Research in drug development: Developing a user-centered web platform for Euretos

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Research in drug development: Developing a user-centered web platform for Euretos

By

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Preface

This report is the result of my graduation project which started in february 2017. At the start of the project, the graduation assignment was still quite broad with a lot of uncertainties. Therefore starting this project was a challenging but rewarding task. The field of life sciences is a complex field and having the opportunity to support researchers in developing new drugs and therapies was an interesting experience.

Without the support and guidance of my supervisory board, the Euretos management and the researchers at the LUMC, this graduation assignment would not have been possible to be executed. Therefore I would like to thank Lianne Simonse as the chair of this project for her guidance and support especially with the trust that was given to me that this graduation project would successfully run its course. Also I would like to thank Boris Eisenbart for mentoring me during this project. His critical view on research methodology and my report helped me with critically reflecting on the performed work and the results. Although near the end of my project Boris has emigrated to Australia, he still provided critical feedback on my report and was more than willing to answer all my question. I wish Boris the best of luck in Australia.

I want to thank Aram Krol from Euretos for offering me the opportunity to graduate at a very interesting biotech company. Without his support and guidance, I would be unable to get an understanding of how life science research translates into software applications and his trust in my design skills to create an improved version of the Euretos knowledge platform. I want to thank Kristina Hettne, bioinformatician at the LUMC for allowing me to use her contacts within the LUMC to get to interview a variety of interesting molecular biologists and bioinformaticians.

A. van Dolder
Utrecht, August 2017

Executive summary

This graduation report provides an analysis of the strategic positioning of Euretos and the development of a user-centered web platform for life science researchers. The methods of analysis include company analysis, market analysis, user research, literature research about user interface design and a small user test study for the new developed concept.

The company analysis and market analysis showed that Euretos has an unique positioning compared to its competitors. The Euretos knowledge platform has a large knowledge database which can be used to accelerate the research process and to better understand the complex mechanisms of diseases. The database size and quality which lead to unique knowledge exploration and expansion combined with the relative low price compared to competitors in the same product form category, gives Euretos a strong positioning. The text mining algorithm and the model framework, makes the database unique. Competitors are not likely to be able to recreate a similar database as it would take considerable investments. The usability of the Euretos knowledge platform offered the opportunity to differentiate from the competitors, while also creating the possibility to appeal to a larger group of users.

For increased usability, the main points of improvement are increased level of trust from the user in the shown results, more possibilities for collaboration with other researchers, and an intuitive, simple, clear, consistent and predictable user interface. A high level of usability and an intuitive user interface resulted in carefully selected number of supported functions. In consultation with Euretos management, it was decided only the functionality that was used most of the time would be chosen as essential features.

The relation map tool was one of these essential features with the most user interaction. Therefore the relation map tool was chosen to be further developed for this project. The relation map tool offers researchers to visually construct disease mechanisms in a model. By adding phenotypes, diseases, proteins and other concepts as dots on a canvas and creating links between these dots to represent relations supported by papers, a model is constructed to represent specific mechanisms. To increase the level of trust, specific filters were added to filter the relations based on date of publications, significance of the paper and the number of papers supporting a specific relation.

The small user test study for user validation indicated that the basic needs of the targeted users were fulfilled. The relation map tool was accepted by the participants as a model exploration and model construction tool. Therefore, it can be said that overall the relation map tool is found to be an appropriate solution to perform research, construct models of disease mechanisms and to collaborate with other researchers.

This report concludes that the studies and user research that have been conducted helped to unveil the users' needs and desires and to some extent the problems they were facing with the current platform. The research about the positioning of Euretos strengthened the idea that improved usability would lead to a better user experience as well as a better positioning for Euretos. The relation map tool was developed as part of the improved knowledge platform. Through user validation, it was indicated that the application is a helpful tool in performing research by constructing relation models for disease mechanisms and that the application probably will offer a smooth user experience. Therefore, the relation map tool will be used as a starting point to redesign the knowledge platform into a user-centered life science research application.

Contents

1. Introduction

This graduation assignment has been executed for Euretos, a biotech company which is active in the pharma, biotech and academic sector to accelerate life science research. They offer a platform with access to over 90 million phenotypic, genetic, proteomic, metabolic and chemical concepts from over 80 data and publication sources in a single big data environment. All this data can be used to perform extensive gene expression analysis, explore disease mechanisms, find gene disease associations and analyse drug mechanisms.

The biotech sector is a booming business according to the biotechnology industry report of EY (2015). Revenue growth has risen from 10% in 2013 to 12% in 2014. Although there are signs of a financial slowdown, the biotech companies have filled financial reservoirs. In 2015 there were still enough investors willing to back commercially unproven technology at development focused biotech companies, many of which are developing into areas as gene and cell therapy (EY, 2016).

Currently there is a trend that the human population is aging, which increases the chance on diseases that comes with aging. This puts a strain on the current healthcare system, as the aging society need more intensive care.Therefore it is vital to invest in research for promising therapies as these developments and innovations are needed to fight complex diseases and keep the healthcare system affordable. The discovery and development of therapies and drugs are resource intensive and the later phases of the drug and therapy development process are increasingly more resource intensive as large scale tests will be needed to declare a drug or therapy effective and safe. Therefore Euretos is developing a software application which can be used to perform more accurate (predictive) analysis during the drug discovery and development phase.

1.1. Problem definition

Euretos are continuously developing their platform and are always exploring new opportunities for their application. Since the start of the company, the knowledge platform has been their main focus. The knowledge platform consists out of a big database with scientific data from academic publications about diseases, genes, human biochemical processes and all other kinds of data that is about the human medical condition.

As the company grew, the application grew with it by adding new functionality. These were often developed as a request from the researchers who already adopted the use of the Euretos software. Soon the platform was capable of performing multiple complex analyses which were powerful tools to be used for biomedical research. This organic growth resulted in a complex platform, but it also influenced the usability of the user interface. The complexity of the platform resulted in difficulties for the new and experienced users to interact with the user interface. This caused a strain on the helpdesk of Euretos in assisting the users with the use of the platform and raised the learning curve even more for new users and thus the initial inhibition threshold to even get started with it.

To ensure future market growth the current strategy needs to reassessed to be sure that Euretos are developing in the right direction. By rethinking what the most interesting user groups and stakeholders are and uncovering their needs, the platform might need to be reinvented to a platform that with a different identity or vision. An important aspect is that the service needs to be designed with the experienced and new users in mind and that they are able to use the service independently with minimal assistance of Euretos' helpdesk. The functions of the platform need to be reviewed and readjusted to the needs of the users. By empowering the biomedical researchers to work more efficiently, they can save time and resources, allowing them to produce more publications and develop therapies and drugs faster and with a lower amount of resources.

1.2. Approach

For this project, a double diamond design process was used, which is divided into four stages: Analyse, define, develop and implement (Buijs & van der Meer, 2013). The analysis and development are divergent phases which are about gathering information and generating options. The definine and implementation phases are about making choices which is a converging process (Figure 1).

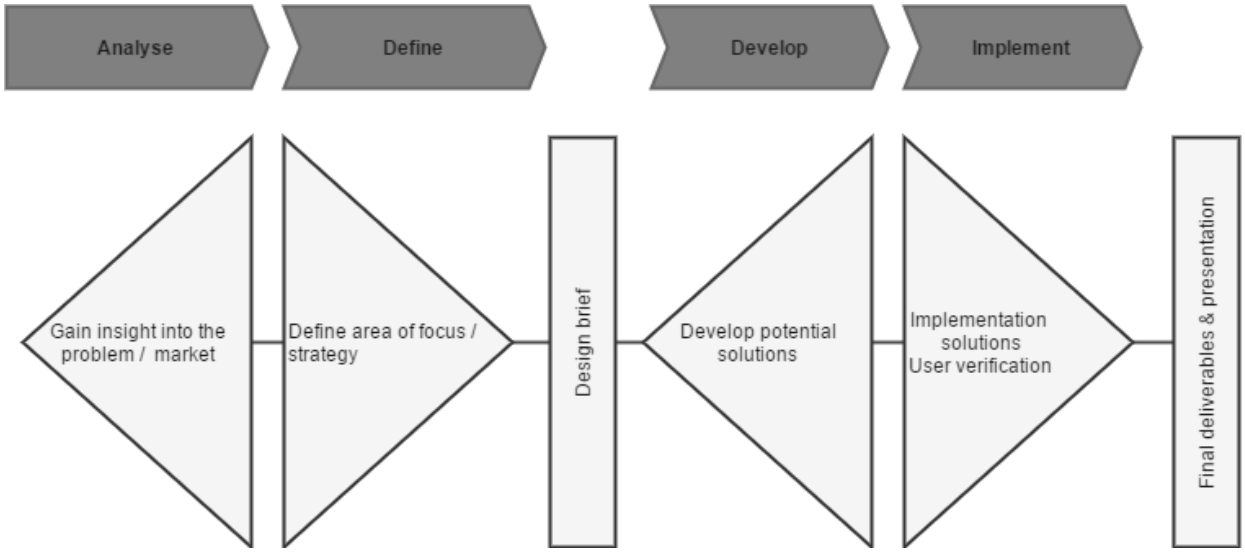


Figure 1: Double diamond design process

The first diamond is about understanding the company, their vision, the context, the market and the users. As Euretos is a biotech company and their users are biomedical researchers, getting familiar with the process of performing biomedical research is essential to get a better understanding what the added value of the knowledge platform is. Therefore a company analysis, market analysis, literature research, interviews and observations were conducted to get a glimpse of the world of biomedical research.

All the inputs of the first diamond is then converged into a strategy and design brief. The strategy stands for the bigger picture where Euretos fits in the world of biomedical research, what value they add and how they can continue to grow. The design brief is more concrete as it gives guidelines for how a product, service or product service system should be like. The design brief marks the starting point of the second diamond.

The second diamond is about developing potential solutions with user centered methods to ensure continuous involvement of the user. This has multiple benefits as it helps to understand difficult concepts in the biomedical sector, shorter feedback loops and results of higher quality (Abras, Maloney-Krichmar, & Preece, 2004). The ideated concepts are then evaluated with the user and Euretos which will lead to a final concept. The design process and results are then presented in a report as well as a final presentation, marking the end of this graduation assignment.

1.3. Drug development

Drug discovery and development is a complex process as it is about discovering the even more complex processes that happen in the human body. As this project is about using tools for biomedical research, a short introduction into drug development is needed to explain certain principles.

The process from scratch to a FDA approved drug can take over 10 to 20 years and is a long process which divided over multiple phases, professions, institutes and companies (Figure 2). It starts with basic research, often at academic institutes, to generate data to develop a hypothesis. The hypothesis is often about the effect it would have, if a protein or pathway is inhibited or activated and if it has an therapeutic effect on the disease (Hughes, Rees, Kalinjian & Philpott, 2010). A pathway is a distinct process which controls and regulates genes in the development of a disease, gene mutation or gene expression (Phoebe Chen & Chen, 2008).

Figure 2: A simplified overview of the development process of drugs

To identify the right target, there needs to be confidence in the relationship between the target and the disease. A target can be anything from a gene to a protein as long as it allows the researcher to explore whether target modulation will lead to mechanism-based side effects, which could be interesting for further therapeutic development. Selecting the right target is important as with each phase, the costs increase exponentially. Therefore a suitable target needs to be efficacious, safe, meet clinical and commercial needs (Hughes et al., 2010). If a target fails to meet one of these requirements, it will not be feasible, viable or desirable to use the target for the development of a new drug. The target however can be at various levels of the human ontology (Figure 3). A change in the DNA can have a huge effect on overlying mechanisms or no effect at all. Making predictions however is very difficult. To fully understand the mechanism of a specific disease, a model needs to be constructed which gives an overview of the most important actors that are related to these mechanisms. This is one of the reasons why drug development can take a long time.

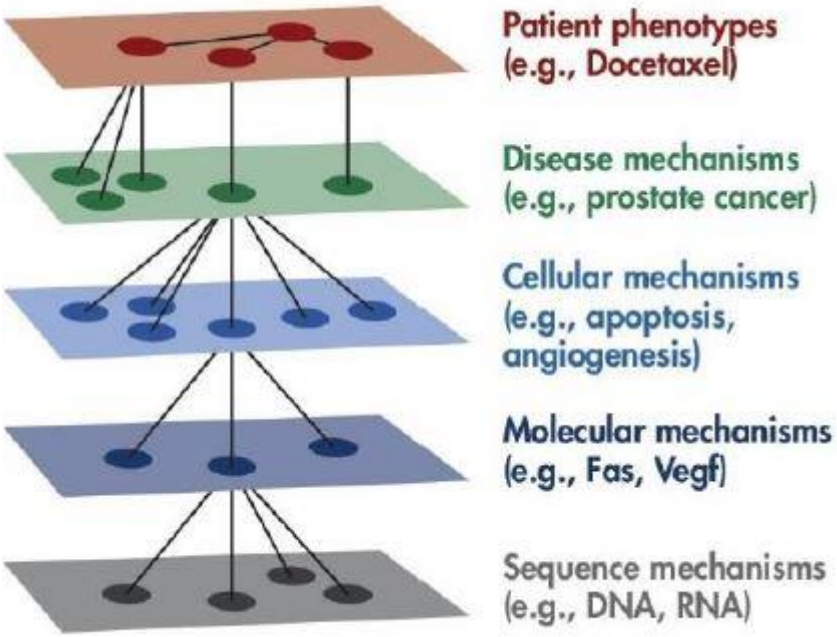


Figure 3: various levels of the human ontology (Koper, n.d.)

1.3. Research goal

The goal of this research is to create a better user experience for the knowledge platform of Euretos. But before a better user experience can be designed, it is essential to get a better understanding of Euretos itself. By determining the best strategic positioning for Euretos by performing market research and a company analysis, it becomes easier to see the connection with the current user group and to understand and establish their needs. A literature study will be executed to have prior knowledge about the field of life science which will be used as preparation for the user research. By performing user research their needs will become more explicit which in turn will be used to develop a concept which is viable, feasible and desirable. This report will start with a company analysis and market analysis to form the foundation for a solid strategy and positioning for Euretos. Afterwards user research will be conducted to establish the needs of the users and a concept will be developed that fits the strategic positioning of Euretos as well as the needs of the target group. The report will end with a section with a corporate entrepreneurial approach dedicated to acquiring new customers through marketing channels to achieve market growth for Euretos (Figure 4).

Figure 4: Report overview

2. Company analysis

Euretos was founded in 2012 with the idea to accelerate biomedical research through multi-omics analysis. Multi-omics stands for the different fields of genomics, proteomics, transcriptomics and metabolomics that are combined into data sets (multiomics, 2017). Multi-omics analysis therefore stands for performing analyses with the use of data from these respective fields. From the start Euretos has been collecting data from multiple data sources to grow their in-house database to perform these analyses. As Euretos started to grow, other parties started to collaborate with Euretos to make use of their extensive database. Euretos already has been collaborating with some of the most advanced life sciences research organisations in the world, including pharma companies, biotechs, academic institutes and research hospitals (Figure 5).

Figure 5: Some of the collaborating partners of Euretos

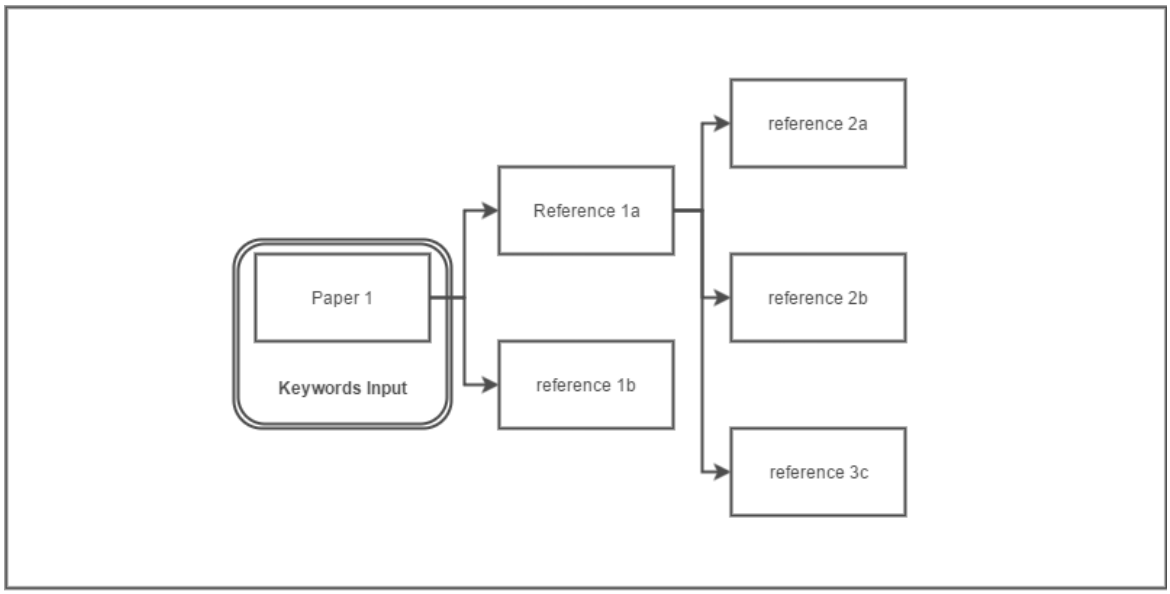
Euretos currently has 25 employees with two offices, one in Zoetermeer the Netherlands and one in Kiev, Ukraine. The management, researchers and helpdesk are situated in Zoetermeer and the programing and coding development team is in Kiev. Although there are already 25 employees, Euretos still has a very lean company structure. Lean means that euretos is trying to maximize its customer value with minimal resources (Ries, 2011). By having its development team outsourced to Kiev, more can be done with the same resources as the labour costs in the Ukraine are lower and the IT sector of the Ukraine has the largest and fastest-growing number it IT professionals in Europe (Ukraine Digital News & AVentures capital, 2016).

The service that Euretos offers is the knowledge platform. The knowledge platform can be used by biomedical researchers to perform all kinds of queries and analyses, like multi-omics analysis, pathway analysis and target identification. What makes the knowledge platform special is that the database is a model driven database. This means that almost all search results also called “concepts”, are directly or indirectly linked with each other. Euretos data mines text from publications and based how often specific concept are co-occurrent they are linked with each other. This means that Euretos can construct relation models based on publications and probability. As these relations models are based on statistics, the researchers does not have to completely construct the relation model themselves. As an example a single disease can be a starting point and based on statistics relevant proteins, biochemical mechanisms and other concepts are then suggested to be imported into the model. Therefore it is easier to find relevant information and put it into perspective with the information which is already present in the model.

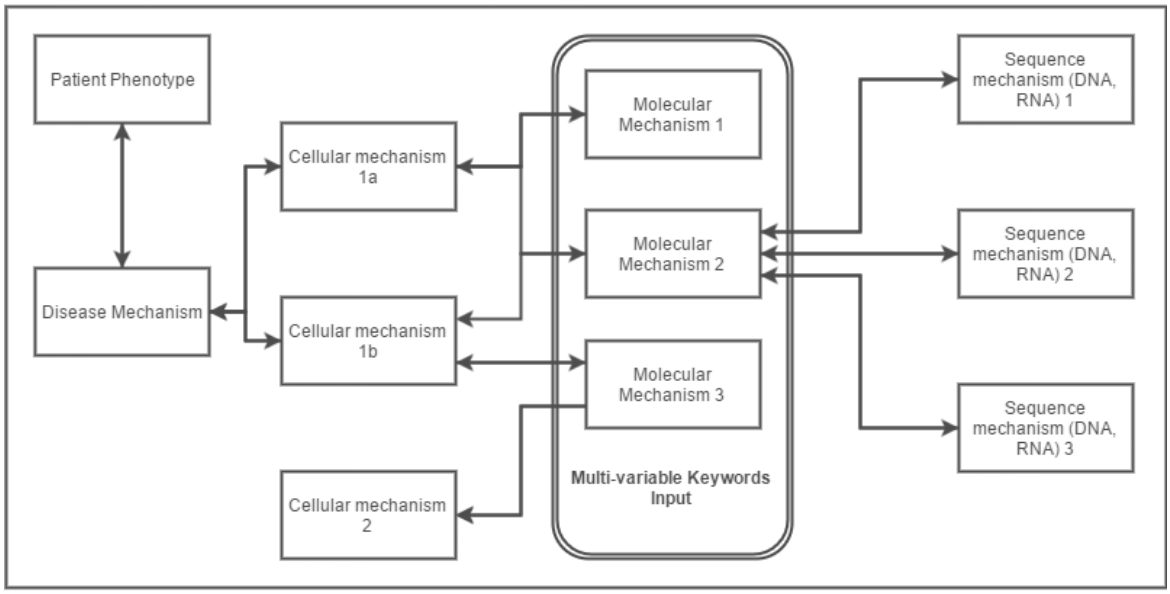
Figure 5 shows an example of a model driven search query. A single or a set of molecules, genes etc. can be used as input and from that point it is possible to find results that are directly or indirectly related to the research question. The use of this biomedical data has significantly increased the chances of selecting a

potential disease target, as the search results are statistically selected, it has a higher chance of being relevant. This in turn results in a more efficient research process (Yang, Adelstein, & Kassis, 2009).

With linear search methods, which do not make use of big data (Figure 6), it is only possible to find links of other papers in the references. Using google scholar as an example for trying to define biochemical mechanisms that are related to alzheimer's disease. The search results will only show results that mention the specific search query. The references in the papers that show up as search results could be related to alzheimer's disease. With just one paper, it is still possible to check the references for relevancy. But with a larger amount of papers, it becomes more difficult to decide which references from all the papers are mentioned often and are probably more relevant to the research question. Constructing a model of concepts and how they relate with each other is therefore a more time consuming task as finding relevant literature takes more time as well as connecting all the papers into a framework or relation model (LUMC bioinformatician, personal interview, March 21, 2017).



