analysis | Analysis SOP | Due date | Process time | Due date - process time | Prioritized | Remove sample from train |
|-----------|---------|-----------|----------|--------------|----------|--------------|-------------------------|-------------|--------------------------|
|-----------|---------|-----------|----------|--------------|----------|--------------|-------------------------|-------------|--------------------------|

Accept sample trains

Figure 5.16: Q_alizer's Sample Trains page

5.4.3 Distribute Samples

Since the samples are optimally allocated to analyses and the sample trains are accepted, it is time to allocate samples to lab technicians, devices and schedule them. This is a process that takes place every morning in the daily meeting in the lab on a big touch screen. On the left side of this page, the optimal sample trains are shown ordered by process time - due date. The user can now click on the sample train and every operator that has the qualification to carry out this task is shown. The user can then select one of them and drag and drop the sample train into the schedule on the right. Once the trains is dropped, a free device for this analysis is allocated to the task. If there is no device free at the desired time, Q_alizer gives a notification and suggests the next free time slot. Unfortunately, the drag an drop does not work in the prototype, due to limitations from the prototyping tool.

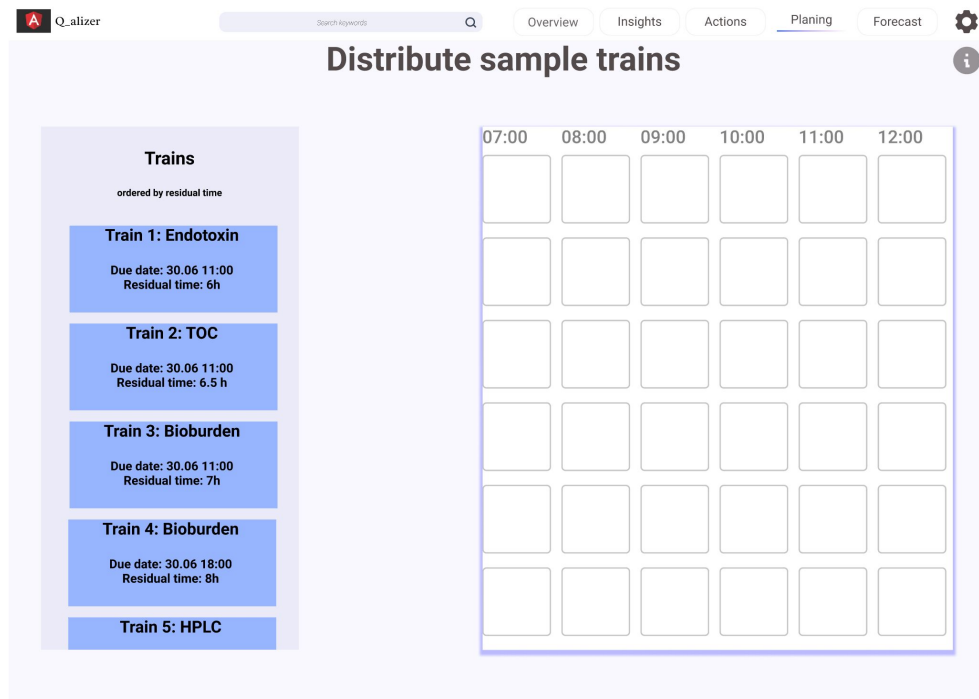


Figure 5.17: Q_alizer's Sample Distribution page

5.4.4 Schedule

Once all task are distributed the workday can start. Everytime a task is started or finished, the lab workers go to the schedule board and change the status of a task. Planned task are grey, running task are blue, successfully finished task are green and unsuccessfully finished tasks are red. An unsuccessfully finished task could for example be an analysis that was finished but did not meet the validation criteria. In this case, Q_alizer automatically generates a new sample train for the repetition of the analysis. By clicking on the task, an overlay opens with additional information to the task. And it gives the users the possibility to add comments or change the operator, if they need to. All these task can be moved to other time slots by drag and drop and they can also be put back into the sample train queue if a task could not be done in that day. In this case, the task is in the sample train queue for the next day.