Lineair search methods



Model Driven Search Engine

Figure 6: Linear search methods vs. Model driven search engine

2.1. Research goal

The business model canvas is a strategic tool to describe and visualise the current business model. A business model describes how an organisation creates, delivers and captures value (Osterwalder & Pigneur, 2010). Therefore the canvas is an effective tool to capture the building blocks that show the logic of Euretos and to explore the options for innovation.

Customer segments

Euretos is momentarily targeting two market segments within the biomedical industry. The biotech/pharma sector and the academic biomedical sector. The main differences between these two sectors are that the biotech/pharma sector are commercialised companies and need to develop and sell products to make a profit. The academic biomedical sector primarily runs on funding from governments and sponsors to perform research and are not focused on making a profit. Therefore, the academic sector can perform more researches into rare diseases or fundamental research, which is most likely to be never profitable. In contrast, the commercial companies need to reassess with every step during research and development what the costs and benefits will be for the next step as every step closer to product launch becomes more expensive and more risky (Langerak, Hultink, & Robben, 2004).

Value proposition

Euretos offers tools and services to perform biomedical research and find the answer to the research questions of the customer. These research question are focused mechanisms within the human body. These mechanisms can be about practically anything as the field of life sciences is very broad. An example of a research question that has been answered by making use of the Euretos platform is: what is a key factor for cell plasticity and promotes metastasis in pancreatic cancer (Krebs et al., 2017)? The knowledge platform supports running queries and analyses in a big data environment, ensuring a higher chance on relevant results. This enables the researchers in the academic as well as biotech sector to find more relevant results on their research questions in less amount of time.

The unique value proposition of Euretos is that their knowledge platform offers a big database which is constructed in a model framework. The framework is not limited to just one study topic, but to multiple topics, like proteomics, genomics etc. This makes it possible to perform multi-omics search queries with results that are based statistics to be more likely to be relevant. This makes it easier for researchers to find relevant papers for their research. This could be compared with a library which instead of having all the books being organised on genre and alphabetical order, the books are organised on how books are similar to each other across multiple genres and how they still are directly or indirectly connected to the same topic.

Channels

To raise awareness among customers about Euretos' platform and services, it uses telemarketing in the form of cold calling, unsolicited telephone calls to potential customers in attempt to sell their services. The platform and successful research conducted with the platform is presented and published at conferences. Also visits to conferences to network with other companies are conducted to raise the awareness about the Euretos knowledge platform. The website offers the option to follow news about the platform or to book a demo so potential customers can evaluate if the offered services are what they are looking for.

As Euretos is a business to business (b2b) company, customers can purchase their services through personal contact or via the website and request contact for purchasing licenses to access the platform. The login credentials are given via email and workshops and tutorials are available to get new customers started with the platform. Further support post-purchase is offered through the Euretos helpdesk and with the Euretos research note series, a data analytics perspective is provided on recent life science publications.

Customer relationships

Euretos values personal assistance as every customer has specific research question they want to answer with the knowledge platform. As the platform may require some experience to perform complex queries and analyses, Euretos offers personal help with using the platform. Also during workshops, personal contact is highly valued and Euretos actively encourages customers to give feedback to improve the platform and the services offered. These workshops can be booked but often Euretos offers these workshop for free as well as part of a partnership.

Awareness of the Euretos knowledge platform is raised through conferences, citations in publications but also researchers talking to each other. The initial point of contact is often via the website through which potential customers can request a trial account. If the use of the platform during the trial is satisfactory, a subscription can be bought to keep using the platform. Regular newsletters are send to the users to highlight new functionality or to show published papers in which the Euretos platform is mentioned as a research tool.

Revenue streams

Euretos has recurring revenues streams in the form of subscription fees for using the platform and transactional revenues for offering a consultancy service and creating a report to answer the customer's research question. The subscription fee allows access to the knowledge platform and the price individually determined based on the kind of sector and number of accounts/users needed for the platform. The consultancy service is a separate service and is primarily used by researchers who don't use the platform.

Key resources

As Euretos is a knowledge intensive company, they rely on human resources. The development team is essential to keep the platform up and running and the databases up to date. Another key resource is the intellectual resource, the big data environment is a big asset which Euretos has constructed over the years. The large data set Euretos has gathered through data text mining from a large number of publication databases can't be copied by its competitors as it takes years to develop the program to data mine the text and compile it into a relation model.

Key activities

One of the key activities for Euretos to keep on updating and expanding its database as it is one of its most valuable assets to keep on generating value for the customers. Without an up to date database, the databases loses its value as the biomedical sector is a fast moving one with new publications every day, which also outdates other publications and the data belonging to that research.

Another key activity is to keep on supporting the users with their research questions and to perform analyses, but also to support the users with the use of the platform with helpdesk support and training workshops/tutorials. Without the support, the current platform might prove to be to difficult to use, which could frustrate the user to such an extent that they lose the motivation to use the platform at all.

Key partnerships

The key partnerships are with the 175+ databases, like Pubmed which is the portal to the database of the United States National Library of Medicine (NLM) or like the National Center for Biotechnology Information (NCBI) which is also part of the NLM. These databases provide publication data for the most important key resource, the database of Euretos. This would fit in the strategic alliances type of partnerships, however as these databases are often funded with public money, these databases are free to access and therefore an official partnership is not needed. Forging such strategic partnerships could be a wise strategy nonetheless to improve data integration and reducing the risk of integration data acquired through data mining which is incorrect. An inherent aspect of data text mining is that so called "false positive" relations are integrated in the database because of a data text mining error. The data text mining algorithm might recognise a relation between concepts while with human interpretation no relation would be found.

Cost structure

Euretos is a cost-driven business as it tries to focus on minimizing the costs where possible and keep a lean cost structure by outsourcing development to lower cost countries like the Ukraine. To keep the databases up to date, Euretos has a fixed costs structure as there are an X number of developers needed to keep integrating, updating and optimizing data from other databases into the database of Euretos. The variable costs part is about the supporting role of the helpdesk as the number of users grows, the level of support should grow with it.

2.2. Competitor analysis

In the biomedical sector there are a lot of different tools for performing research and every institute, company and researcher has his own preferences based on prior experience and expertise. Some tools have overlap in functionality and some tools are often used side by side as they complement each other. To still give a small overview, a few competitors were picked that were often mentioned during interviews with bioinformaticians and molecular biologists.

Ingenuity

Ingenuity is one of the largest and most experienced companies specialised in performing model driven multi-omics analyses with over 15 years of experience. They were acquired by Qiagen in 2015 for 105 million dollar. Their software has a lot of functions like advance pathway analysis tools and inherited disease mutation database. As Ingenuity is one of the oldest and most advanced, it is also one of the most expensive one with a single user license costing more than 10.000 dollars a month. The reason why Ingenuity has a relative high price is because in contrast to Euretos, Ingenuity does not use data text mining only but all entries in their database are checked individually by employees of Ingenuity. This gives a high quality database with less false-positive entries but the trade-off is that they cost more and that their database is smaller than the database of Euretos. As Euretos only employs data text mining, the database of Euretos can be updated in a more regular basis and therefore the database is more up to date with the most recent discoveries.

Open targets

Open targets is a free and open online search platform focused on pre-competitive research, enabling systematic identification and prioritisation of targets (Figure 7). Their goal is to predict whether modulation of a target is likely to provide therapeutic benefit, much earlier in the drug development to safe the resources of the customer. Their platform is simple and they also allow to search in small batches, the result are however limited as they currently only have integrated 13 data sources.

DAVID

The Database for Annotation, Visualization and Integrated Discovery (DAVID) is a free online platform for performing gene-disease analysis, pathway analysis and gene-biology association analysis. This tool was developed for bioinformaticians in particular and also has advanced options for complex analyses. The database however is not always up to date as they release a new version once every 2 - 6 years.

Onion model

If the competitors a placed in a onion model, it shows that Ingenuity and Euretos are within the same product form as they are both model driven search engines and analysis tools (Figure 8). Open targets and DAVID partially offer comparable functionality but do not have the big data environments which Ingenuity and Euretos do have. The NCBI, Pubmed and Google Scholar can be seen as generic competitors as they are sources for publications. These companies however do not offer advanced analysis tools or have a model driven approach but make use of linear driven search methods (Figure 8).

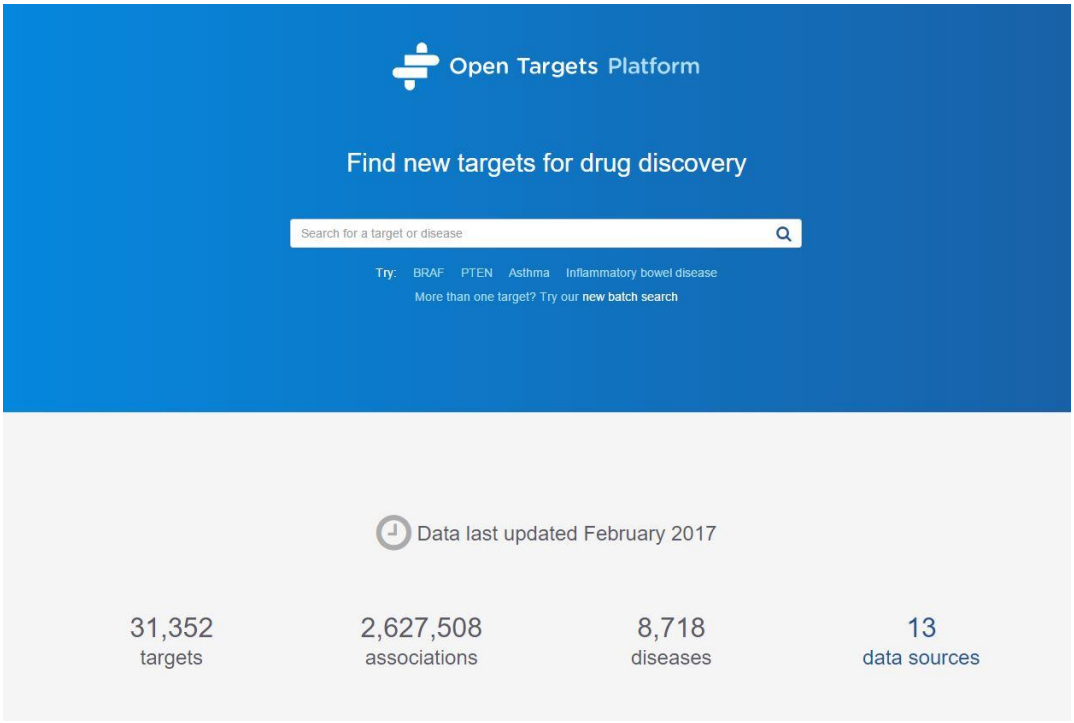


Figure 7: The simple user interface of Open targets

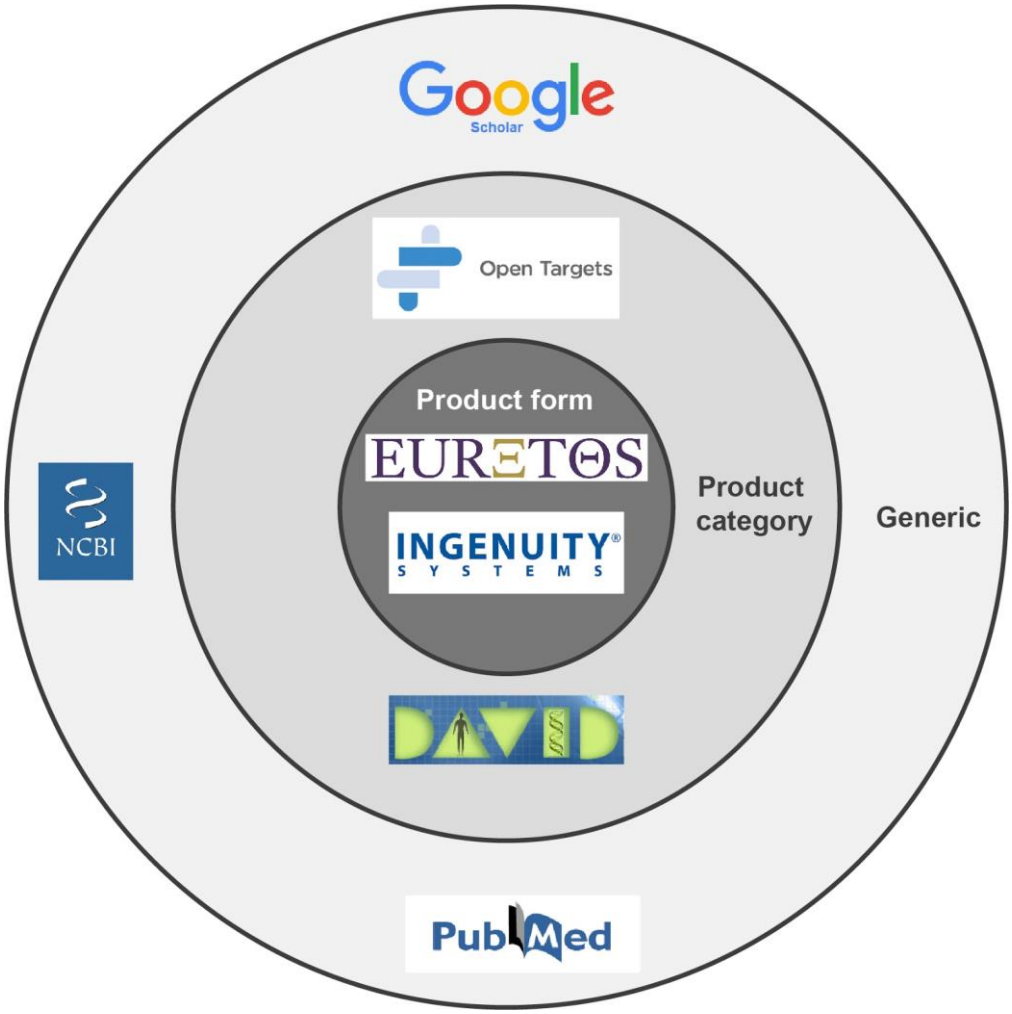


Figure 8: Union model about the positioning of the competitors

2.3. Strategy wheel

To compare the strategic strengths of Euretos in comparison with its competitors, the strategy wheel gives a visual overview of the company's competencies (Figure 9). To determine the scores, input was used from the founders of Euretos as well as interviews with bioinformaticians and molecular biologists.

When looking at pricing, it becomes clear that Euretos fills in the gap between the free open platforms and the expensive platforms. This however does not mean that having a lower price than engenuity affects the quality of the database. The free platforms however do show a lower quality of their database. This mostly accountable to the fact that updating and integrating databases costs human resources and free platforms don't have any revenues except for subsidy from governments or donations/support from companies.

The consultancy and support service of Euretos gives an extra competitive edge over its competitors. Therefore it has a higher score on support, there is however still room for improvement to gain even better competitive edge. With usability and functionality it is clear that the more functionality or options a platform offers, it becomes more difficult to keep the user interface simple. This in turn can have a negative effect on the usability (Stern, 2014). Having a lot of functions can be a design decision but this also means that extensive support is needed. Adobe Photoshop for example has a lot of functionality but also large libraries with tutorials and manuals. Deciding on the number of functions for an application is therefore also a strategic choice as can have an effect on the positioning of the product. Open target for example is one of the newest competitors with its launch in 2015 and they have restricted number of options and this is directly visible in the graphical user interface as it looks simple, modern and easy to use (Figure 7).

Academic collaboration is beneficial for the development of the platform as it increases the credibility of the company. The more Euretos is mentioned in publications, the more trust will be gained from researchers. It is also another channel to reach potential customers and show them a new research method by using the Euretos platform. Collaborating with academic institutes costs resources and therefore a balance is needed between the costs and the benefits. Overall it appears that Euretos is an all-round mid to high range platform which certainly can be attractive for biomedical researchers.

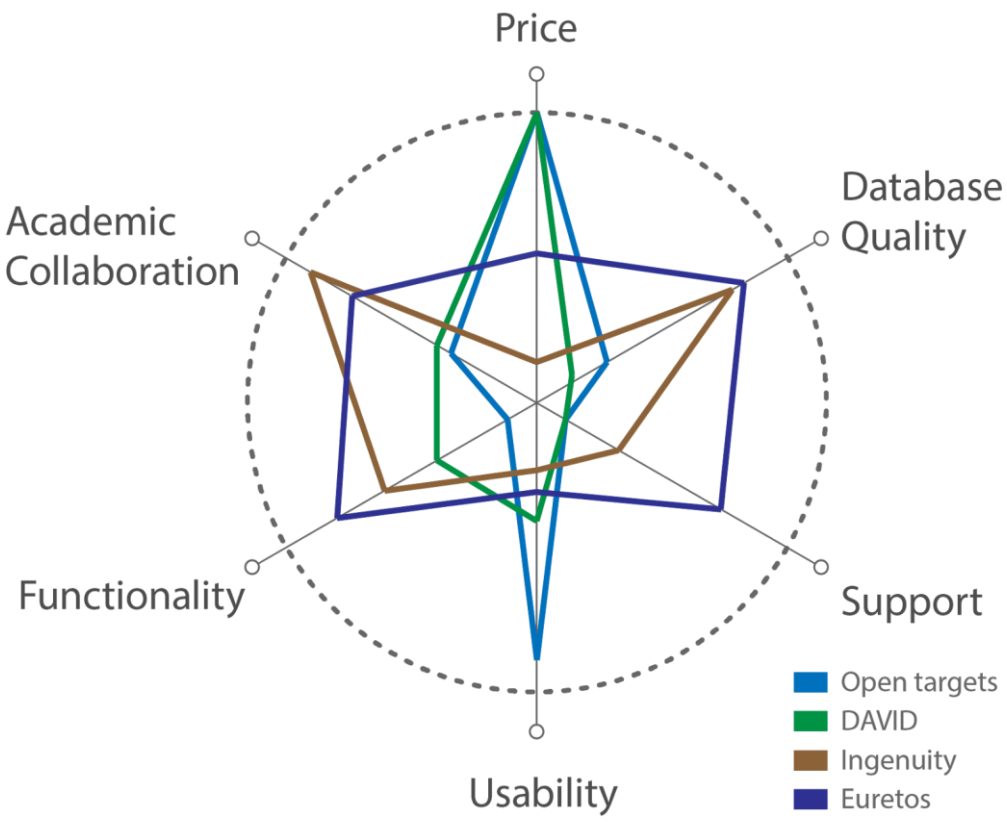


Figure 9: Strategy wheel

2.4. SWOT analysis

To position Euretos in its business context and make strategic decisions, a SWOT analysis was performed. A SWOT analysis gives insight in the internal strengths and weaknesses and the external opportunities and threats.

Strengths

- Outsourced development team lowers the need for resources
- Lean company structure lowers the overall cost structure
- In-house big data environment with 175+ integrated databases
- Close collaboration with research institutes ensures higher quality development of the knowledge platform

Weaknesses

- Relative high fixed costs to keep the database up to date
- The usability of the knowledge platform has room for improvement
- The knowledge platform suffers from bugs which negatively influences the user experience
- There is no software tester in the development team to find these bugs

Opportunities

- Customers value the large database as it gives more relevant results and better predictions, integrating more databases could further enhance the results
- Improving the usability could make the knowledge platform more interesting for other target groups like molecular biologists
- Adding extra filters and standard scripts could partly replace the need for programmed scripts

Threats

- Databases counteract data miners form retrieving data
- Engenuity could expand their database to get comparable results to Euretos
- Intellectual Property in the Ukraine is not very well protected

2.5. Discussion and implications

The positioning of a lower priced model driven big data search and analysis tool is a strong positioning for Euretos as the direct competitor, Ingenuity, costs more and has a smaller database. The data text mining algorithm is a unique feature which is difficult to copy for competitors and it would take time to construct a database of the same size as Euretos' database. The goal to reach more customers and scale-up makes sense as their value proposition is strong and the chance on a quick competitor reaction is low. The low usability however makes it difficult for Euretos to grow without investing in more employees to provide support for the new customers and maintain the same level of support for current users.

To search for opportunities to provide a better service and improved usability, more knowledge about the actual users are needed. What are important factors for users to use the Euretos platform? Which barriers do current users see for continuing and expanding their use of the Euretos platform? What are the steps of the research process of our target group? These questions will help to get a better grasp of the context in which the knowledge platform is going to be used and it will help to formulate a strategy for Euretos.

3. User research

To perform user research with researchers in the field of life sciences, first a literature study was conducted followed by interviews. The literature research revealed that the field of life science research and drug development are too large to make generalisations of the diverse processes that are used in the research and development process of drugs. Most literature is very specific literature about a specific research but not about the research and development process itself. For this reason, the interviews were conducted to discover how bioinformaticians and molecular biologists perform research, how their process looks like, how they use computer software and what their research related problems and concerns are.

Method

Bioinformatics and molecular biology are very complex fields and preparing interviews without any prior knowledge would not have been possible. The interview guides (Appendix A) were written based on knowledge about the drug development process and questions from Euretos. The guides were piloted with a bioinformatician who also works for Euretos and improved if anything. All the interviews were audio recorded with and based on the level of novel information, some interviews were transcribed. All participants were asked to perform some tasks they have been working on while using the Euretos platform while thinking out loud to give insight into their strain of thought. Their actions were observed and discussed afterwards.