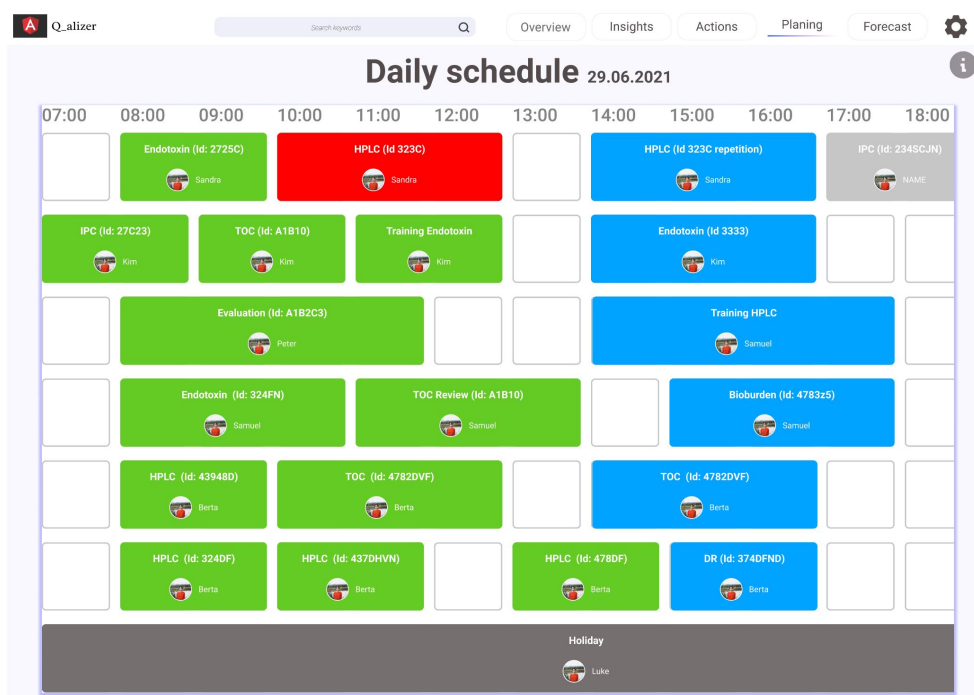


Figure 5.18: Q_alizer's Daily Schedule Page

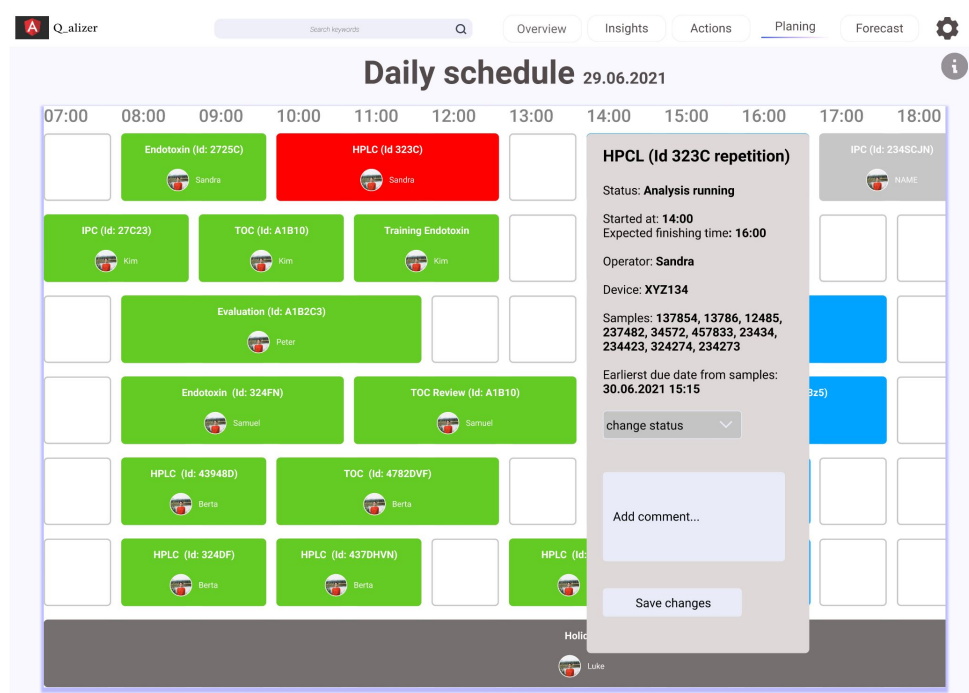


Figure 5.19: Q_alizer's Daily Schedule Page opened task

5.5 Forecast

This section is dedicated to forecasting the KPIs of the laboratory.

5.5.1 Forecast

This page shows the forecast of different KPIs calculated by the data Q_alizer has tracked in the background. The user can select a timeframe for the forecast and also which KPIs he wants to contemplate by clicking on the filter symbol on the top right corner of the graph.

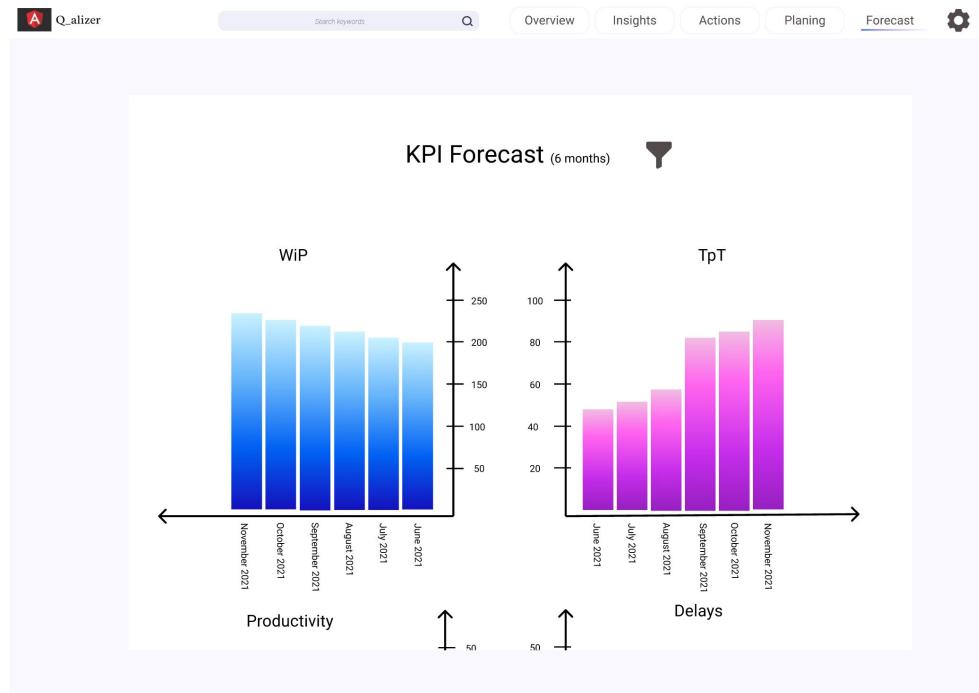


Figure 5.20: Q_alizer's Forecast page

5.5.2 Simulator

This page acts as a simulator for the different KPIs. In contrast to the forecast page, this simulator allows the user to specify different parameters. For example, if a lab leader knows that in three months five new projects will start, he can enter the number of samples he will get each month, the number of analyses that have to be done, the number of devices and employees he has in each month. The KPIs get then computed by the inputs the user gives. This allows a realistic forecast of the future. It is especially useful to see if the current resources are also enough for future sample income.

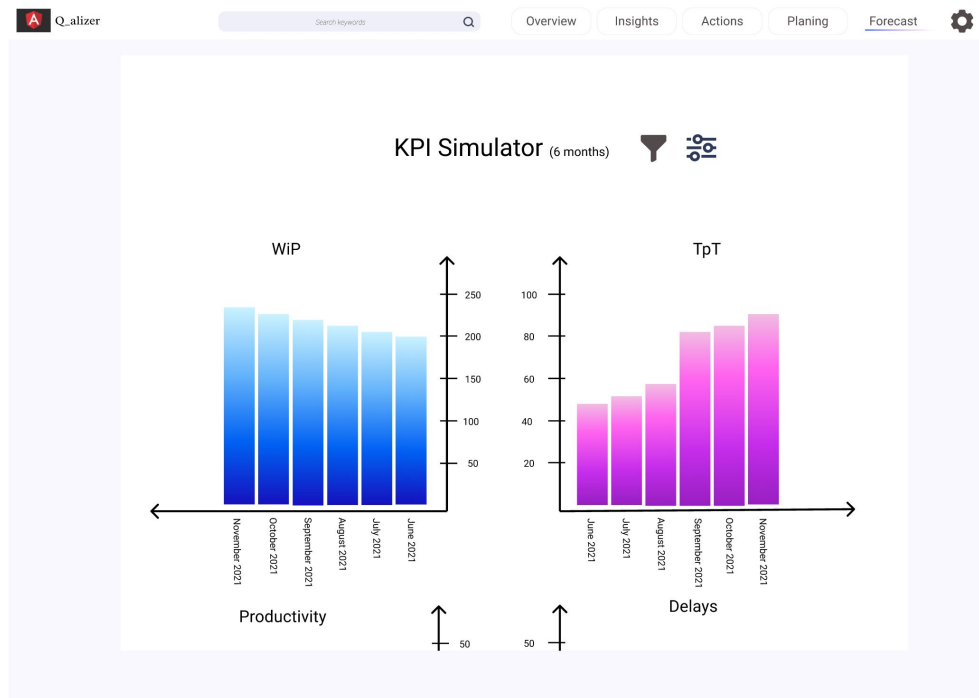



Figure 5.21: Q_alizer's KPI Simulator

 Q_alizer

Search Keywords


Overview


Insights

Actions

Planing

Forecast



June 

general information:

number of projects

enter number

number of samples

enter number

Analyses information:

number of Endotoxin Analyses:

enter number

number of Bioburden Analyses:

enter number

number of TOC Analyses:

enter number

number of pH Analyses:

enter number

Devices Information:

Frequency

50

50

Figure 5.22: Q_alizer's KPI Simulator Input

5.6 Settings and Goals

In this section, users can set their monthly goals for each KPI and change themes.