In total six bioinformaticians from the Leiden University Medical Center (LUMC) were interviewed about their research process and the use of computer applications to support their research. The bioinformaticians of which two males and four females, ranged in age from 20 to 45 and all had a degree in bioinformatics, from which three had more than 15 years of experience in the field of bioinformatics.

Three molecular biologists, two from the LUMC, male and female and one female molecular biologist from the Dutch Techcentre for Life sciences all within an age range of 25 to 45, with one molecular biologist having more than 15 years of experience in her field, were interviewed.

3.1. Research process in drug development

During user research there were strong indications that the research process of molecular biologists and bioinformaticians at academic institutes are quite different from each other. The similarities are that the goal of their research is to discover new biomedical knowledge and write a publication about it. To start a research a research proposal is written and a grant is assigned. This grant is often assigned to an individual researcher for a duration of 4 to 5 years with the amount ranging from 200.000 to 300.000 Euros.

Molecular biologist

A molecular biologist is a researcher which studies the structures and functions of cells on a molecular level. As diseases are caused on a molecular level, molecular biologists are very important to develop drugs. To research diseases and develop drugs, governments and patient organisations provide money in the form of grants for a particular research. Biomedical researchers can then apply for the grant to start their research (Figure 10).

After a molecular biologist has received a grant, the research process start with systematic review to find all relevant literature related to the subject of the research. This process takes at least a month and at the same time, the molecular biologists gets set up in the lab. Pubmed is one of the most used because all the medical articles are published in this database. During this phase up to 1000 articles are read. Review articles are preferred in particular as they recap what already is known about a specific gene or protein. The references are then used to find more relevant knowledge which help to create a complete overview about the disease.

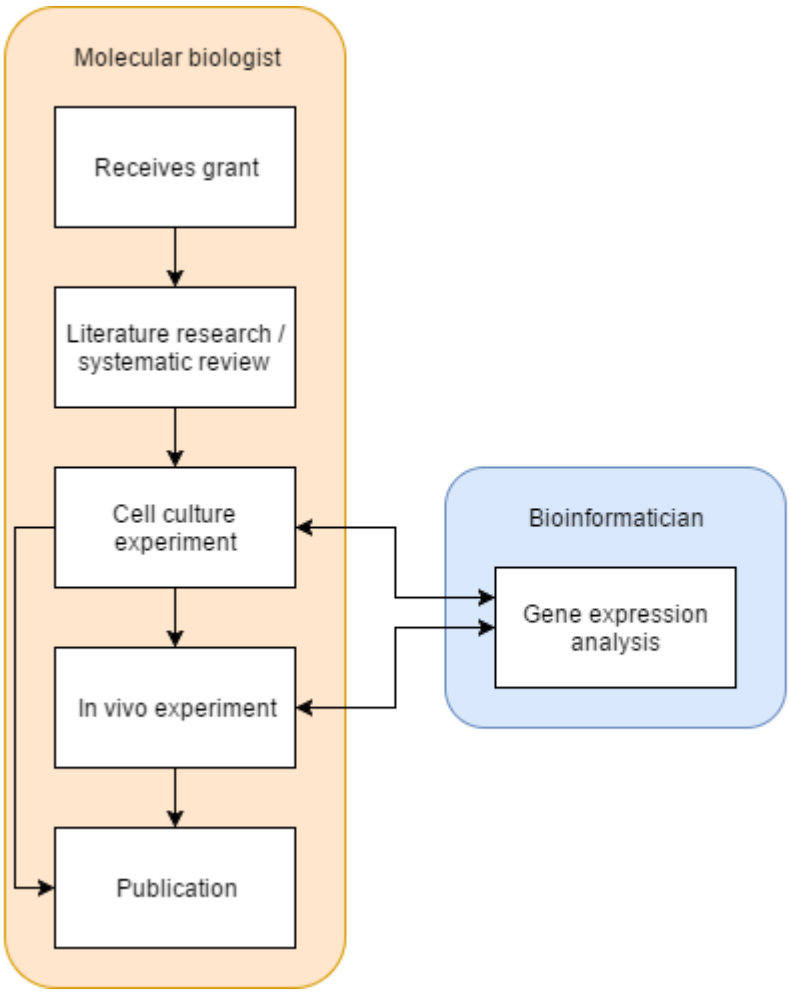


Figure 10: Research process of a molecular biologist at the LUMC

"You start with a huge amount of literature, as you don't know much about the disease and the technology used." - LUMC Molecular biologist

Reviewing literature is an essential phase for the research of a molecular biologist and as there are a lot of articles, the interviewees stated that making the right choices to which publication to read or not are important skills. Whether to read a paper is based on the two questions: is it relevant to my research and can the publication be trusted? In this case, trust means that the research in the paper has been executed according to academic standards, the paper is not outdated and preferably cited by other research papers as well. In most cases this means that a paper is assessed on publication date, authors, publication source and how often it is cited. A smooth user experience is partially based on the possibility to be in control of these parameters and the results that are shown with any computer application. With all the relevant literature knowledge a framework is constructed, sometimes with the Euretos platform, to decide on where there are knowledge gaps and how further research could help into gaining a better understanding of a specific disease mechanism.

"It sometimes dates back to 1970, then you need to ask yourself how relevant such an old publication still is. Especially because back then the research technology was not as advanced as it is now" - LUMC Molecular biologist

The next step is to start experiments. To prepare for the experiments, molecules are designed which can target a specific sequence of DNA. To design the molecule, online tools are used as there are a lot of pharmacodynamic parameters to keep into account, such as melting temperature or bonding strength. The first experiment is on skin cells which contain the disease. The new designed molecules are then inserted into the cells during a process called transfection. After that, the RNA of the cell gets isolated to inspect if the mutation which causes the disease has been removed. The process of developing the molecule is a bit of a trial and error process as not all of the designed molecules have the desired effect. Depending on the impact of the results of this cell culture experiment, an article can be written for publication.

After the cell culture experiment, in vivo experiments are started. In vivo experiments are experiments conducted on living animals, often mice. The most effective molecules are then inserted into the mice to observe the effect on the phenotypes, biomechanisms and DNA. If the experiment has been successful, an article is written for publication. The process from systematic review, successful experiment and publication can take a lot of time as 9 out 10 therapeutic experiments fail.

During the cell culture experiments and in vivo experiments, often the help of a bioinformatician is required to perform gene expression analysis. As the bioinformatician often is not specifically involved with the complete research, it can take some time before the molecular biologist has its results back. This is the reason why some molecular biologists have decided to learn a statistical programming language to perform simple analysis themselves. The gene expression analysis is combined with multi-omics analysis to make better predictions of how a next experiment can be improved to yield better results and to find explanations for the results of past experiments. For these analysis, different applications can be used like DAVID, Euretos or Engenuity, depending on the preference of the researcher and the budget of the grant.

“In the future there will probably be no difference anymore between molecular biologists and bioinformaticians. It will still take probably 15, 20 years. The bioinformatician as a helper will disappear in the future.” - LUMC Bioinformatician

Bioinformatician

Bioinformaticians are researchers who perform research based on information technology. They use statistical programs to analyse and predict the biological processes that occur in the human body or other mammals used for in vivo experiments. The same way as with molecular biologists, bioinformaticians can apply for a grant to perform research about a specific topic or disease (Figure 11).

After receiving the grant, the bioinformatician often starts with a gene list for further analysis. This gene list can be extracted from databases or can be acquired from prior experiments performed by molecular biologists. These genes are then grouped into pathways or other parameters. The next step is to further analyse and determine which genes are associated with the disease. These analyses are very complex and often based statistical chances of genes being related with specific pathways. Different databases are used to run these queries and the larger the database, the higher chance something significant comes out of the analyses. Further research is then required, for instance with gene expression analysis before an article can be written for publication.

“The most common method to look at gene sets is to look at the processes, the pathways and it can lead to phenotypes and diseases.” - LUMC Bioinformatician

As the research of a bioinformatician is on theoretical basis, lab experiments are sometimes required to test the hypotheses. As bioinformaticians are not trained to perform experiments in the lab, molecular biologists perform the experiments. The molecular biologist is often also busy with his own research and therefore preparing and executing the experiment can take quite some time.

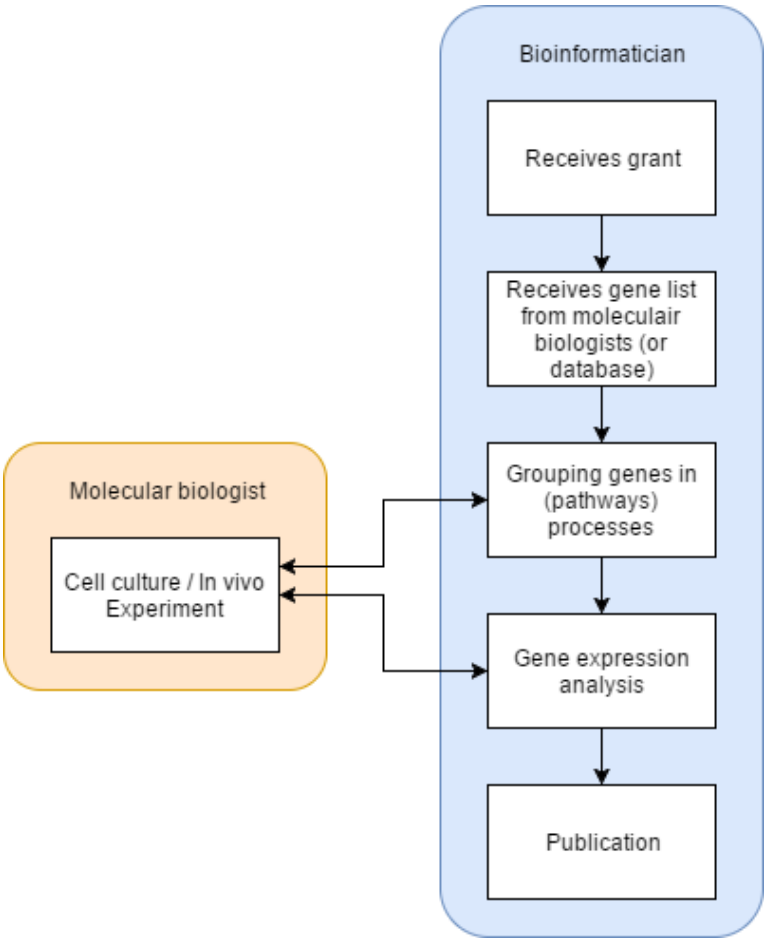


Figure 11: Research process of a bioinformatician at the LUMC

Interdisciplinary collaboration

For performing research it became clear that molecular biologists and bioinformaticians can work separately, but they are still often dependant on each other to find relevant results (Figure 12). This interdisciplinary collaboration is often based on goodwill to help each other. As this collaboration is often unpaid and only the expenses are covered because of tight budgets, the requests from colleagues does not always have priority. This results in delays, making the research process even longer. Despite the delays, the collaboration is often essential to evaluate and validate research results to increase validity, resulting in a publication with more impact. The process of therapeutic research and drug development is a complex system with interdependence on different disciplines to find new knowledge which in the end may lead to the development of new drugs (Figure 13).

“Me as a bioinformatician, collaborate a lot with biologists. They perform the lab experiments and I perform the analysis. Afterwards we will sit together to discuss what I have found.” - LUMC Bioinformatician

Using the knowledge platform

During the observations, it became clear that to understand the user and all the specific actions the user wanted to perform, more knowledge about molecular science and bioinformatics was needed to fully understand what their goal was for using the knowledge platform. The observations however did point a few problems out. The navigation of the knowledge platform was often confusing and at some points frustrating. The user interface did not support the user's workflow in guiding the attention to the next needed functions which gave the user the feeling to be searching all the time. Also a lot of bugs were present, like pressing a button with no result or buttons with an unclear function.

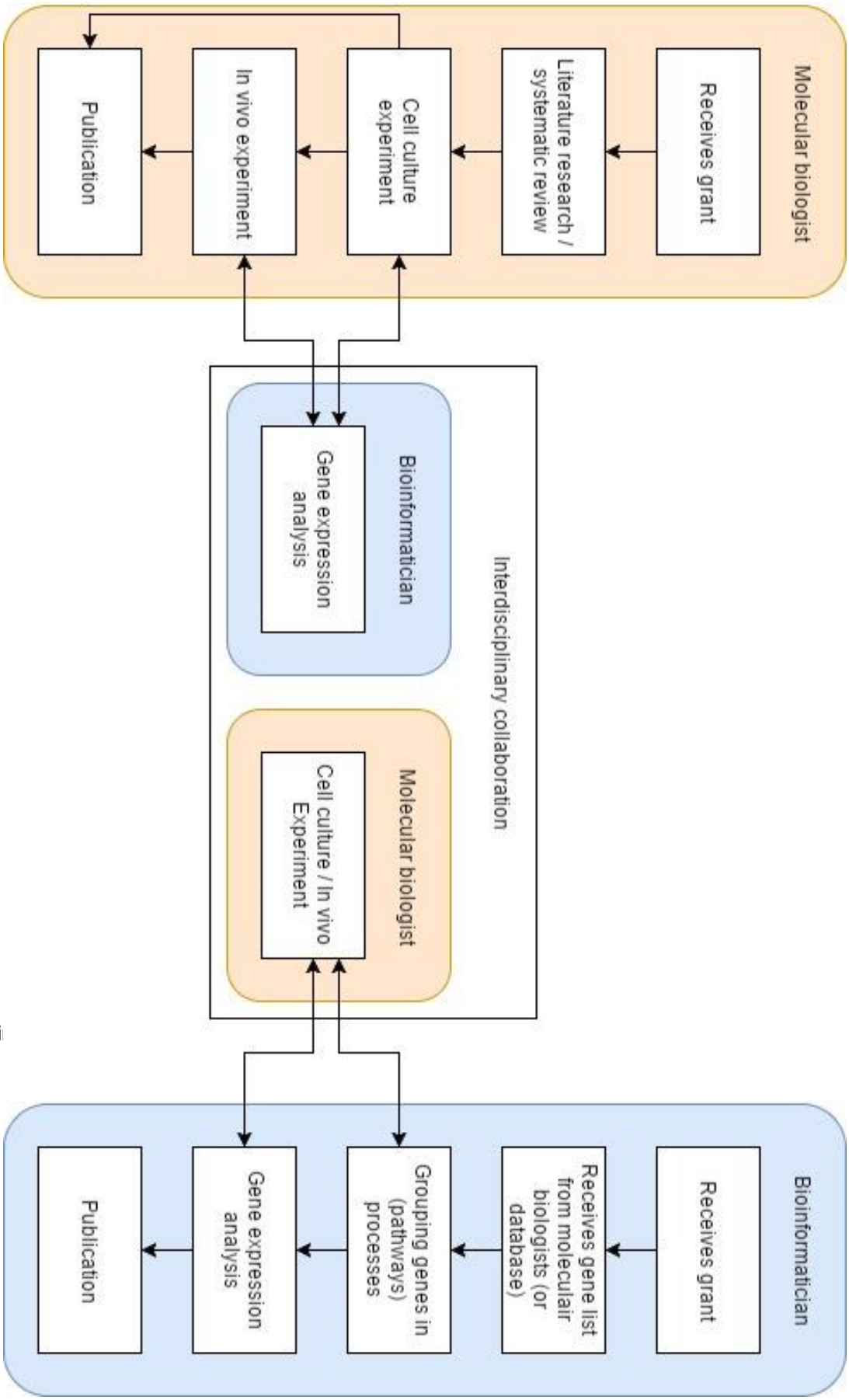


Figure 12: Interdiscipli

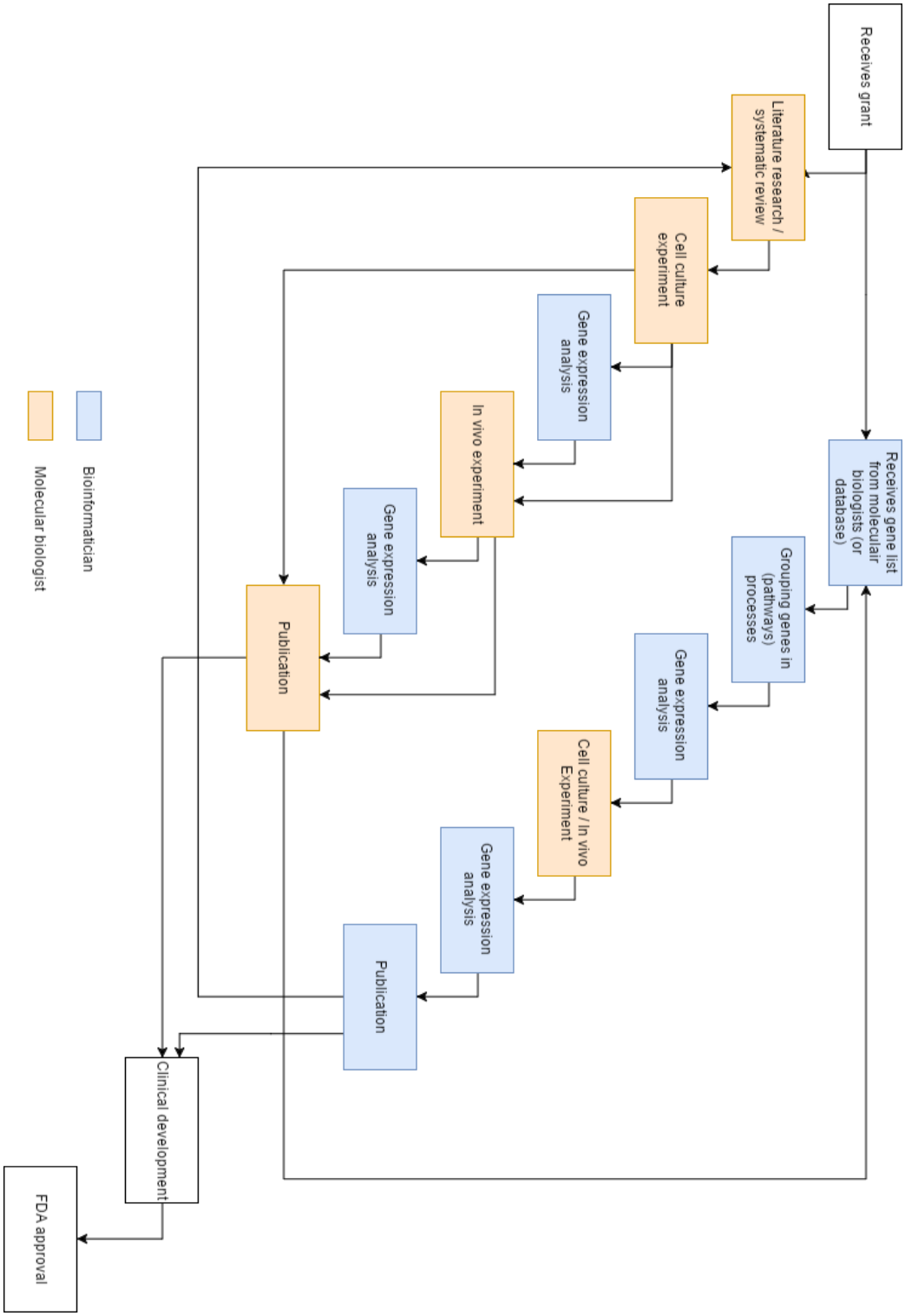


Figure 13: Molecular biologists and bioinformaticians research process interdependency

3.2. User categorisation

After the interviews were conducted, within the user groups of molecular biologists and bioinformaticians, distinctions could be made on their preferences of how to perform research and how their workflow looks like (Figure 14). A trend can be seen that molecular biologists start to perform simple tasks of a bioinformatician by learning to program statistical analysis scripts. The interviewee however mentioned that the large majority of molecular biologists however do not have any knowledge about programming.

For the bioinformaticians, a distinction can be made on their preference for a graphical user interface (GUI) or syntax programming by using direct access to the databases. The bioinformaticians however do not perform lab experiments and therefore remain dependant on molecular biologists to perform lab experiments.

If all the interviewees were to be categorised into these categories then there would be one molecular biologist, two hybrid molecular biologists, four bioinformaticians and two computer engineer bioinformaticians. All though these numbers would not be representable for the complete field of life science research and the interviewed (hybrid) molecular biologists have confirmed that the largest group are still the molecular biologists that do not have any programming knowledge, there are some indications that this mostly due to the relative higher age of the group of molecular biologist and that this is probable to change in the future.

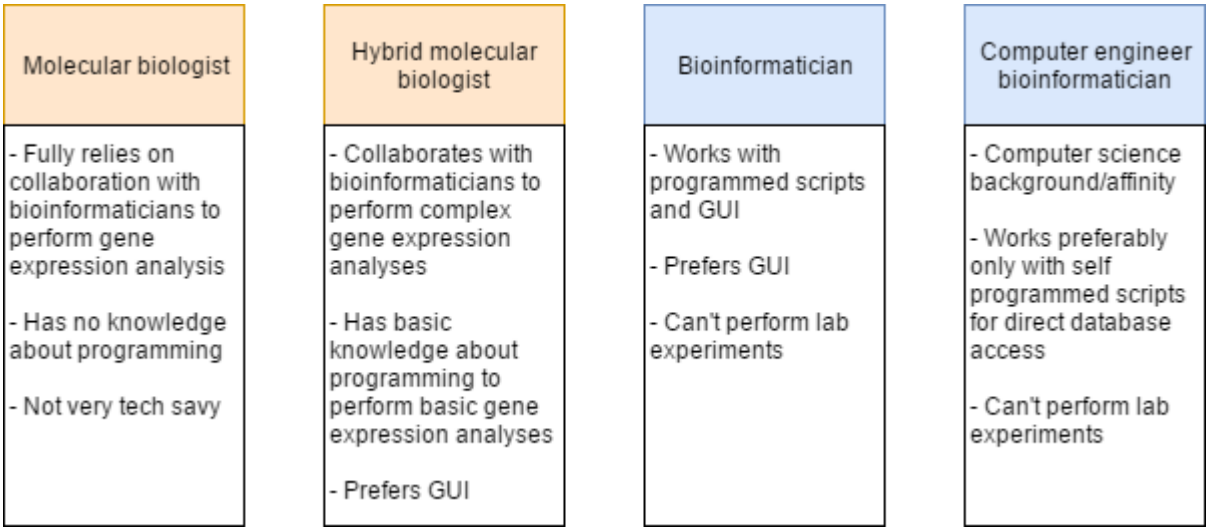


Figure 14: User groups

Although the knowledge gained about molecular biologists and bioinformaticians were rich and insightful, the number of interviews and observations were limited due to the difficulty to reach the target group. Also the user research was limited to the academic field while the commercial field for drug development also remains a interesting group. Due to the high level of confidentiality, no researchers at pharmaceutical companies were willing or allowed to be interviewed.