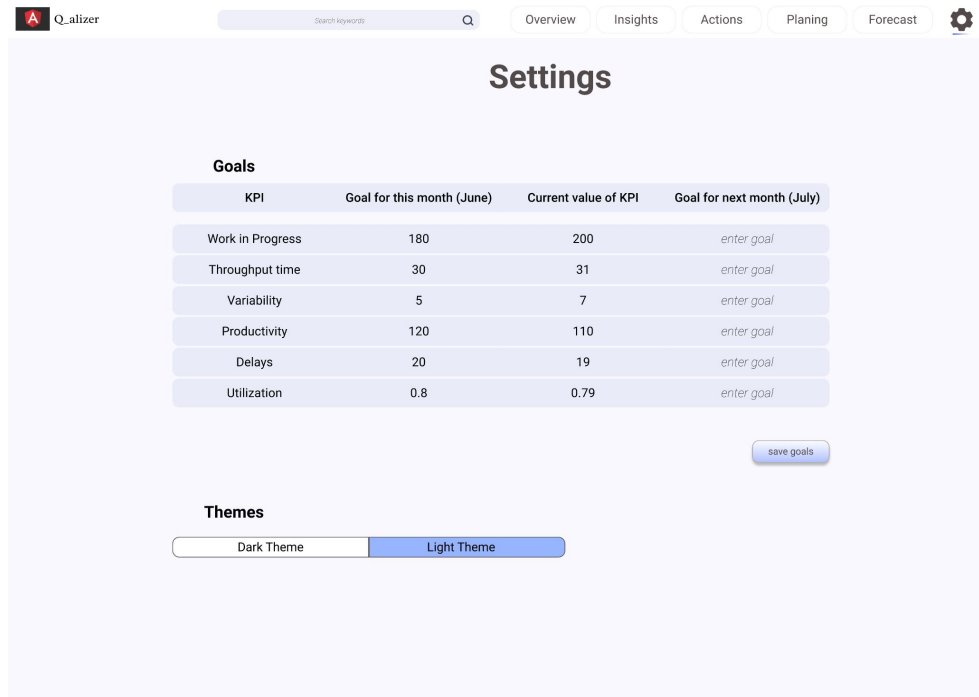


Figure 5.23: Q_alizer's Settings and Goals page

Chapter 6

Evaluation of new prototype

To see what users think of the new functionalities and the new design, an evaluation took place. For that, users clicked through and explored the prototype by themselves and expressed their thoughts and opinions in a meeting. The main question asked in the meetings are:

- What was the general impression you had by clicking through the prototype?
- Which features of the prototype could be of great use for you and why?
- Which features provide not great use for you and why?
- Are there parts of the prototype that are unclear or ambiguous to you and why?
- What do you think of the structure of the prototype? Was it logical to you?
- Do you like the design of the prototype? What do you think about the colors used? Was everything clearly seeable to you?
- Do you have any suggestions for improvement?

6.1 Aspects users did not like and improvement suggestions

All interviewed reported that in the change graphs on the insights sections it is not clear to them on what the change is referencing. If it is to the time period before or to what exactly. Further, they find it hard to find the page to set the goals, it is not logical to them, that goals are set in the settings section.

Users complained that the prototype does not scale in full screen on a bigger screen.

Even though they like the information buttons, they do not like that by opening them the screen is nearly completely covered. It would be better if the information overlays do not cover the actual screen such that they can read the information and compare at the same time.

For the planning feature, users wish that the scheduling is done automatically by Q_alizer and that then they can drag and drop tasks they want to change. Like this, a lot of time could be spared. Further, it is not clear to them what the ID in the schedule is referencing.

Often, users did at first not see, that a lot of pages are vertically scrollable, a visual hint to that is wished.

In the throughput time graphs, they wish to have separated goals rather than overall goals. For example, they want to have the possibility to set the goal time frame of a review to 3 days.

As an improvement, one user suggested that the forecasting of KPIs is also included in the monitoring graphs. Like this, they would have all the information in one place and could monitor and forecast at once.

Instead of setting the filters for every graph individually, they would like to set the filters once for the entire page. This allows them to view all the aspects of a selected case without setting the filters over and over again.

6.2 Aspects user did like

All interviewed users did very much like the overview page of the prototype. They reported that having an overview of all KPIs is very useful to them and that they like the functionality to set monthly goals for each KPI. This helps them to monitor and improve the performance of their laboratory. Further, this overview is useful to show other employees the performance of the lab at the end of the month and helps in exploring new goals for the next month. They find it very nice that they can set goals now and they find monthly goals a very accurate time period. They also like the information about the samples that are currently in the lab and that they can directly navigate to the planning section by clicking on the go-to planning button and to all the insight sections by clicking on the big bubbles of the diagram.

Generally, they like the insights sections very much. Especially, the work in progress distribution diagram is very useful for them. Further, they like the change diagrams in the KPIs work in progress, productivity, and throughput time. It is of great interest for them to see, where exactly the KPIs have changed by different groupings. They reported, that for example often the work in progress only grows in one project, and these diagrams make it easy for them to see such patterns at a glance. Some of the users also did like the lab comparison graphs, others reported that they do not use them, since they do not have similar labs doing the same tasks. They reported that this is a feature that is more useful for global lab leaders. Another feature that caught their interest is the impacts on the throughput time page. They reported, that it would be very useful to have such a feature and to know, at which point in the impacts graph they are currently at. Like this, they can better estimate what actions they can take in the future in order to decrease the throughput time.

Users reported that the page with recommended actions is very nice and useful, even if they do not fully understand how it works in the background.

Users also really like the whole planning tool. Especially the automatic calculation of the optional sample trains would be very useful to them. Further, they reported that the schedule page is also nice and they would like to have such an overview about who is doing what at the moment. Users do not think that it creates too much additional work to go to the board and update the status of a task because lab workers do need to report the completion of a task anyways to their supervisors.

Users also like the forecasting and simulating functionalities, it allows them to take a look into the future and also provide their supervisors with data-based evidence, that they sometimes need more employees or devices to stem the amount of work.

Further, they like that the prototype has information buttons that explain every page.

They reported that the design is beautiful, but also that this does not really matter to them. It feels harmonious and consistent and did not distract them from viewing the data.

The navigation order is logical to them except for the setting of goals as mentioned in the section before.

Chapter 7

Discussion

This chapter reflects on the whole thesis, the methods used, the insights gained and the results that have been accomplished. It also gives an outlook on future work.

7.1 Reflections on the methods used

This work followed the HCI design process until the phase of implementation and deployment. The overall approach has been perceived beneficial and well structured.

The interviews with industry representatives have been very insightful and the number of interviews (four people in three interviews) seemed to be just right. These interviews have put a great benefit to the requirements engineering phase and users also felt valued and esteemed because they were involved in the future development of the tool. Even when it was not easy to find interview partners, since the Q_alizer has not been used by many people so far and also these people have high loaded schedules in their companies, the insights gained with these interviews clearly helped to recognize the problems users face in their laboratories and what functionalities should be added to the new prototype in order to support them better.

The weekly meetings with Meocon's employees about their vision of further developing the tool helped to understand their wishes and also gave some good ideas on what functionalities could be added to the tool. It was especially interesting to talk to people with all different kinds of backgrounds since front-end, back-end, and chemists have different opinions how such a tool should look like. From back-end employees, insights on what data is available and what can be implemented with this data came to know. From front-end employees, insights on which designs are possible to implement could be gained. And from chemists and former lab leaders, insights on the daily work of those people were pointed out. It is very interesting to work with all those different people together. The weekly meetings with Meocon's employees helped a lot in guiding through this whole project.

Creating a design sketch before prototyping helped to organize the ideas and make sure to be on the same page as Meocon's employees before actually creating the prototype in Figma. Prototyping with Figma allowed simulating the new functionalities to a great extent, which helped the users in evaluation to understand the new ideas. Despite that fact, Figma also has some limitations that prevented the prototype from being a fully working prototype. For example, there is no drag and drop functionality that would have been used in the scheduling

sample trains functionality of the prototype. Further, by on-click one can only configure one action but oftentimes, more than one would be more appropriate to show the real behavior of the prototype. For most parts though, the Figma prototype was very representative and could simulate an implemented product to a great extent with clickable objects and scrollable pages. Overall it feels like an implemented application, which makes it a great way to prototype.

The evaluation of the prototype with two lab leaders was insightful and the feedback provided was helpful in creating ideas on how to process with the Q_alizer in the future. It would have been better to get feedback from more than two people, to see different perspectives. This was unfortunately not possible due to the heavily loaded schedules of lab leaders at that time. While the feedback on new functionalities was deep and of great use, the feedback on the design aspects was superficial. One reported that the design does not really matter to him. This is also feedback but to ensure that the design of the prototype is really appropriate, further investigations have to take place. A think-aloud test on the prototype with more than two users would bring more insights on how well the design aspects fit users' needs. Despite that fact, since very few negative things were reported to the design, one can assume that it was clear to them and did not distract them from investigating the data visualizations in the dashboard, which is a good sign.

7.2 Prototype: ready for implementation?

Taking into account users' feedback, the new functionalities are appreciated and wished. Especially the monthly KPI goals, the work in progress distribution graph, the planning and scheduling functionalities, and the forecasting and simulating functionalities. Generally, users are impressed by the new appearance and functionalities this prototype has. Despite that, the prototype is not yet ready for implementation, since there are some things that have to be further investigated and at best, further design cycles have to take place. More to that in the next section.

7.3 Future work and improvement suggestions

In developing the prototype further, one should go through design phases again. There is some feedback given in the evaluation that should be considered in the next design cycle. In the change graphs on the insights pages, one should provide the user with more clarity that it is comparing to the last time phase. The information overlays should not overlap the actual prototype page, but rather sit on the side such that users can read the information and view the page simultaneously. Further, one could think about how making the scheduling automatically in a meaningful way. For example, let the Q_alizer schedule the tasks automatically and then let the users the possibility to drag and drop them around, if they wish changes to the schedule. A visual hint that the pages are scrollable is also desired. One could think about how to merge the monitoring and forecasting graphs into one such that users gain more insights at once and can better compare the results and the forecasting. Further, the filtering of graphs lets space for improvement. Users wish to set filters only once for a page. An idea here could be to create filter packages that the user can then drag and drop into the graph and thus filter the graph more easily. For example, there could be a filter package called "most changed WiP in projects" and then in the background all filters to get this information is applied. This would ease the use of the tool for users. There it would also be possible to let users create those filter packages by themselves.

Further, Meocon should think about which features are possible to implement with the data that is actually available and which features are worth collecting more data. If they finished the next design cycle another evaluation should take place and they should repeat these processes of design, prototype, and evaluation until their vision and users' needs are fulfilled to a great extend. Then, the prototype will be ready for implementation and development.

Chapter 8

Conclusion

This work has researched the needs of Q_alizers users and the compatibility of these needs with the current version of the Q_alizer. It proposed new functionalities and a new design for a laboratory management tool called Q_alizer.

The interviews with industry representatives have shown to be valuable and opened a new sight upon users' needs in this tool. As a result, users are content with the Q_alizer and value it as a tool to help them perform their everyday tasks in the pharmaceutical companies. Despite that, they still wish for some more functionalities, especially for planning, scheduling, and forecasting in the laboratory. Meocon wants to further develop the tool and transform it into a standalone tool, that does not need any consulting support from Meocon's employees. This requires the tool to have the possibility to set and monitor goals for KPIs and also needs additional KPIs such as Productivity, Utilization, and Variability. It also needs to visualize the impacts these KPIs have on each other and present the insights and the resulting actions directly to users.