3.3. Discussion

Regarding the user research there were a number of limiting factors. The first limiting factor was that interviewing this target group was difficult as everyone had a lot of knowledge about their fields and were responding primarily with jargon. This made it more difficult to understand the deeper meaning of their answers. Asking to simplify was not always possible as it was about complex subjects. During analysis some of these unclarities could be clarified by consulting the managers at Euretos. In addition some

interviews were performed later in time which allowed the interviewer to gain more knowledge about the field of life sciences and therefore some older transcripts were reanalysed to search for missed insights. This resulted in statements being strengthened or soften according to the new interviews and comparison with the older interviews.

A second limiting factor is the sample size. The small sample size does not justify a generalisation for the complete field of life sciences. It does however give a first indication of how this field operates and how research is conducted. The recruitment of participants proved to be more difficult than expected as most researchers are very committed to performing research and therefore do not have much time to be participating in a user research study. The sample also is primarily focused on research institutes with almost all the participants being part of research groups at the LUMC. This prevents making generalisations for academic research institutes. The pharmaceutical sector is another interesting target group. The pharma sector however is especially cautious with revealing information as research methods and processes that lead to the successful development of drugs are very valuable. Therefore assumptions were made that as scientific life science research need to be of academic standards, the research methodology might be similar as there are specific standards for performing experiments. Nevertheless, most statements have been discussed with Euretos managers, whom have daily contact with academic research institutes as well as companies within the pharmaceutical sector and they were able to help confirm certain explorative insights and assumptions.

4. Strategy

The business model canvas has shown that Euretos heavily relies on human resources to keep their big database up to date and to keep on integrating more databases. This big database is one of the key features of the knowledge platform which makes it stand out of the competition. Other commercial competitors like engenuity are very expensive and therefore significantly affects the budget for performing research. Euretos is an interesting alternative as it costs less. The strategy wheel shows that Euretos could become an all round company by investing in the usability and the support of the use of the knowledge platform (Figure 15 & 16). By increasing the usability, the need for personal support drops and the variable costs for providing the support drops as well. At the same time allowing the users to work more independently because of the intuitive to use platform, online tutorials could positively influence the feeling of support. Another benefit is that the knowledge platform becomes easier to scale bigger to more users as they can use the platform independently and with less support from the helpdesk.

By targeting not only bioinformaticians but also attracting molecular biologist with an attractive and intuitive to use GUI, a larger group can be targeted (Figure 17). Performing research is more of an individual effort than a collaborative one and grants often don't give much room for including more researchers. Full interdisciplinary collaboration during the whole research therefore does not happen a lot. Collaboration is however often essential to explore, evaluate and validate results. When this happens, the research process often gets a bit delayed as the primary researcher needs to wait for the external researcher to make time to perform the analysis or experiment. This delay can be a few weeks to a month as the request does not have the priority of the external researcher. Therefore Euretos could benefit from the trend that molecular biologists are starting to perform the gene expression analyses themselves. By facilitating molecular biologists to perform simple gene expression analyses themselves with a GUI instead of the need to learn programming or the need for collaboration with a bioinformatician, could lead to a faster research process.

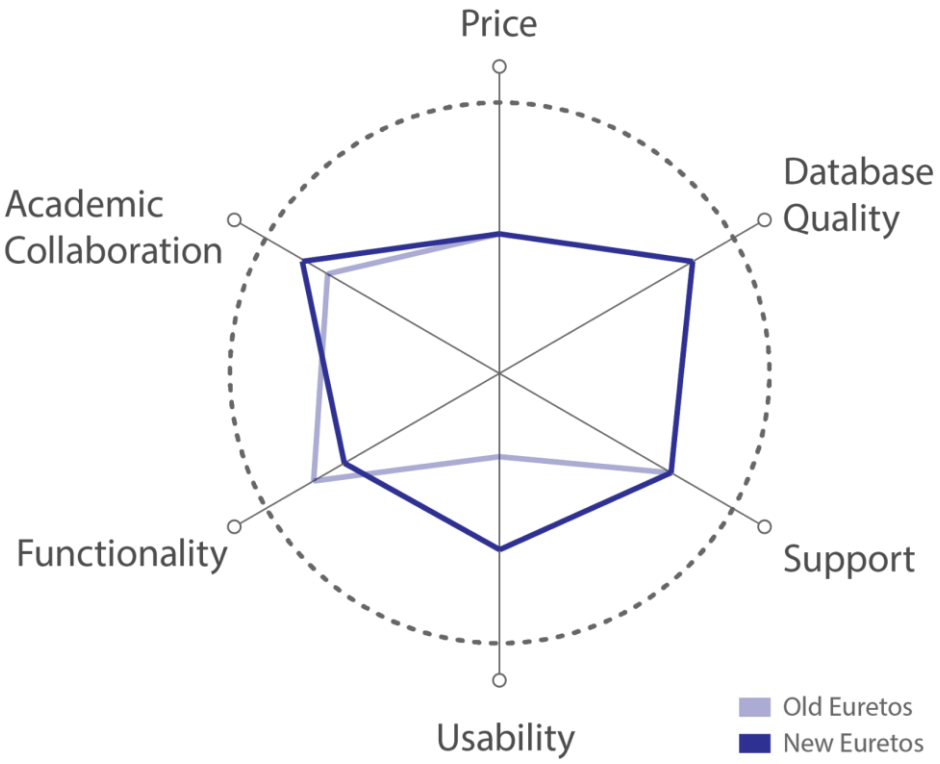


Figure 15: Strategy wheel with the new positioning of Euretos

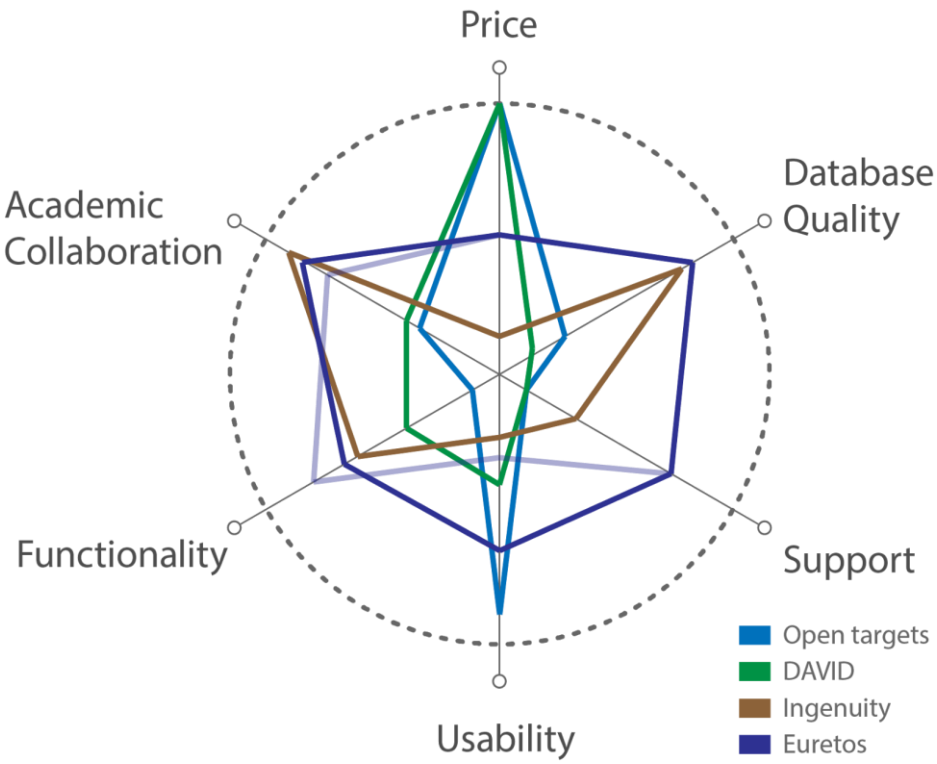


Figure 16: Strategy wheel with the new positioning of Euretos compared to its competitors

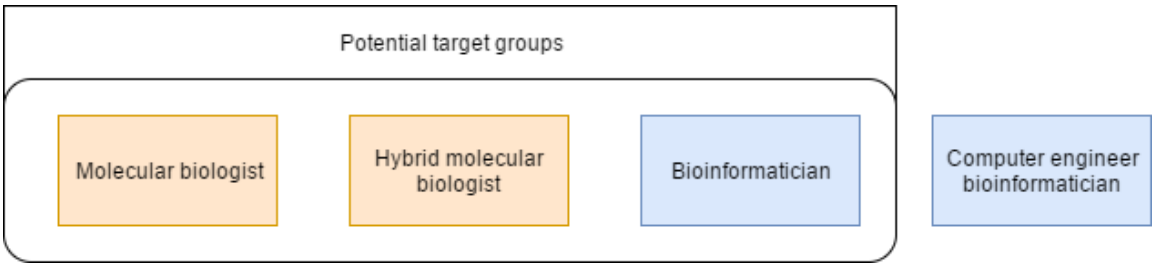


Figure 17: Potential target groups scope

4.1. Design challenge

As discussed in the previous chapters, improving the scalability of the Euretos knowledge platform by improving the usability and expanding the target groups is needed to ensure market growth. To improve the usability, the functionality of the platform needs to focus on the similar needs of the molecular biologist and the bioinformatician. The platform needs to enable the user to perform search queries and analyses without overloading them with difficult workflows. To achieve this, certain criteria can be composed:

- Usable for molecular biologists
- Usable for bioinformaticians
- Prevent information overload
- Logical workflows
- Easy navigation
- High level of independent use
- Balance between usability and functionality
- Intuitive design

These criteria however cannot directly be translated into user interfaces. Research into what these criteria implicate for the design must first be performed

5. Digital interface design

To design an intuitive user interface, we first need to understand what a suitable user interface is and what the key elements are to make it intuitive to use. Therefore research was conducted by reading literature, web research, looking at presentations, analysing award winning interfaces and performing a interview with a UX lead designer from Philips healthcare.

5.1. Command line interface (CLI)

The history of digital user interfaces start with the first computers which at the time used a command line interface (CLI). A CLI is an interface that can be interacted with through a screen and input from a keyboard (Figure 18). They keyboard is used to give a command to the computer which tells what task to perform. One of the most popular computers which used this type of interface, was the Commodore 64 (Figure 19). The Commodore 64 was released in 1982 and with over 17 million models sold, it is listed as the best-selling single computer model of all time by the Guinness Book of World Records (Griggs, 2011). The Commodore 64 was for many consumers their first computer with the capability to run primitive games and run basic office applications.

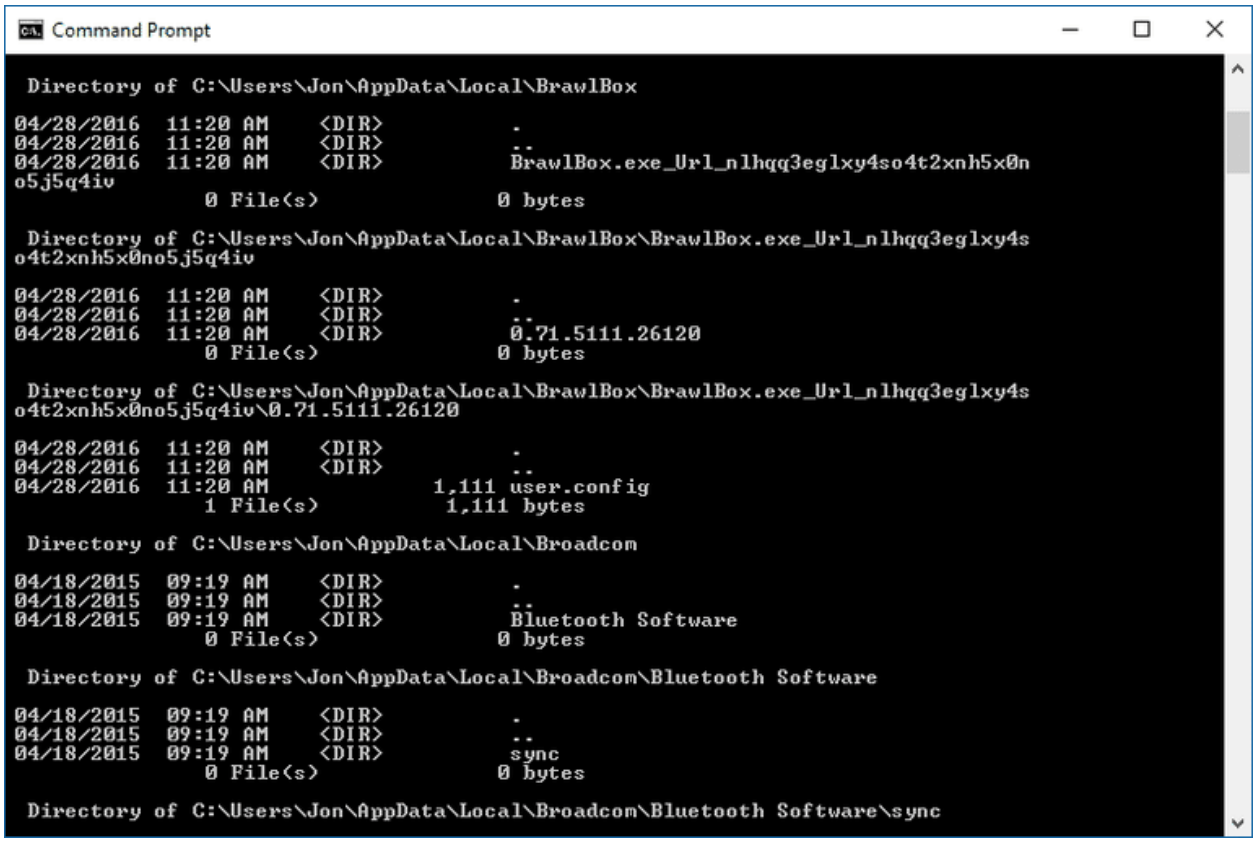


Figure 18: Command prompt, command line interpreter application (Fisher, 2017)

To interact with the Commodore 64, the user could use the arrow keys on the keyboard to select a command from a menu of command options or type in a command to perform an action. A modern example is the command prompt command line interpreter application which is available on the windows operating system (Fisher, 2017). The downside of a CLI is that the user needs to memorise all the commands and that a typographical error in the command result in the computer refusing to perform the command as it does not recognize the command.

Figure 19: Commodore 64 with a command line interface (Bertram, 2005)

The positive side of a CLI is that it is very suited to run batch processes, applying a single operation multiple times (Lal, 2017). An extension is programming own code to be performed by a command. This offers a lot of freedom to what the application will be doing but it takes extensive knowledge of the user to write the code and give the command to let program run. The bioinformatician with a computer engineering background won't have any troubles using a CLI as they are familiar with coding and using command lines. They will be able to connect with the database of Euretos through the application programming interface (API) and run their own code to perform analysis. Non-expert users, like our potential target group of molecular biologists and bioinformaticians without a computer engineering background, however will not be able to use a CLI as they lack the knowledge to code their own applications and therefore need an alternative to use the Euretos database.

5.2. Graphical user interface (GUI)

The adoption of a graphical user interface started in the early 1980's with the Home Screen for Xerox Star and Apple Lisa Computer (Figure 20). The interfaces were based on the use of a mouse, along with key UI elements, windows, clickable icons, and pull-down menus. Windows run self-contained programs, icons were meant to be clicked for execution, menus provide a readily available list of commands, and pointers allow the user to visually track the mouse (Lal, 2017). The interface allowed direct "what you see is what you get" (WYSWYG) manipulation of the windows, icons and menus. The user interface created a forgiving experience by allowing users to undo previous actions in contrast to the command line interface where it is impossible to undo previous run commands.

The consistent use of familiar icons and menu options allowed the user to learn to use the interface easier. The user was given control by keeping a continuous dialogue of request and response, supported by progress bars to keep the user informed about the process and give an extended feeling of control (Lal, 2017). The GUI developed further over time and is now widely adopted across a lot of devices like, photocopiers, smartphones, laptops, coffee machines and much more. The possibility to easily operate a device, often without much prior knowledge or experience, is the core strength of a GUI if designed correctly and consistently.

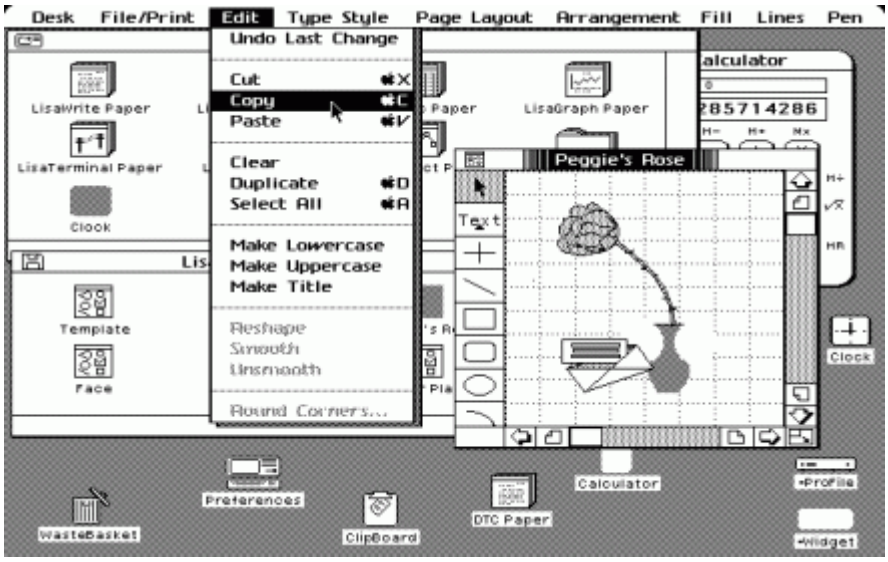


Figure 20: Screenshot Apple Lisa (“Mac History”, 1983)

Figure 21: Current interface of a Apple Macbook (“macOS Sierra”, 2016)

5.3. Designing digital user interfaces

The design of a digital interface is an important aspect of how the user experiences the services offered. A bad user experience can result in a user's response to avoid the service. Products come in many forms and a digital service is just another form of a product. Just as with physical products, the appearance of a digital

service is as important as the interaction with the product. The appearance of the product, in this case the interface, is a medium for communicating information to the users (Nussbaum, 1993). A user interface with a lot of buttons might communicate a very complex service with a lot of features for professionals opposed to a simple layout to communicate ease of use. Having own design principles can help to create a recognizable corporate character (Forty, 1986).

It is the task of the designer to design a product that is especially pleasing to the target group, while simultaneously satisfy relevant design constraints (Lawson, 2006). The design of the product appearance and the product interaction has a lot of freedom when it comes to digital services. Nevertheless there are still conventions which can be used as design guidelines for designing digital services. These conventions can be categorised in the following subjects: Concept recognition, content and user control (Figure 22).

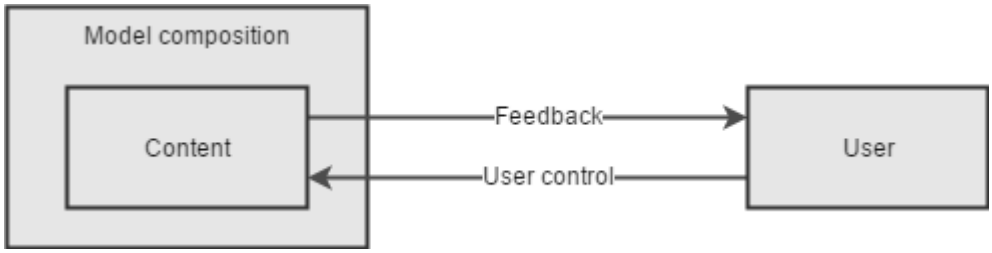


Figure 22: Digital user interface design framework

5.3.1. Concept composition/recognition

A concept is the notion of an object, product or experience. With each concept comes expectation in which way a user can interact with the concept and what the outcome will be. By learning and experiencing, the notion of an existing concept can be refined and new concepts can be created (“macOS Human Interface Guidelines”, 2016). It is important to manage the right expectations with the right concept to prevent frustrations or confusion with the user.

The use of known concepts like a pen, coffee machine or google is not difficult. But it is also not that simple either. To write a phone number with a pen you need skills like coordination, knowledge how to hold a pen etc. These skills now come quite natural because they are in the muscle memory. The knowledge how to write with a pen becomes implicit and the use of a pen becomes intuitive based on the ability to recognise patterns that indicate the dynamics of the situation (Klein, 1999). The same goes for using google, knowing how to use the keyboard, know where to type in and what command to give. These actions are in the implicit memory and this lowers the cognitive load on the user which gives the possibility to think about the main goal, like what to type in as a search query. Getting familiar with these concepts takes time, like learning to use a pen, make coffee or use google but over time it becomes easy to do. With known concepts, the use becomes intuitive (Stern, 2014).