The interviewees' feedback and meocons vision have been taken into account and the wished additional functionalities have been included in the new prototype. The prototype has a completely new design, applying best practices and design principles in order to offer users the best possible experience. The prototype presents the insights in a direct way, without tons of filtering being necessary. It further shows possible actions in order to improve the KPIs directly to users and let them set and monitor goals for their KPIs. It has new functionalities for planning and distributing work and lets users take a glimpse into the future with forecasting functionalities. This way, the tool has become independent of Meocons consultants and lets users work on their own together with the tool.

The users' feedback on the prototype has shown that they are impressed by the new functionalities of Q_alizer, especially the planning, distributing work, and forecasting functionalities. Also, Meocons employees are satisfied with the new direction the prototype is leading their Q_alizer in the future. This concludes that this work successfully proposed new functionalities and design for the Q_alizer and brings value to the tool by bringing it closer to its users' needs, brings value to its users by helping them to explore the data and take the right actions, and also brings value to Meocon as a company by opening a new view on how to extend their tool in future.

"Give somebody a tool that patently saves them time, energy and frustration and they would be foolish not to embrace it; [...]" (Bailey and Vidyarthi, 2010) [2]

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Chapter 9

Appendix

9.1 Interview Protocol drafts

9.1.1 first version

- First, I would like to know something about your daily work. What are your main tasks in your company?
- How long have you been using the Q_alizer? How long do you use it per day?
- What is your overall experience with the Q_alizer and why?
- Which features of the Q_alizer are you using the most and why?
- Which insights do you gain with this feature and how does it help you to perform your daily work?
- Are there other features you use often? What do you use them for? What are the insights?
- Did you experience any problems while using the Q_alizer? Which ones and when did they occur?
- Does the Q_alizer offer features that you did not understand and what was unclear?
- What do you think about the planning feature of the Q_alizer, did you already use it?
- What do you think of the start page of the Q_alizer? Do you find it convenient?
- Did you miss explanations in parts of the Q_alizer and where would this be?
- Can you think of information that would be useful for your work that is not presented in the Q_alizer? What would it be?

9.1.2 second version

- First, I would like to know something about you and your daily work. Can you please tell me something about you, your background and also a little bit about your position in your company and what your tasks involve?

- On a normal day, tell me about how you use Q_alizer in your daily tasks? How does it help you perform your tasks?
- What is your overall experience with the Q_alizer and why?
- Tell me about the features of the Q_alizer you use most? In which cases do you use it?
- Which insights do you gain with this feature and how does it help you to perform your daily work?
- Are there other features you use often? What do you use them for? What are the insights?
- Did you experience any problems while using the Q_alizer? Which ones and when did they occur?
 - Can you tell me about a recent example when this problem raised?
 - How did you deal with/resolve this problem?
- Does the Q_alizer offer features that you did not understand and what was unclear?
- What do you think about the planning feature of the Q_alizer, did you already use it?
- What do you think of the start page of the Q_alizer? Do you find it convenient?
- Did you miss explanations in parts of the Q_alizer and where would this be?
- Can you think of information that would be useful for your work that is not presented in the Q_alizer? What would it be?

We are coming to the end of the interview. I would like to thank you for taking the time to talk with me about the Q_alizer and your experience with it. It was very interesting to hear your point of view, and this will help me a lot in improving the Q_alizer.