The Recognition Primed Decision (RPD) model of Klein (1997) shows how rapid decisions are made based on prior experience (Figure 23). By judging the familiarity or prototypicality of the situation, the user will make a decision on how to act. Because the RPD model is based on the users using their existing experience, Klein (1998) sees it as a model of intuition. The recognition of the situation has four aspects; plausible goals, relevant cues, expectancies and possible actions. These aspects determine what the user will do as a reaction. The moment a design becomes too atypical for a concept, the cognitive load is raised to find out what the purpose of the product which distracts from the original goal. Therefore it is important to have the right cues to raise the correct expectancies. An atypical design might result in the user not noticing what the possible actions are and he might have wrong expectancies of the outcome. When the user is not able to categorize the concept into a specific category because it does not have the right cues, like product appearance, the user might not consider to use it (Creusen & Schoormans, 2005). An example of such situation is with the Philips Alessi coffee maker which has an atypical design that confuses the user how it operates in comparison with a typical coffee maker (Figure 24). Therefore it is important if a user interface needs to be used intuitively, it needs to resemble existing concepts that are used by the target group.

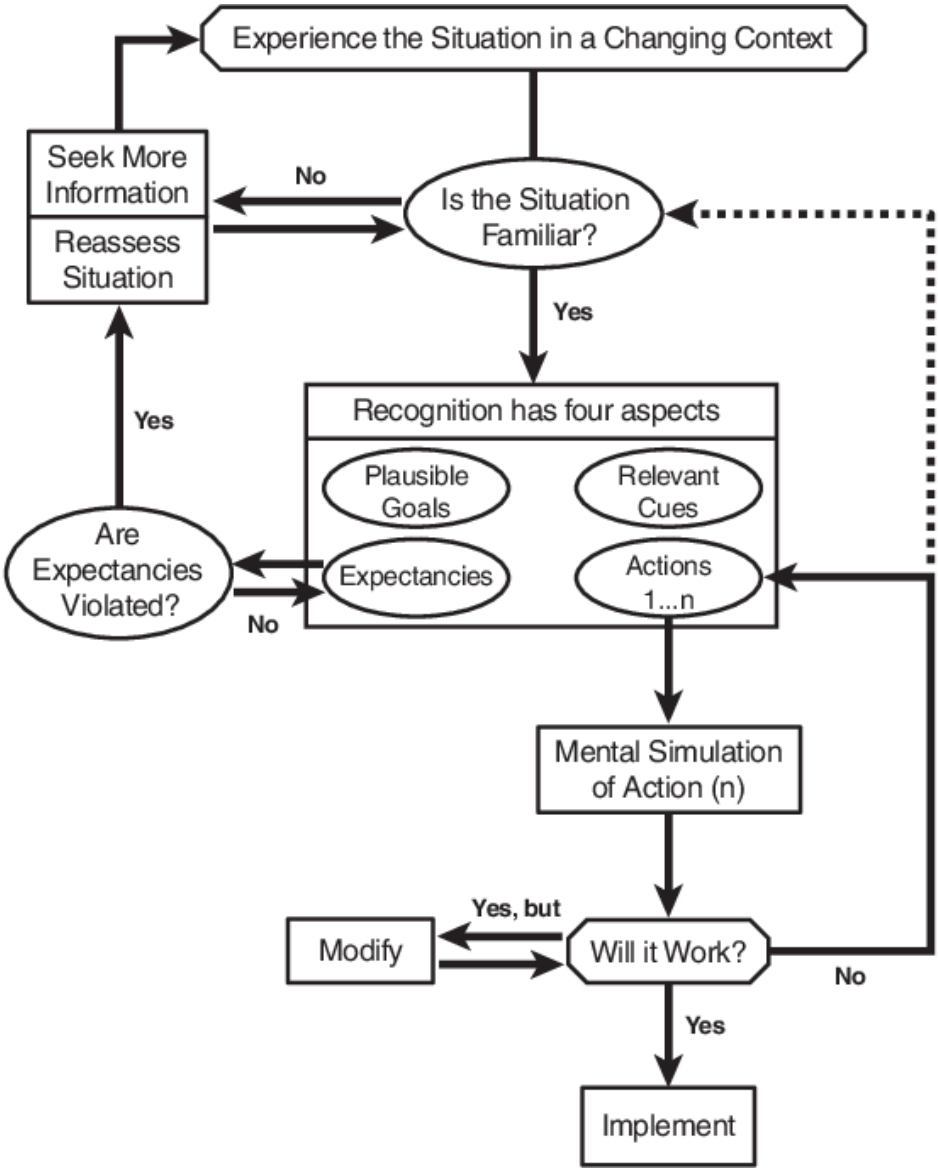


Figure 23: Recognition Primed Decision (RPD) model (Klein, 1997)

Figure 24: A typical (Left) and an atypical (Right) coffee maker (Creusen & Schoormans, 2005)

When creating new concepts because there are no existing concepts to make use of, the user needs to get familiar with the new concept. Failing to educate the user with the new concept can result in a failure of the product as the user does not know what purpose the product serves. Therefore it is important to realise that the target group is essential to determine when a concept is intuitive to use. Flying a plane might be intuitive for pilots but for others it becomes an impossible task. The same goes for bioinformaticians and molecular biologists trying to perform a search query for specific gene sets and performing set analysis. It is important to determine what aspects and functions are intuitive to use and which parts are still too difficult to use without guidance. By balancing between prototypical concepts, like a google-like interface for search queries and new concepts for performing gene set analysis, the user interface can be focused on intuitive use.

5.3.2. Content

After having decided on which concept composition would suit best, it is time to decide how the targeted group is positioned on the scale from a sporadic user to a professional (Figure 25). Sporadic users won't use the service for prolonged periods of time and therefore the service needs to be simple and the number of options need to be restricted. For professionals who rely on the service for longer periods of time, the focus is on utility and efficiency to perform the task as quickly as possible. This translates to a complex service with a lot of functionality with all the options in plain sight (Stern, 2014). An example is the comparison between Microsoft Movie Maker (Figure 26) and Adobe Premiere pro (Figure 27), both are video editing software but targeted at different target groups. Microsoft Movie Maker has a simple user interface which allows to edit a movie by selecting short video clips, cropping them to the right length and encoding the clips to one movie. Adobe Premiere Pro serves the same goal of editing video clips but offers a wide range of extra features and options to adjust the video clips. In this case, the user interface shows a lot of these options in plain sight which allows the user to work more efficiently if the user has experience with the software.

Figure 25: Expertise level positioning

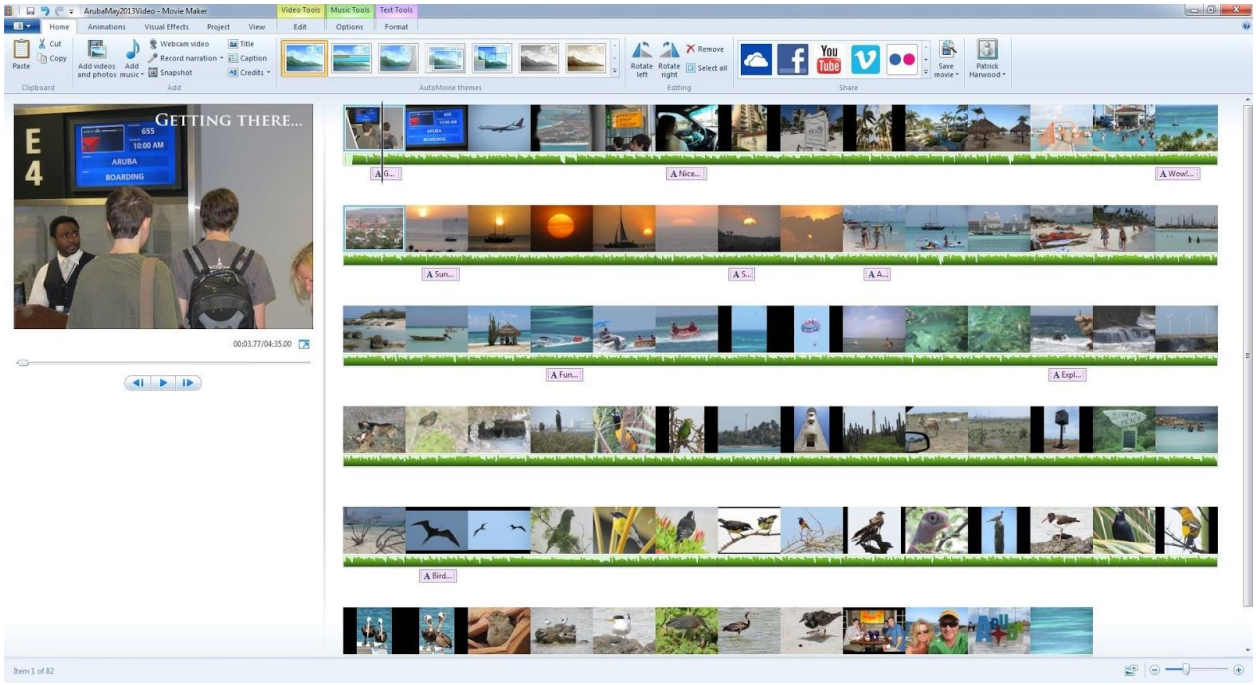


Figure 26: Microsoft Movie Maker (Small, 2013)

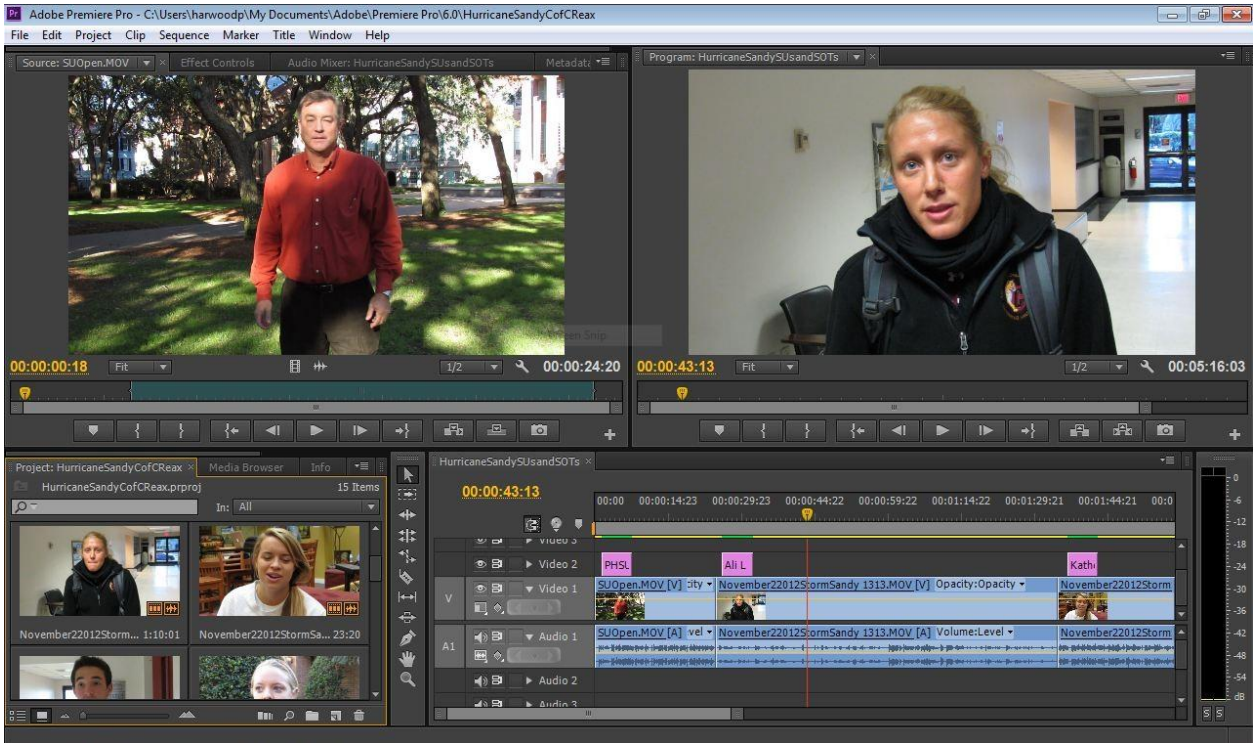


Figure 27: Adobe Premiere Pro (Small, 2013)

The decision which expertise level is suited for the target group is the input for the design of the user interface. The main rule to increasing the usability of the user interface is by decreasing the cognitive load of using the user interface. Krug (2005) describes this as “Don’t make me think!” The idea is that the user has all kinds of questions when looking at a website. These questions can be about navigation, the look of a button, placement of objects, if links are clickable and many more simple questions. Every time the user has a question, he needs to think unnecessarily which increases the cognitive load (Figure 28). Therefore it is important to make all aspects of the user interface as obvious as possible. This can be achieved by making icons, buttons, links, layouts, text and interactions self-explanatory. People don’t like to puzzle and if the website isn’t obvious and easy enough, it can affect the confidence in the site and the publisher (Krug,

2005). Over simplifying however could result in a user interface too simple to fit the needs of the targeted user group as complex functions are not implemented. Therefore it is important to make well thought through trade-offs when designing the user interface.

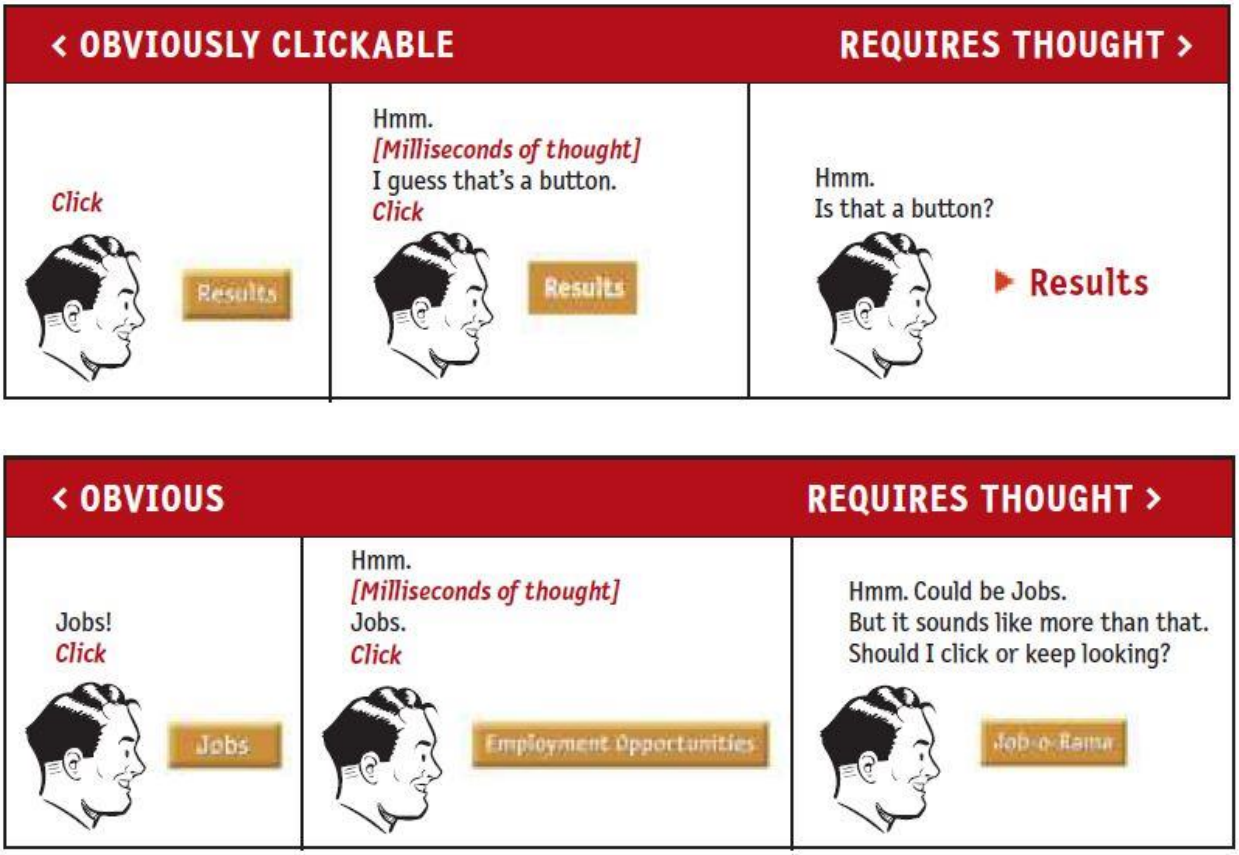


Figure 28: The effect of web design elements on the cognitive load (Krug, 2005)

Another important aspect to keep in mind is that people are not going to pore over each page, reading all the text, figuring out how things are organized and weighing their options before deciding which link to click. The reality is that people scan quickly and often click on the first link or icon that catches their interest and vaguely resembles the thing they are looking for (Krug, 2005). There for it can help to establish a top 3 of most wanted features per page based on the needs of the user. By using the top 3, the design can be changed to let the visual hierarchy determine which elements catches the eye of the user first. There are several attributes of a web component which have influence. Attributes such as the size, color, location, text style, icons and images of components can manipulate in which order the user evaluates all the elements (Djamasbi, Siegel & Tullis, 2011). When used correctly, the user is guided to find what he needs easier and quicker resulting in a better user experience.

5.3.3. User control

The user always needs to be in control to be able to perform their tasks. An important aspect is navigation to guide the user through the experience of use. There are three questions which are important when it comes to navigation (Stern, 2014).

1. Where am I now?
2. Where else can I go?
3. What will I find when I get there?

These questions can help to spot problems when navigating the website. If unable to answer one of these three questions, the user will probably get confused to what next steps to take to progress with their task. If the user interface fails to help the user to find their way around, they are less likely to stay longer or come back (Krug, 2005). Therefore the navigation needs to be clear, simple, consistent and predictable (Figure 29). Simplicity, clarity, consistency and predictability aid in recognizing the four aspects of recognition in the RPD model (Figure 23) which are plausible goals, relevant cues, expectancies and possible further actions. As Klein (1998) sees the model as a model for intuition, it can be stated that the four factors for user control directly contribute to the level of intuitiveness of the user interface.

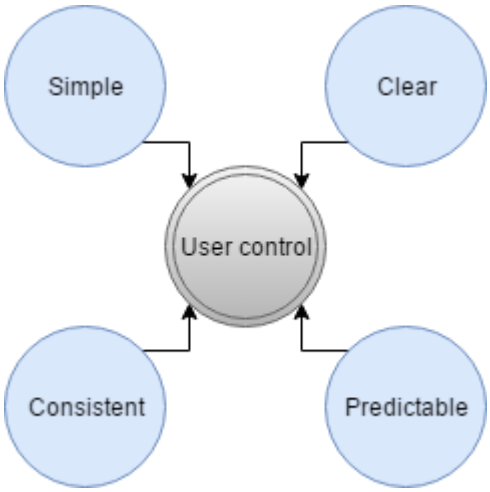


Figure 29: Four factors for user control

Clear navigation can be achieved by using unique and descriptive headings which are conceptually related to the content it describes. This can be in the form of text, icons or both to educate the user if the icons are not self-explanatory enough. Often there is not enough space to do both and therefore giving an icon button a hover state with an explanatory text can help to educate the user and to learn specific icons and to give feedback if an icon is clickable. Doing so makes it easier for the user to follow a specific task sequences (Shneiderman, 2010). By reusing headers and icons consistently, the user will be able to see what options are available (Where can I go?) and predict what will happen when activated (What will I find when I get there?).

To help navigating through the website and the various features, menus are essential for comfortable navigation. Presenting all the possibilities at the same time is not only impossible but also impractical. To make navigation simple, it is better to only show options which are needed at a specific point in a task sequence and hide options which are less used to prevent the user from getting overloaded with options, information and icons. The downside of using menus is that the items hidden in the menu are less likely to be discovered in comparison to items which are in plain sight. Therefore a trade-off needs to be made by deciding which functions need to be in plain sight, which ones can be hidden in menus and which functions should be not be included. To help decide which functions should be directly visible, the 80/20 rule can offer some guidance. The 80/20 rule means that 80% of the time, the people only use 20% of all the functions (Stern, 2014; de Regt, 2017). By optimizing the design for the 20% of all the functions, the user will have a better experience using the interface as the most used options are in plain sight, reducing the effort needed to find the wanted function.

Another important feature is the possibility to undo previous taken actions, also called forgiveness (“macOS Human Interface Guidelines”, 2016). The user will not always immediately find exactly what he is looking for. He will make predictions about the expected result for a specific action. If the action cannot be reversed, the user is less encouraged to discover possible results and therefore he will be less likely to find his way

around. This will make the user think twice before performing a next action based on intuition and because of this the predictability will be negatively affected, lowering the intuitive level of use.

An example of a user interface which demonstrates the characteristics of clarity, simplicity, consistency and predictability is Evernote. Evernote is an award winning digital platform for note-taking and note-keeping across multiple devices like desktops, laptops, and smartphones and tablets (Webby awards, 2017). It supports multiple kinds of documents and media formats to be placed into a note and it has integration with other apps and services (van Arnhem, 2013). Because of the vast amount of possibilities, the user interface is kept simple and consistent, and the interactions are clear and predictable (Figure 30).