9.2 Mock-up Designs

9.2.1 Sketch

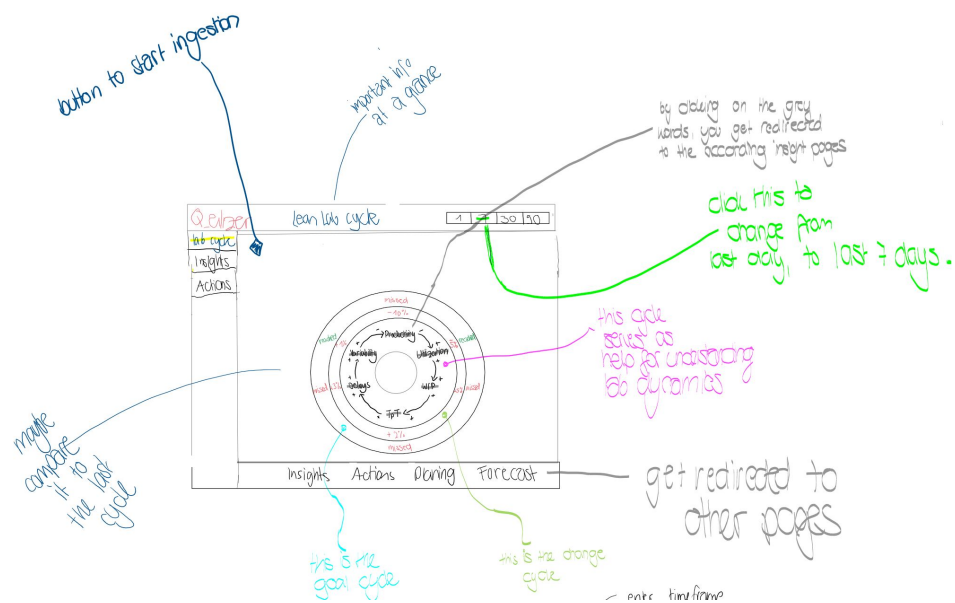


Figure 9.1: Prototype Sketch

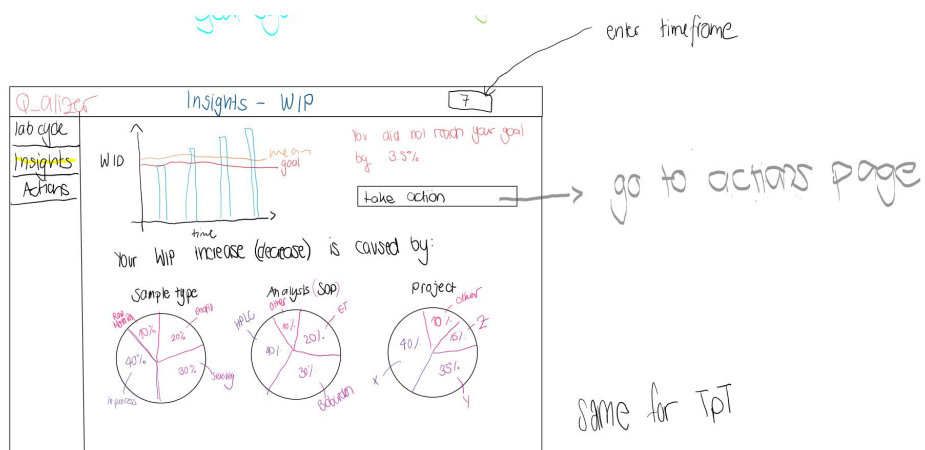


Figure 9.2: Prototype Sketch (1)

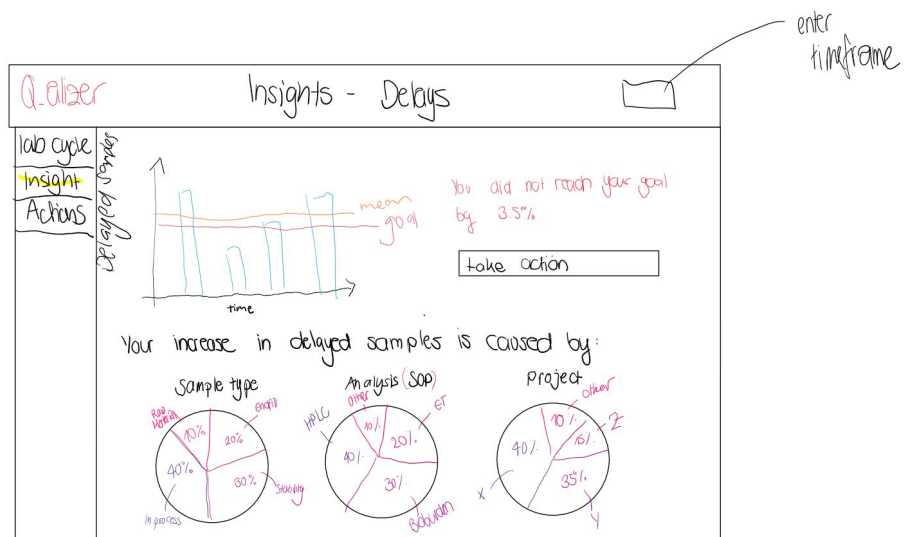


Figure 9.3: Prototype Sketch (2)

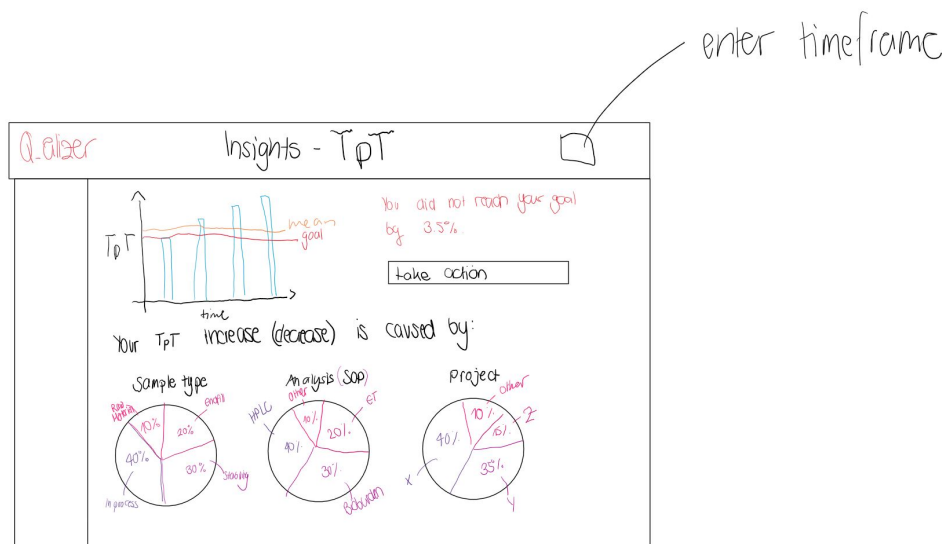


Figure 9.4: Prototype Sketch (3)