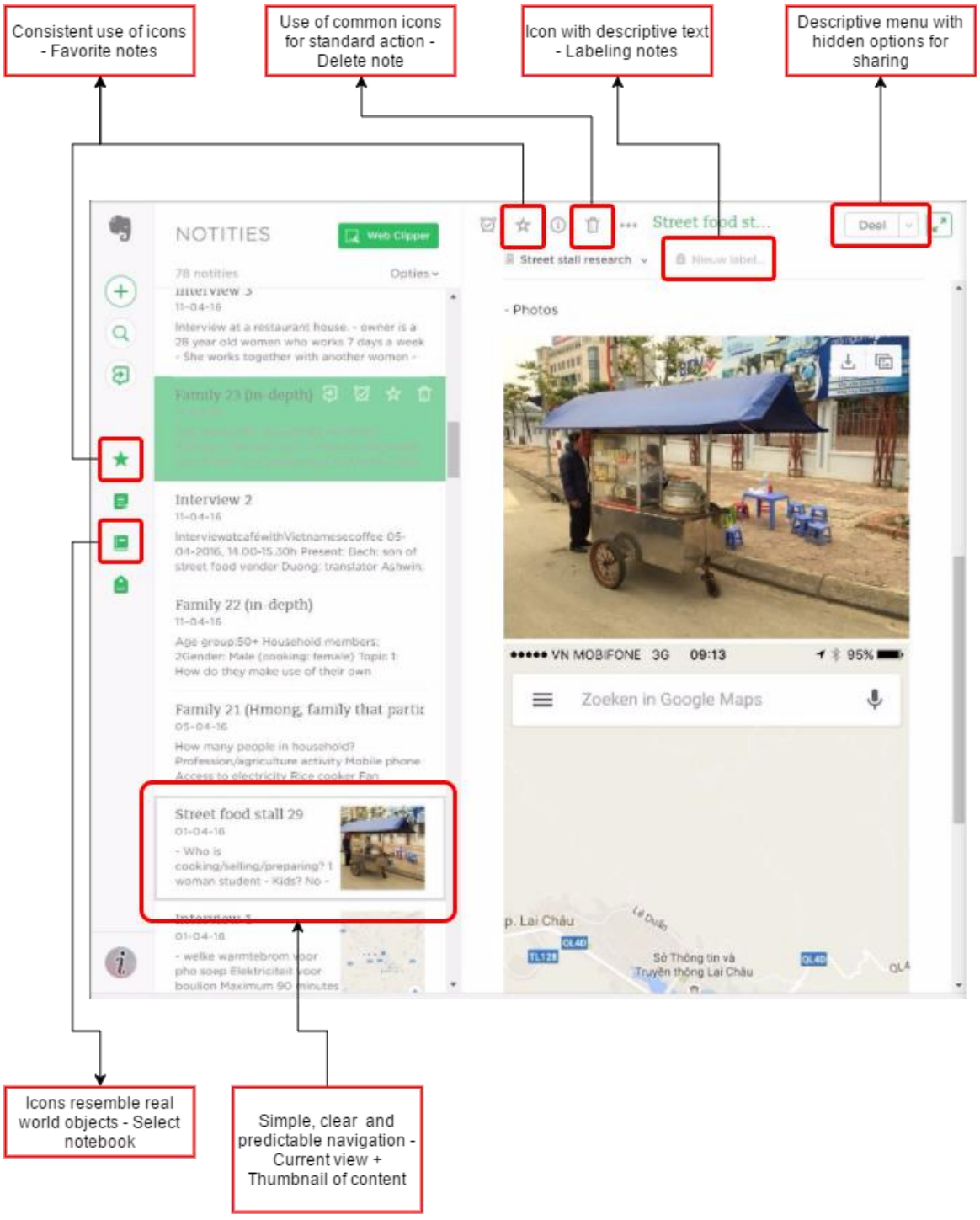


Figure 30: User control elements of the Evernote web application

5.4. Target group positioning

As previously discussed, the choice for an intuitive user interface has multiple implications. Intuitive means that the user needs to be able to perform the right actions based on intuition to get the wanted result. The choice to perform a specific action is based on the belief that doing so will give the expected result. In other words, the expected results need to be predictable based on the relevant cues to trigger a specific expectancy. Intuition however is quite personal and a reaction is dependent on the background of the user. This means that a user interface can be intuitive but it is dependent on the target group (Stern, 2014).

If a user interface needs to be intuitive for a large variety of users, the interface needs to be very simple and clear. This however does affect the number features the interface can support and therefore it also affects the functional value it can offer to the user (Figure 31). Therefore it is important to determine to whom the user interface needs to be intuitive and to determine which features to implement based on positioning in comparison with the competitors.

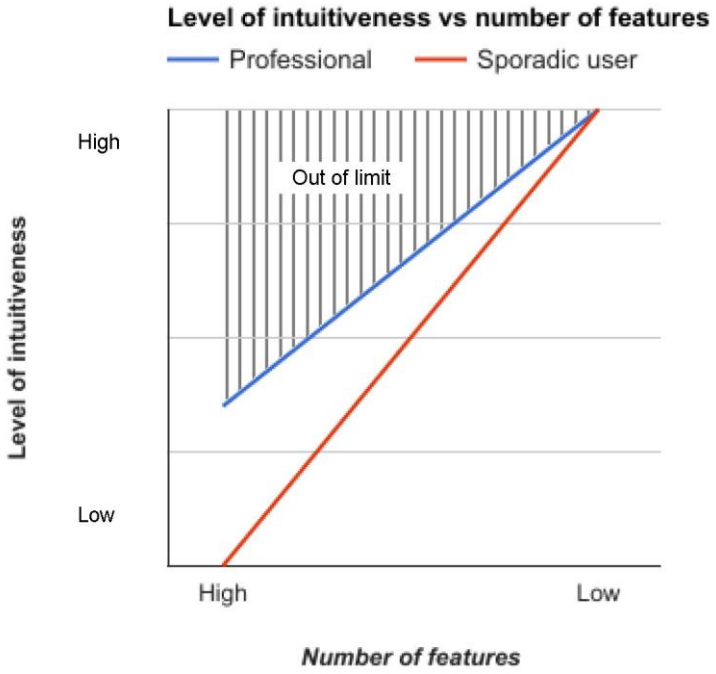


Figure 31: The effect of the target group positioning from sporadic users to professionals on level of intuitiveness and the number of features.

5.5. User validation

In the end, intuitive use remains a difficult to predict aspect. With user testing, it will become easier to predict if the user interface has the wanted level of intuitiveness, usability and still offers enough features to be of value to the user. Small studies can already have a quite large impact on the number of usability problems found (Barnum, 2010). With only 5 users, the optimal return of 85% of all the problems will be found (Figure 32) (Nielsen, 2000).

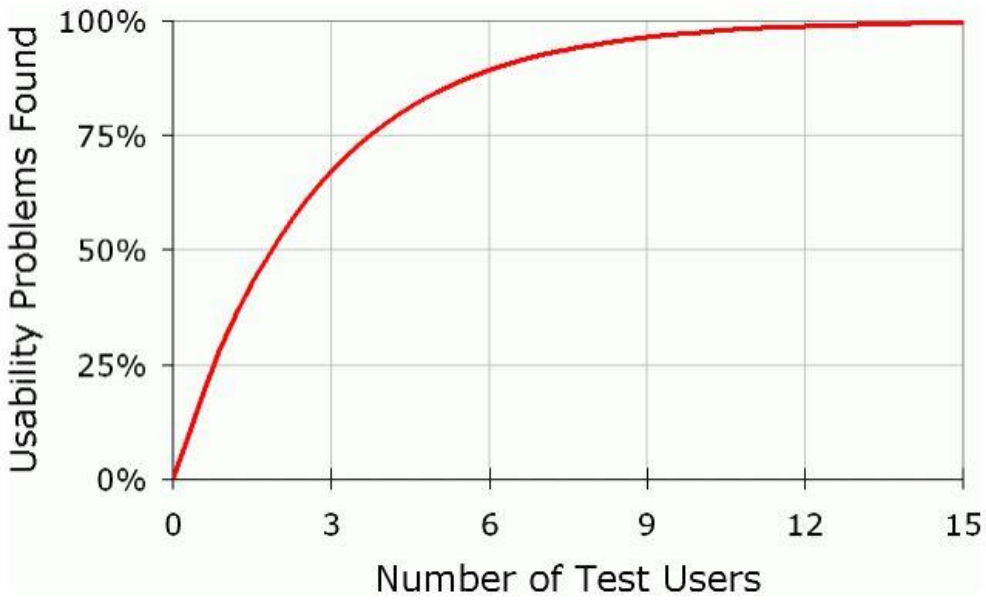


Figure 32: The number of test users and the percentage of usability problems found (Nielsen, 2000)

To conduct a small user test study, there are a few essential elements to get positive results (Barnum, 2010) (Figure 33). First a user profile needs to be established. As there is a wide variety of users, it is best that the user profile is based on the most common group. Based on this user profile, participants can be recruited to perform a user test. For larger test, more profiles can be added. Secondly, the test users need to perform tasks to give feedback. Therefore task-based scenarios can simulate real goals of users and uncover their method of progressing towards the final goal. During the test, a think-aloud process encourages the participants to share their thoughts. It helps to understand their experience and also to hear why they perform specific actions and what they think about the process. The last step is to adapt the software based on the reactions and the gained insights into the experience of the test users.

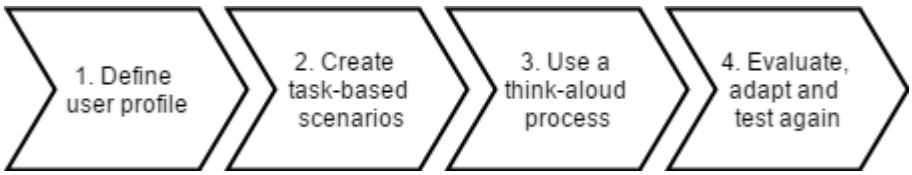


Figure 33: Steps for performing a small user test study (Barnum, 2010)

6. UI/UX design guidelines

To ensure that the interface designs across the platforms look similar and behave similar, design guidelines can provide building blocks which can be used to design the user interface. Therefore the Euretos UI/UX design guidelines document was created (Appendix B). The guidelines primarily focuses on aesthetic aspects such as colour palettes, icons, typography and buttons, but deciding on these aspects needs to be done while keeping in mind how it will be used.

As colour can be used for drawing attention, it is an ideal instrument to be used to attract the attention of the user to specific elements such as headers which give structure to a webpage. Drawing attention to structure elements is important as it supports the ability of the user to scan a page and understand the goal of a specific section much more quickly (Johnson, 2013). Using colours does not necessarily mean that the design will be very colourful, depending on the target group, using grayscales can also be quite effective. Therefore it was decided that using grayscale colours with the support of the purple colours that fit the Euretos logo would be used for the design of the new platform (Figure 32). This also creates a feeling of brand identity as the colours of the logo are recurring in the design of the platform, a practice which can be seen at more platforms such as the use of green for the Evernote application (Figure 28).

The Euretos design guidelines document is just a simple guideline but it supports in designing an application which complies with the four aspects of user control; simple, clear, consistent and predictable. Therefore the creation of the design guidelines is an important step to ensure a more intuitive user interface design.

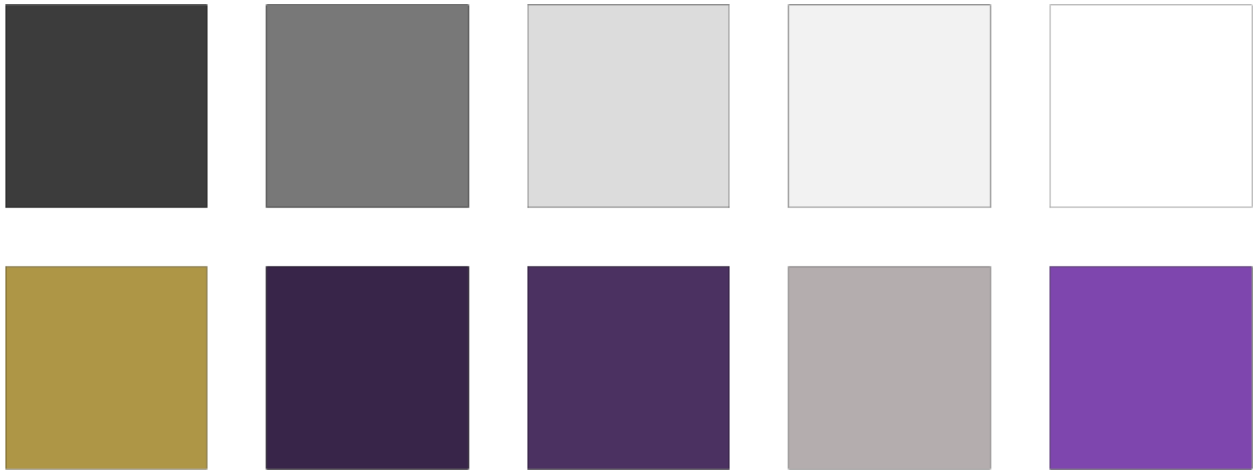


Figure 34: Euretos UI design colour palette

6.1. Design Brief

Euretos is developing a renewed version of the Euretos knowledge platform with the Cerebrum project as its working title. The new platform will be focused on molecular biologists and bioinformaticians working academic institutes as well as pharmaceutical companies in the western world. As the current version has grown into a platform with extensive and complex tools, the usability has decreased to a point where users are avoiding the service. Therefore the new platform will go back to basic functionality with a focus on easy navigation to increase the usability and to guide the user to the needed functionality. The main functionality has been chosen by looking at the most used functions and after discussion with Euretos management.

To increase the sense of user control, the platform needs to be clear, simple, consistent, and predictable. This means that all the headers need to be descriptive and self-explanatory. The navigation through all the functions and tools need to be through progressive disclosure to prevent a too high strain on the cognitive

load of the user. The Euretos UI/UX design guidelines gives the building blocks to design a consistent and predictable platform.

Cerebrum tools

The Cerebrum platform needs to be built up around three tools, the ReSearch tool, the relation map tool and the set analytics tool. These tools need to be integrated with each other as the output of one tool can serve as the input for the other and vice versa (Figure 35). The idea is that the platform is an ecosystem of available tools to explore and analyse big databases of publications and libraries of sets with multi-omics data in a GUI environment.

ReSearch

The ReSearch tool is a search tool to with a google like functionality where the user can type in a search query. The results can consist out of publications, concepts and gene sets. From this point publication or concept detail screens can be opened or a set can be selected to perform set analytics with. The concept detail screen is a screen which gives extra information about specific concepts like diseases, genes, proteins etc. The publication detail screen shows more information about a specific publication, like the abstract, relevant articles, other articles from the same author etc. From both detail screens, more analysis tools will become available in later releases.

Set analytics

The set analytics tool is an analysis tool for concept, protein and gene sets and their expression values with corresponding literature and how it all relate to each other. Sets can be uploaded directly by the user by opening the Set analytics tool directly or by opening an existing previously used set from set management. Another option is to use the output of the relation map as input for the set analytics tool.

Relation map

The third tool is the relation map tool which can be used to construct models out of concepts, genes, diseases, proteins etc. and how they all relate with each other based on publications and database entries. It is a method to make relations visual and explore relations to construct a model. The relation map project manager can be used to resume working on previous relation maps or to create a blank map for constructing a model manually. Sets from the set management of from the ReSearch results can also be used as a starting point for exploring and constructing a model.

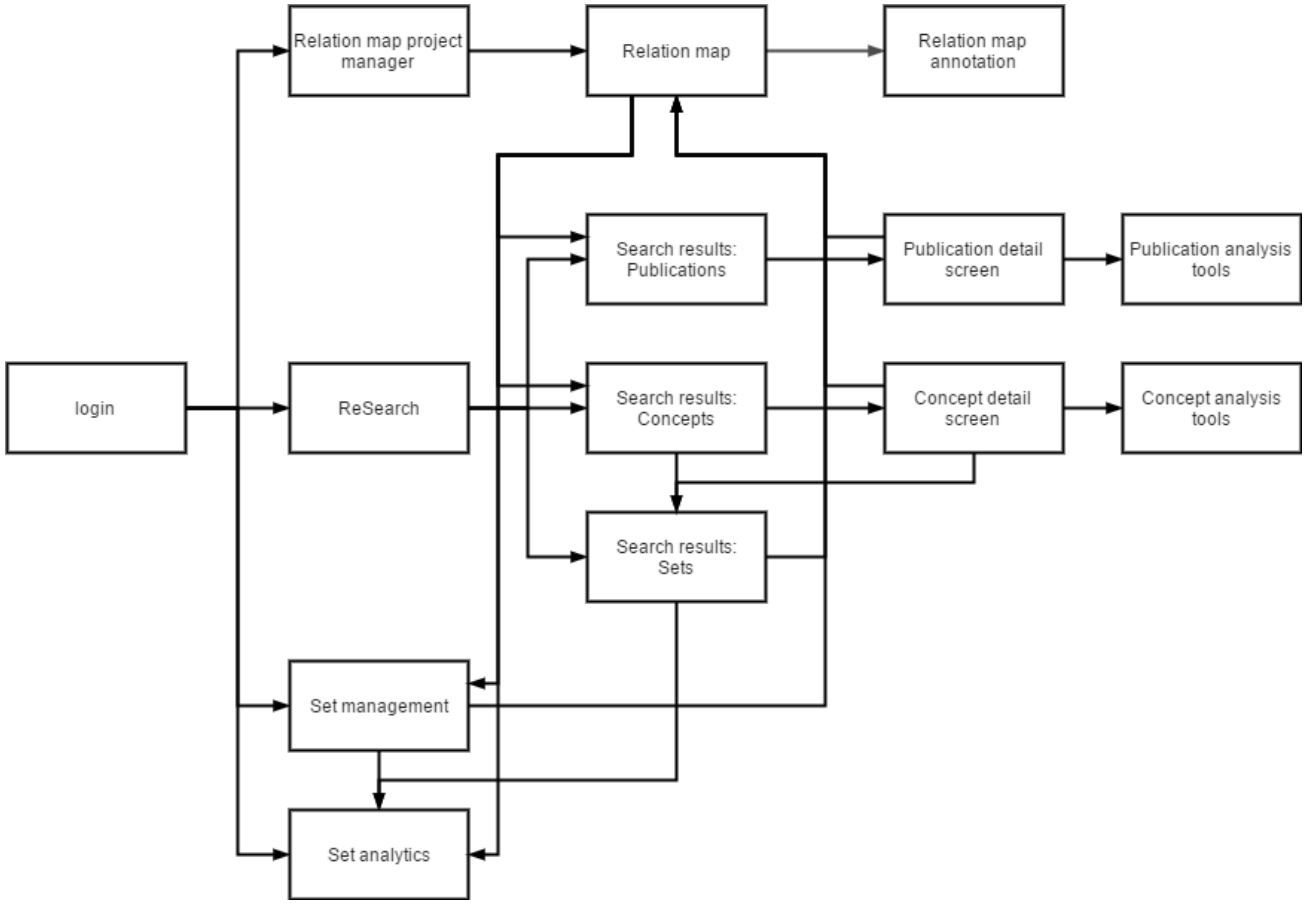


Figure 35: Tool integration of the cerebrum platform

Scope
For the design project the focus will be on the relation map tool as it is the most interactive tool of the platform as there are quite a few options to explore for constructing models. The flowchart (Figure 36) of the relation map tool shows possible flows for using the relation map tool. Based on the flowchart several flows can be derived. The most important actions are:

- Create a new blank relation map or load a previous relation map project via the relation map project manager
- Filtering concepts/relations based on categories, relation type, publication date, impact factor and/or publications per relation
- Adding concepts or importing sets to the model
- Finding a related concept for one selected concept in the model
- Finding relations between two to five selected concepts in the model
- Finding a concept which is related to both of the two selected concepts in the model
- Creating custom relations between two selected concepts
- Finding co-occurring publications for selected concepts up to five concepts
- View details of selected concepts and relations
- Annotating relations and the model
- Tutorial walkthrough
- Improve collaboration between researchers

These actions need to be as simple and clear as possible while giving the user as much control as possible. An important factor is that the source of a relation can always be found as this creates trust from the user in the results that are shown. Especially for molecular biologists and bioinformaticians, it is important that the sources are clear and that the results can be manipulated to ensure validity as not every source is up to date or has the wanted impact factor.

The design will be in the form of mock-ups which can be used by the development team to be programmed into code and develop the application. If the development of the application has progressed enough that there is a functioning application, then the application will be used for further user validation. In case that the application is not yet functional enough, a mock-up prototype will be made with the mock-up designs to still perform a small user test study for user validation.