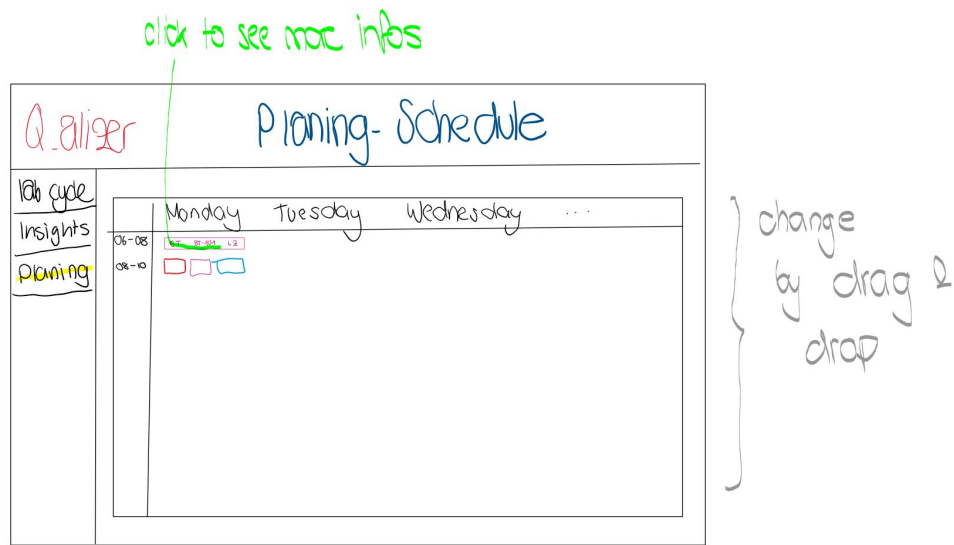


Figure 9.5: Prototype Sketch (4)

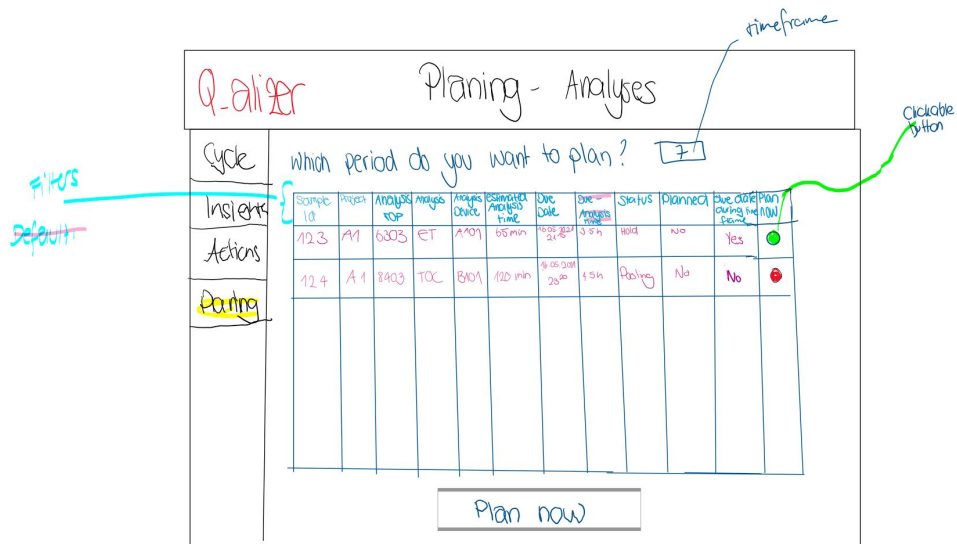


Figure 9.6: Prototype Sketch (5)

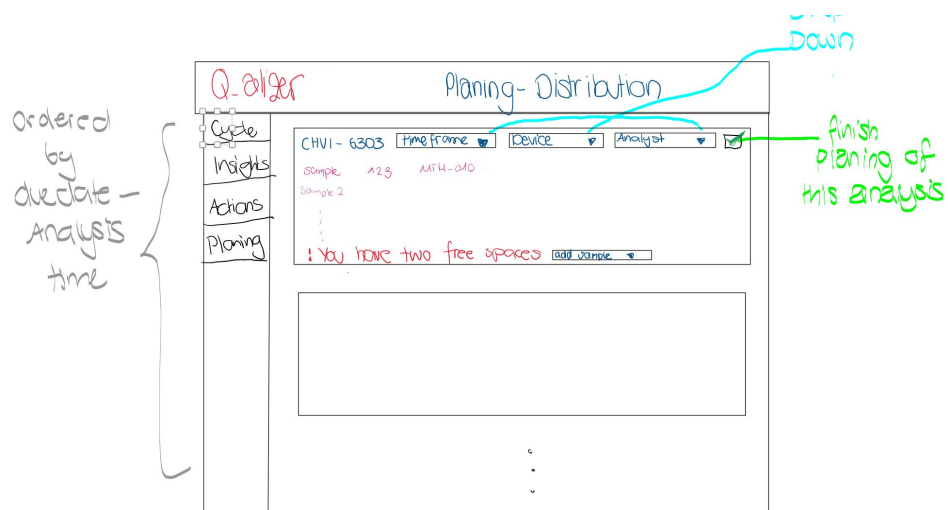


Figure 9.7: Prototype Sketch (6)