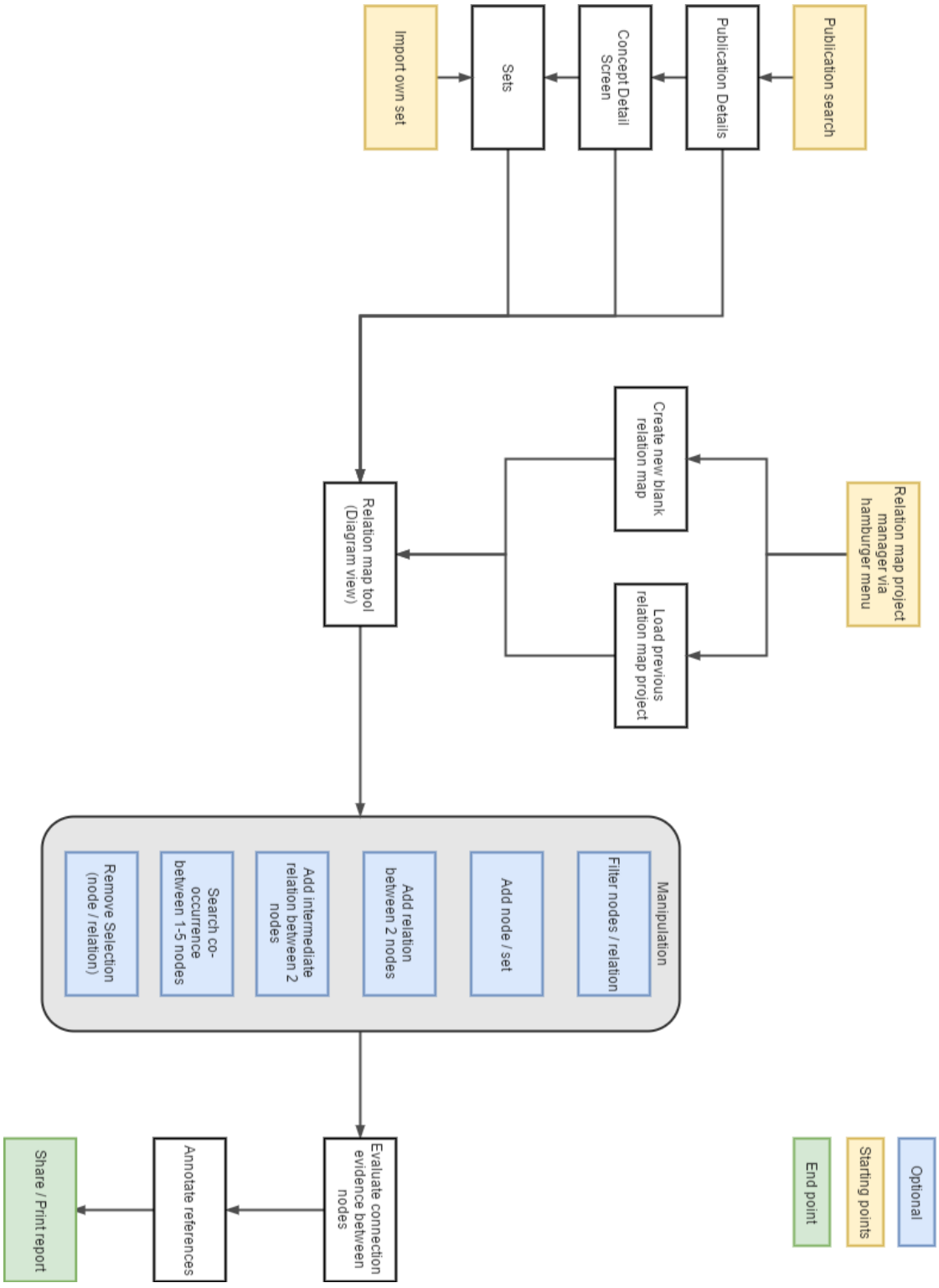


Figure 36: Relation map tool flowchart

7. Relation map design

All the mock-ups were designed with the gained knowledge about usability in mind and the design guidelines to create a consistent look and feel. There was a continuous dialogue between developers, high profile users and the management to discuss design decisions and interaction flows during the design process. This ensures that the mock-ups will be close to the wanted service and that it is ready to be used by the developers to convert it into a working application. All mock-ups can be found in appendix C.

Relation map project manager

The relation map project manager can be found by clicking on the relation map button in the top navigation bar (Figure 37). This section shows recent projects with preview thumbnails in the dark gray banner, sorted on when it was opened for the last time. The section below shows all the relation map projects with tags, involved concepts and when it was opened for the last. By unfolding project, all the concepts that are used in the model are shown. This can help the user to decide which project to open and continue working on. Another possibility is to start a empty relation map by selecting the blank option in the top left.

The layout and design of the relation map project manager resembles the design of google docs to increase the level of familiarity with the user (Figure 38). The search bars but also the options to sort the projects on title, tags, concepts and date gives the user more control to find the project he is looking for. After selecting a project or a blank project, the user will be redirected to the model view of the relation map tool.

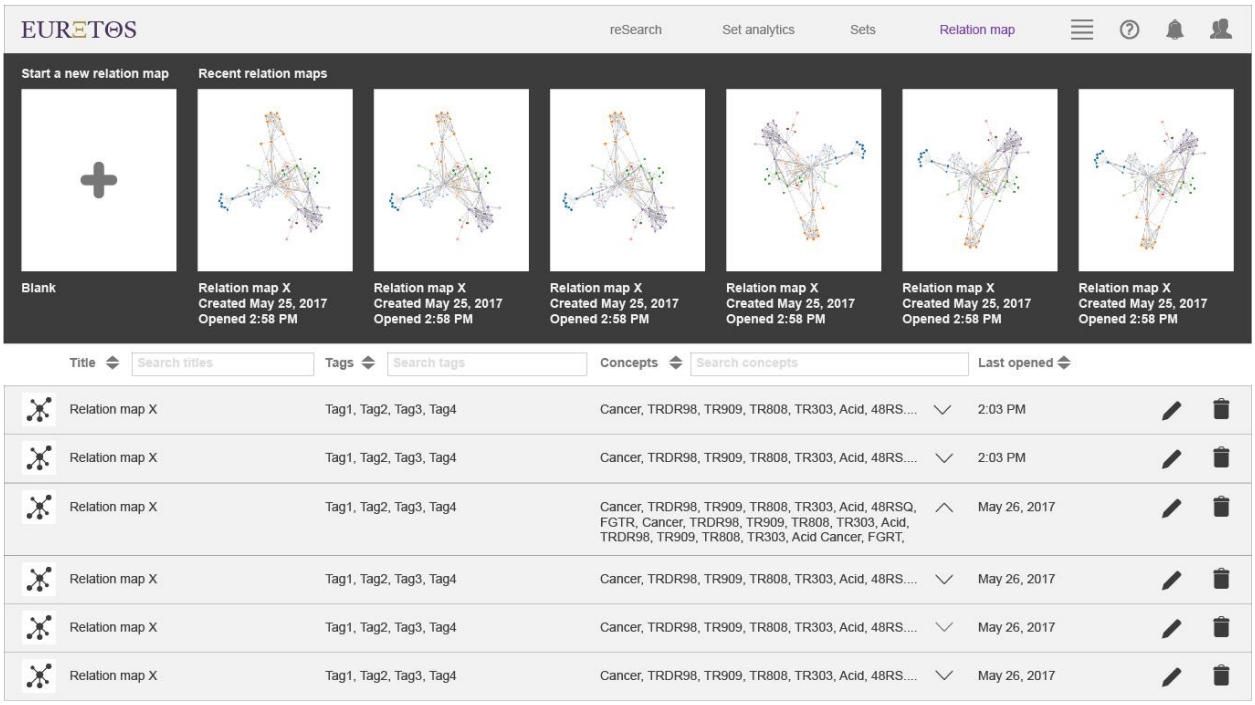


Figure 37: Relation map project manager

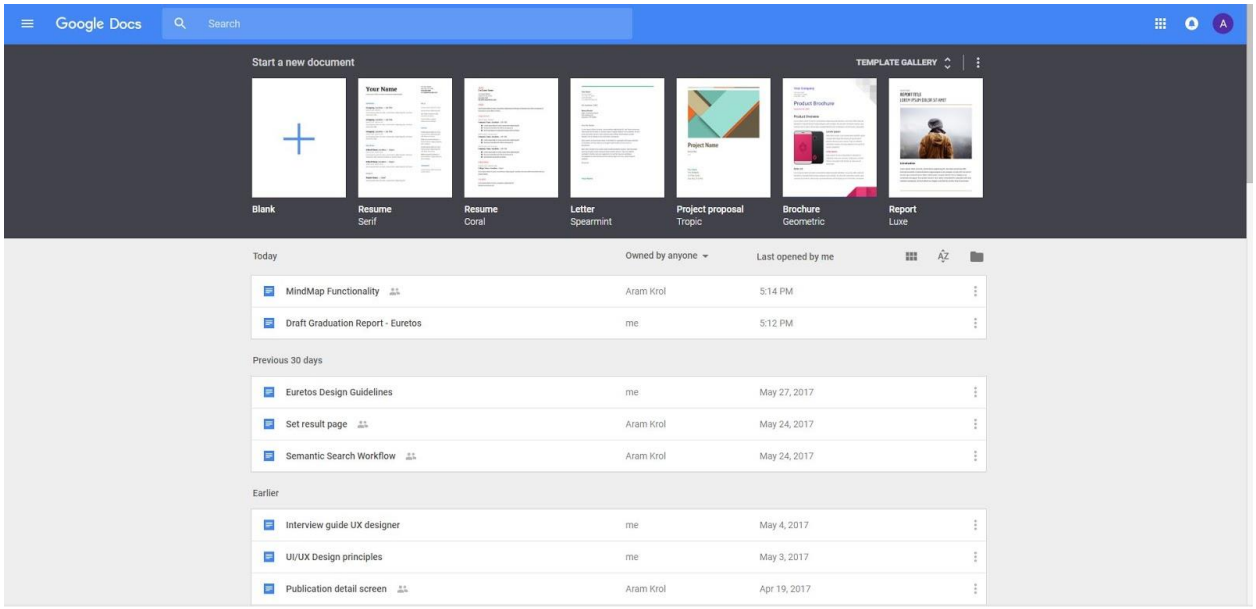


Figure 38: Google docs document manager

Relation map tool

The basic layout of the relation map tool consists out of manipulation options on the left, the model diagram in the middle and the annotation manager section in the bottom which can be activated by unfolding that section (Figure 39). The model consists out of nodes which represent concepts and lines which represent relations. All the nodes can be individually selected and dragged to change their location. The nodes can also be deleted allowing the user to only show the concept that are relevant for their research. All manipulations to the model are automatically saved except for the location changes of the nodes as this puts a too high strain on the server capacity. To tackle this problem, all the locations of the nodes in the model are saved every 5 minutes. If the user decides to leave the relation map tool, all the locations of the nodes will also be saved. The save functionality helps the user to focus on creating the wanted model while not having to be concerned about losing work due to unforeseen circumstances.

The nodes and links are generated by existing scripts called a force-directed graph. Making use of existing scripts is a method to reduce the development time for the developers as creating and coding completely new functions can take quite some time and resources. The trade-off for something completely original does not weigh up to the investments needed and therefore it was decided that making use of the force-directed graph still allows enough room for customisation as it is a very flexible script.

The project's name is shown in the top left section and tags can be added to aid the user in organising all the models. The title and the tags are also visible in the relation map project manager increasing the recognisability of the projects.

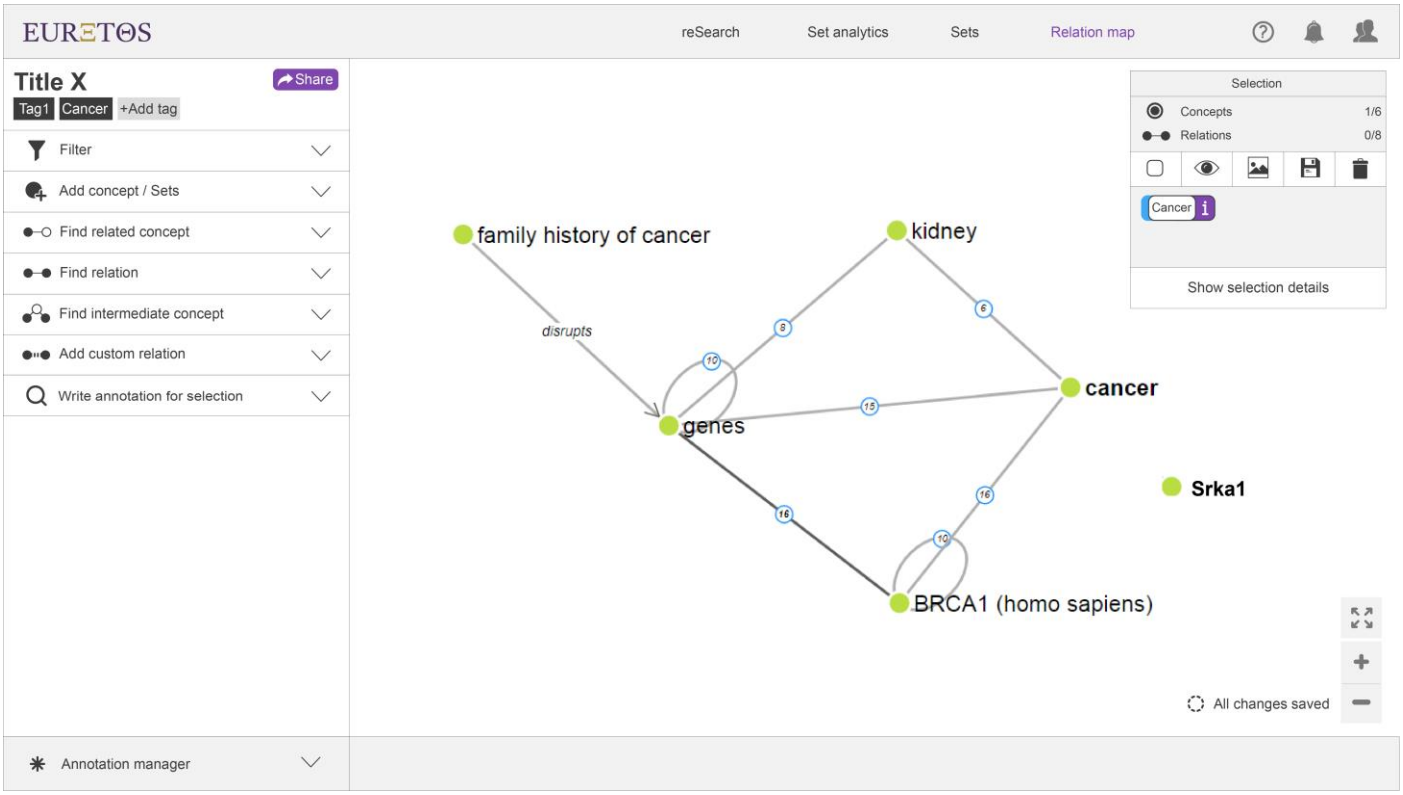


Figure 39: The relation map tool with a relation model

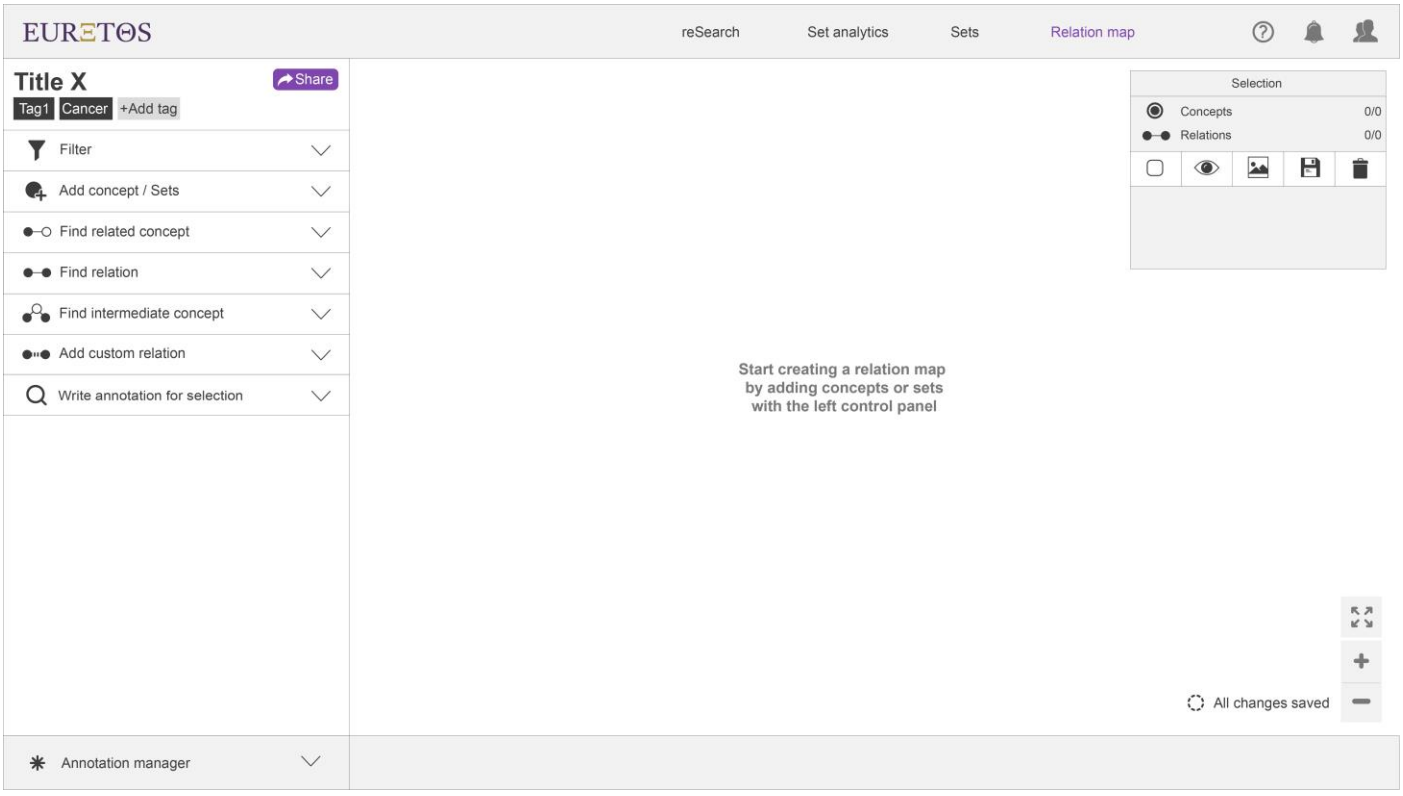


Figure 40: Blank relation map project

Filtering

The filtering panel is designed to give the user more control over the concepts and relations shown in the model (Figure 41). The filter panel has the following functionality:

- Locate keyword on map: a type ahead filter to find specific concepts. This can lead to multiple concepts and users can select concepts they want to highlight in the relation map.
- Category filter: Filter the shown concept categories by selecting which type of concepts should or should not be shown.
- Relation type: Filter the shown relation types by selecting which type of relations should or should not be shown.
- Publication date: All the relations between concepts are based on publications. By filtering on publication date, only the relations will be shown which are supported by publications that were published within a specific timeframe. The filter will be in the form of a slider which visually depicts the number of publications for each impact factor.
- Impact Factor: Filter relations according to the impact factor of the publications. Only relations are shown with at least one publication that fits in the impact factor range. The impact factor of a publication is higher when it is published in leading journals as this increases the validity.
- Publication per relation: Filter relations according to the number of publications (evidence). Only relations are shown with at least one publication that meets the requested impact factor. The filter will be in the form of a slider which visually depicts the number of publications for every link.

After filtering, only links and connected nodes are shown which adhere to the filter criteria. All the filters can switched on or off by making use of the tick boxes in the header of the specific filter.

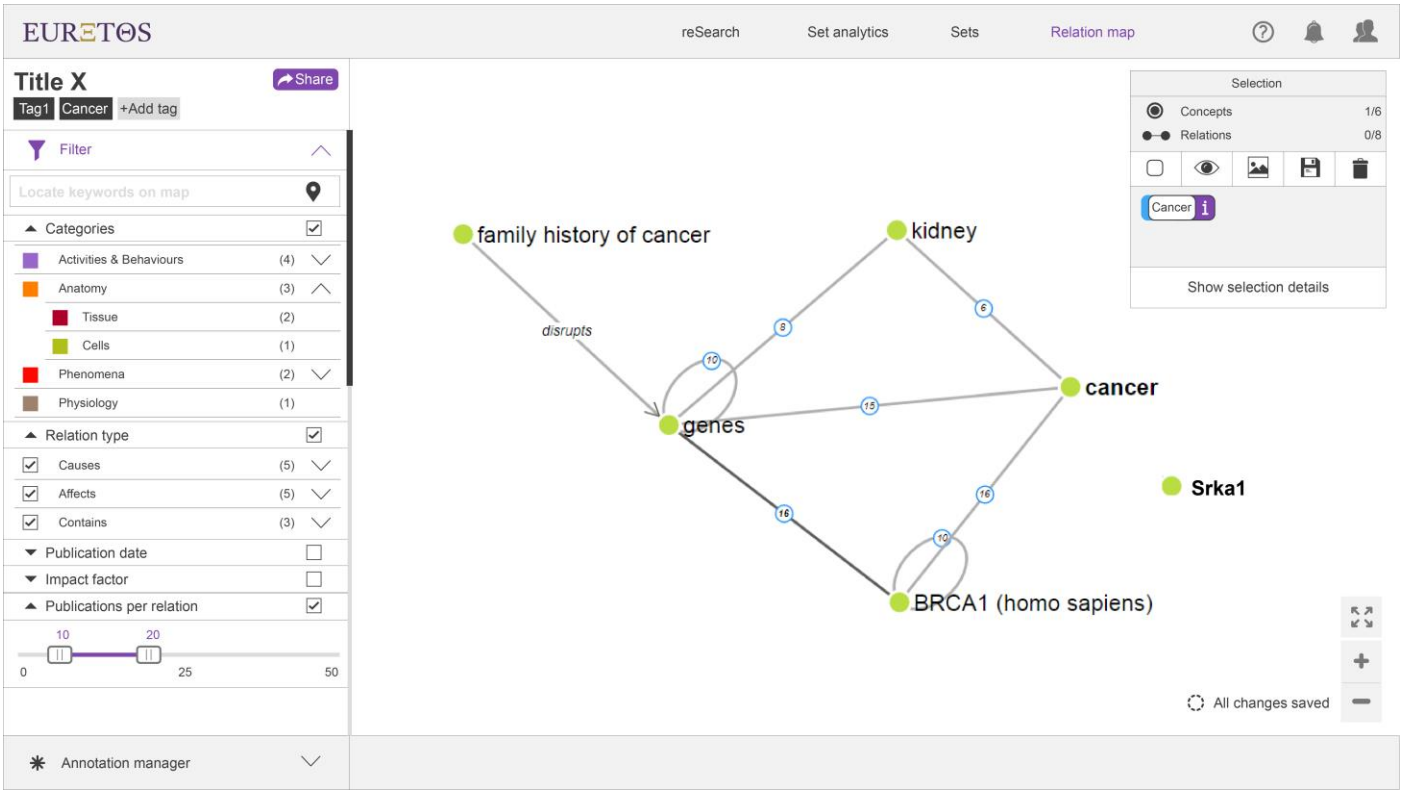


Figure 41: Filtering options for the relation map tool

Add concept / Sets

Activating the “Add concept / Sets” option, unfolds a section where the user can type in the name of a concept (Figure 42). Existing concepts are shown as recommendation, but also the possibility to add a custom concept is possible. If there are any existing relations between the new concept and the concepts in the model, these link will be automatically generated. The option to import set allows the user to use existing sets from the set manager or upload his own set files.

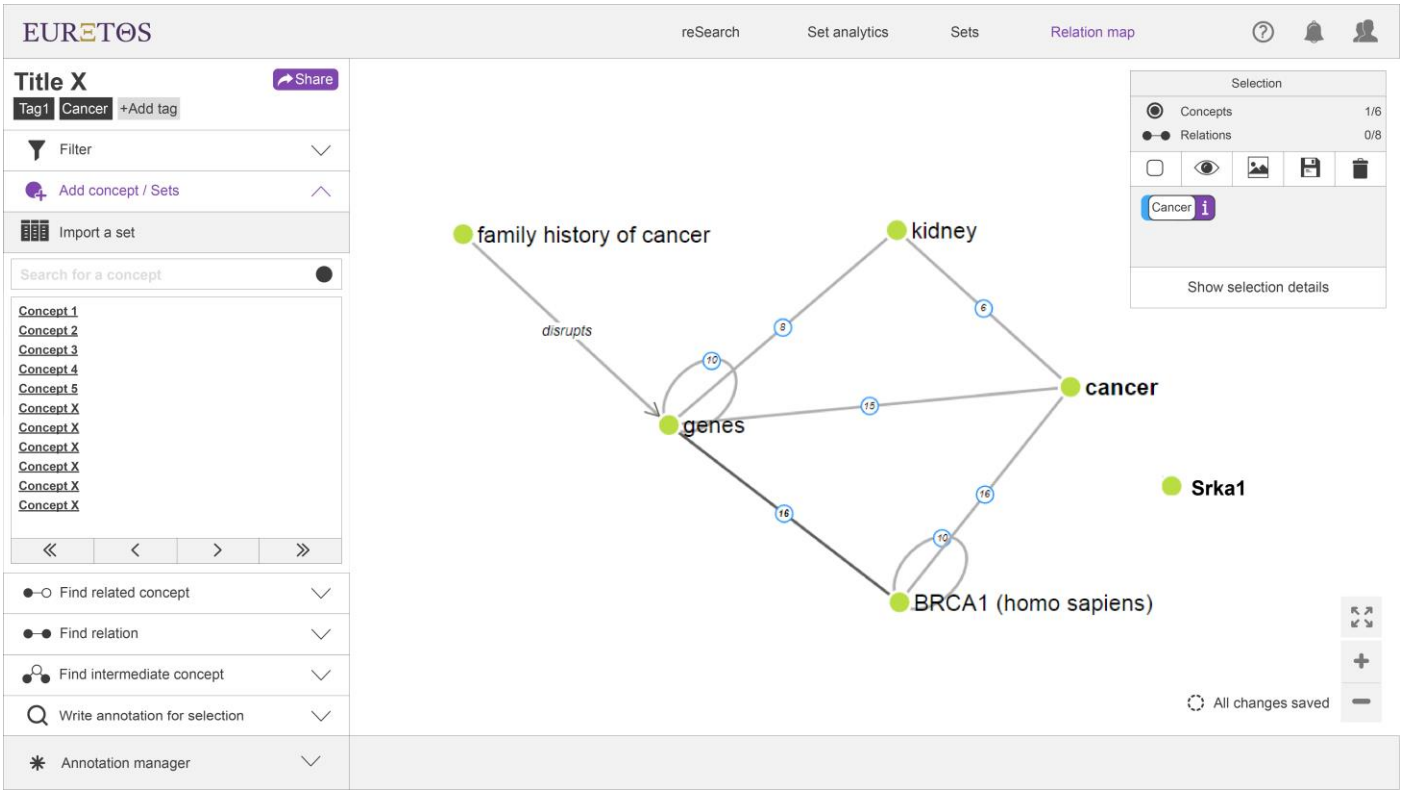


Figure 42: Add concept / sets for the relation map tool

Find related concept

If the user selects one concept from the model, the option comes available to look for other concepts which are related. This way the model can be further constructed. Activating the “find related concept” button makes a screen pop up with the concepts for which evidence exists that there are relations in the form of publications. The number of relations per concept are given as well as the number of publication to support the statement (Figure 43). Unfolding the concept gives more details about which specific relation types exist between the concepts (Figure 44). For these relations also the number of publications are specified. To give full disclosure about the source of the information, the number of publications can be clicked upon to open another tab of the browser which leads to the ReSearch function with a specific search query to show all the details of the publications supporting the relation.

The ReSearch screen is similar screen like google scholar to show publication. The only difference is that the filter options are a bit different. The publications can be further analysed by filtering on publication date and impact factor. Pressing a link of the publication leads to the detail screen of the publication allowing the user to find the actual source of publication like pubmed or other sources. By presenting the publications in a familiar fashion like google scholar, the user will have less difficulties to understand what information is presented and how to interact with the user interface

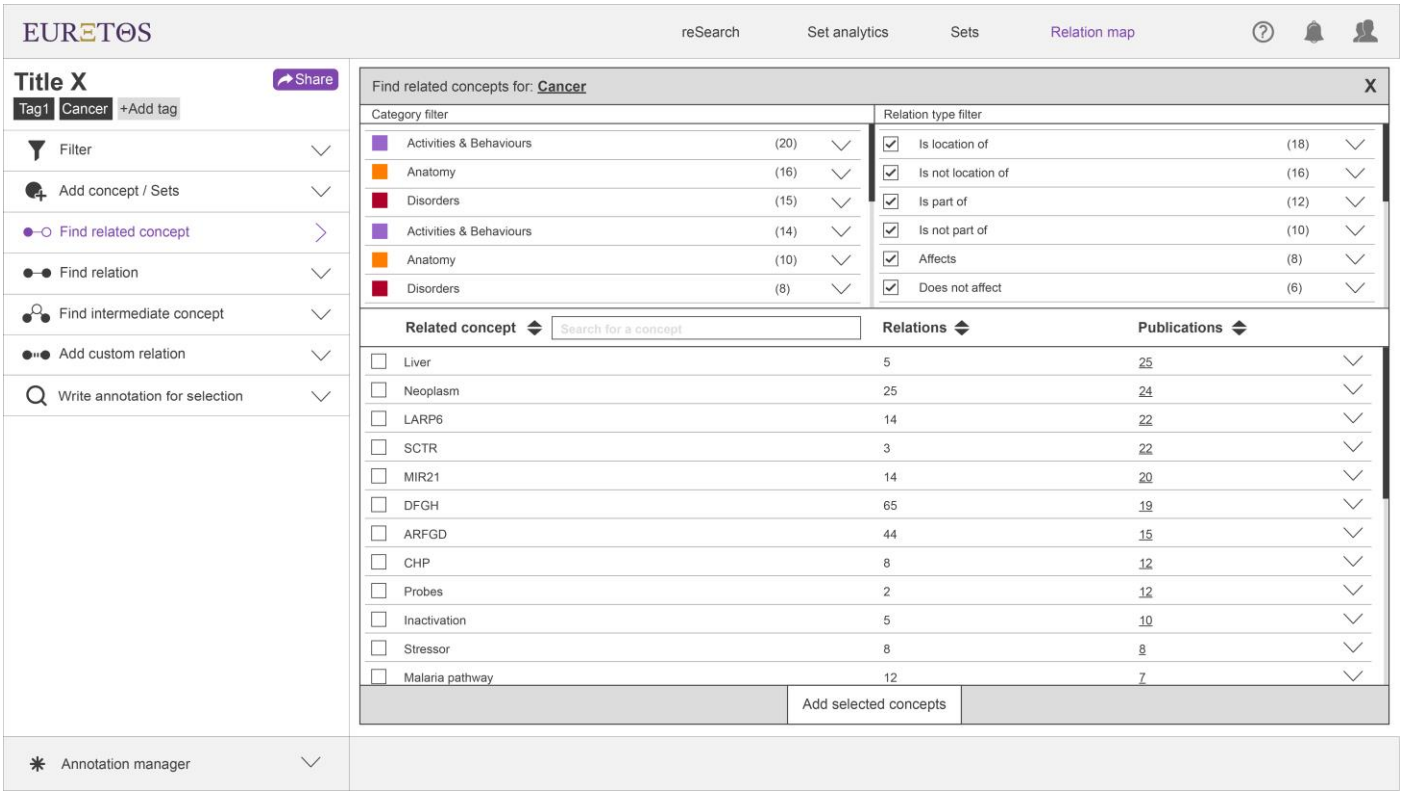


Figure 43: Find related concepts for a specific concept in the relation model

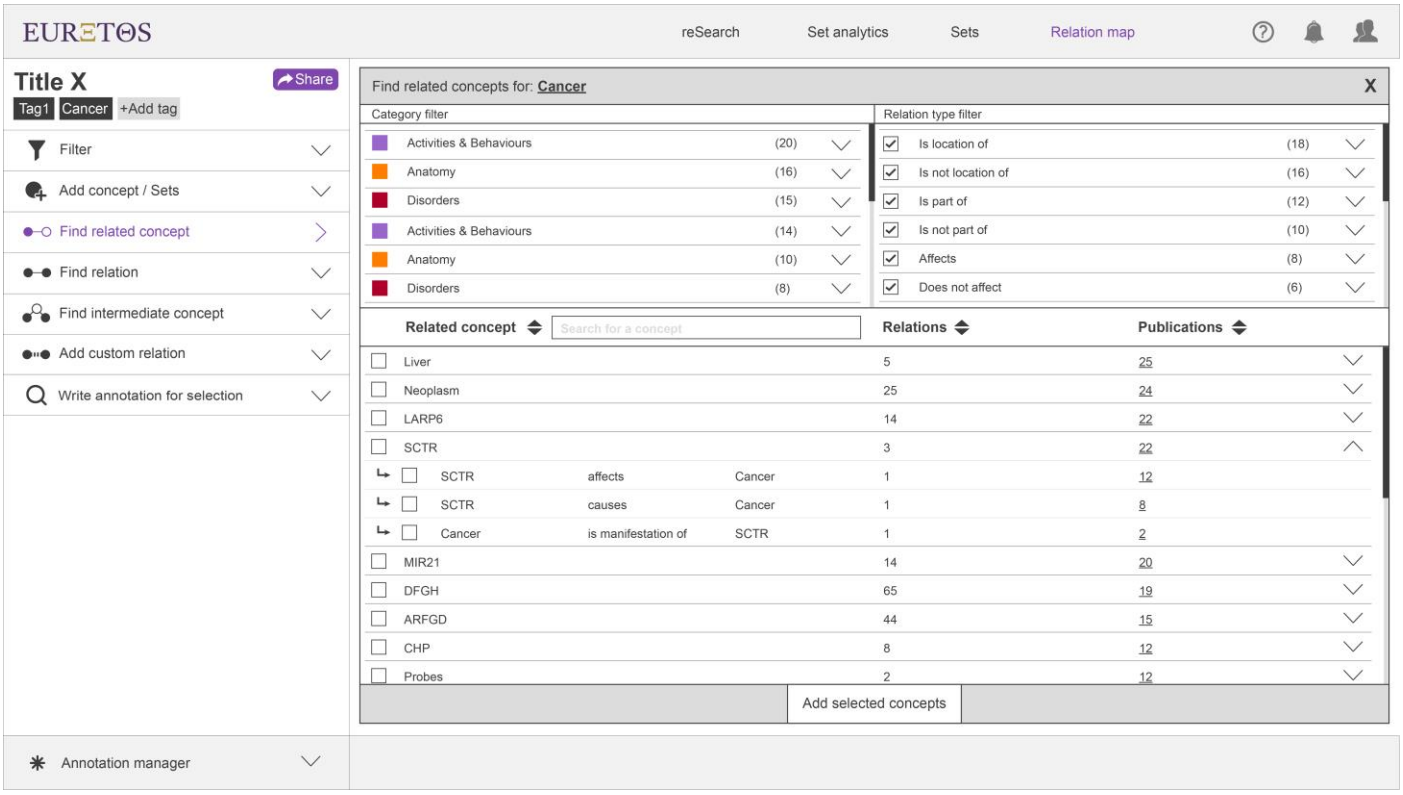


Figure 44: Unfolded detail screen for specific relations for a related concept

Find relations for selected concepts

If the user wants to look for relations between concepts which are already present in the model, the user can select two to five concept in the model and activate the “Find relations” button. A screen will pop up with a list of all the relations between the selected concepts for which evidence exists (Figure 45). The number of relations can be further analysed by using the evidence filters which affect the number publications to support a relation. If for a specific relation no publications comply to the evidence filters, the relation will not be shown in the list.

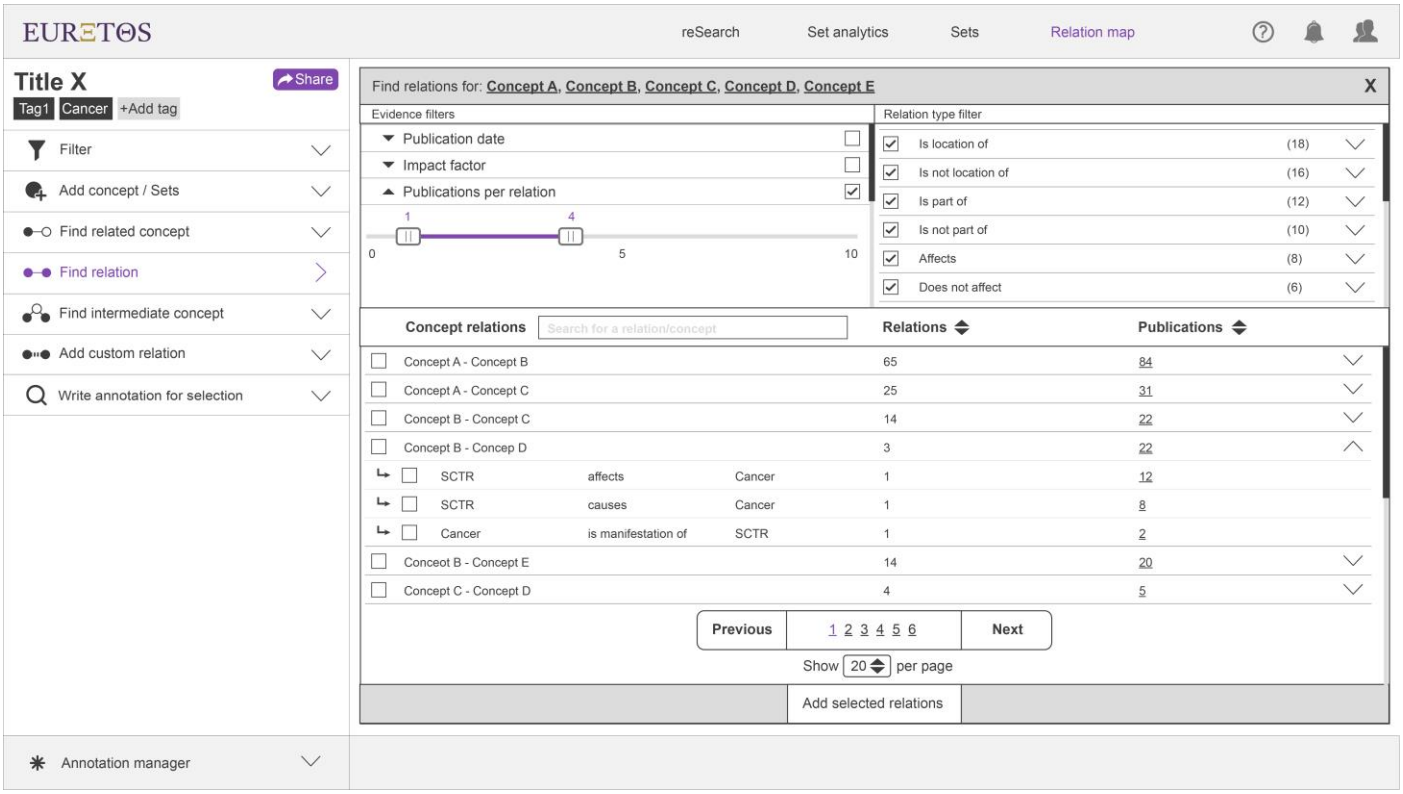


Figure 45: Find relations screen for specifically selected concepts from the relation model

Find intermediate concept

The option “Find intermediate concept” enables the user to search for concepts with publication which mentions both concepts in the same publication (Figure 46). If a single publication mentions both concepts in relation with a third concept, the likelihood that that all the three concepts are related is much stronger than if the relations would be mentioned in separate publications. The same evidence and relation type filters are available just as the possibility to unfold to see the specific relation types (Figure 47). Clicking on the underlined publication numbers opens a new browser tab with the ReSearch screen showing all the publications to support the relations.

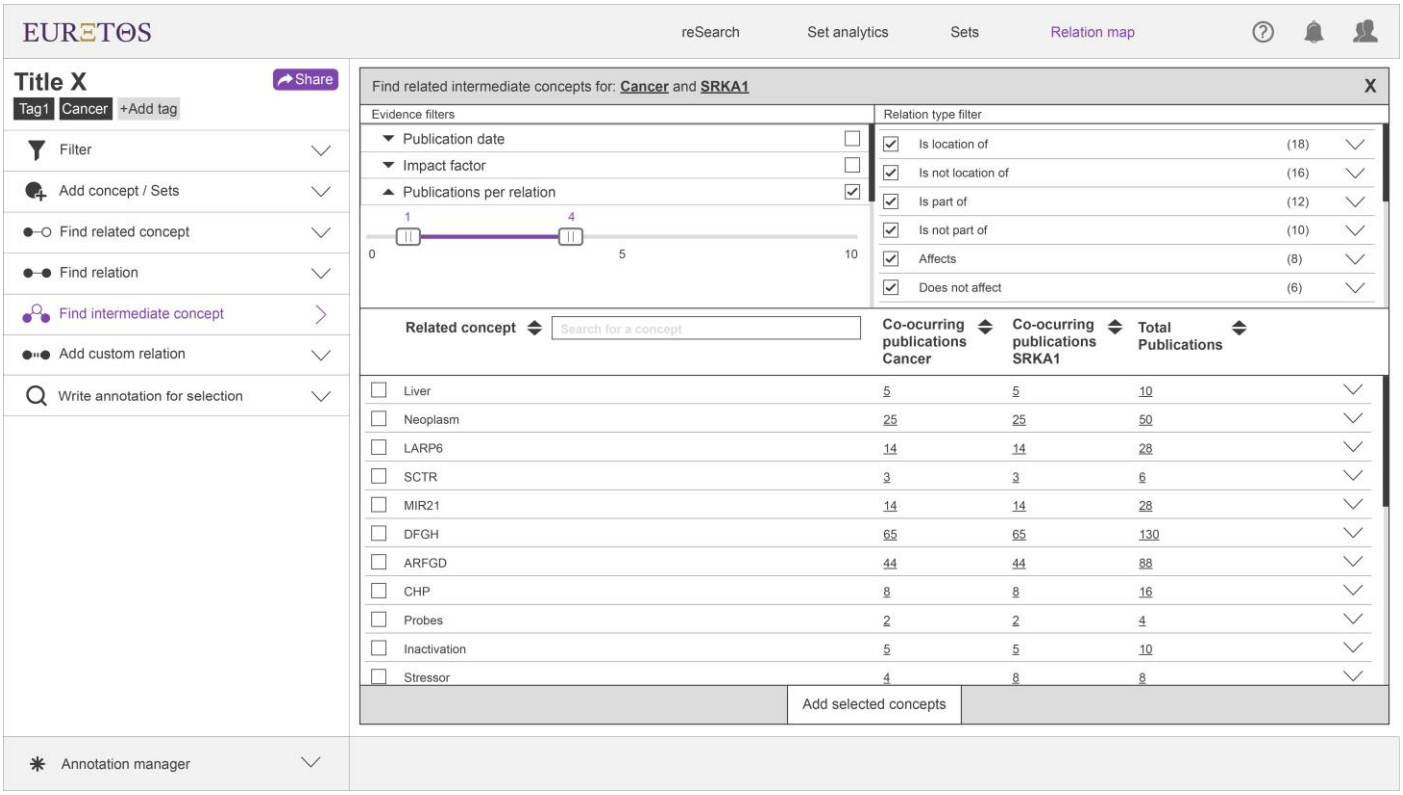


Figure 46: Find related intermediate concept for two selected concepts

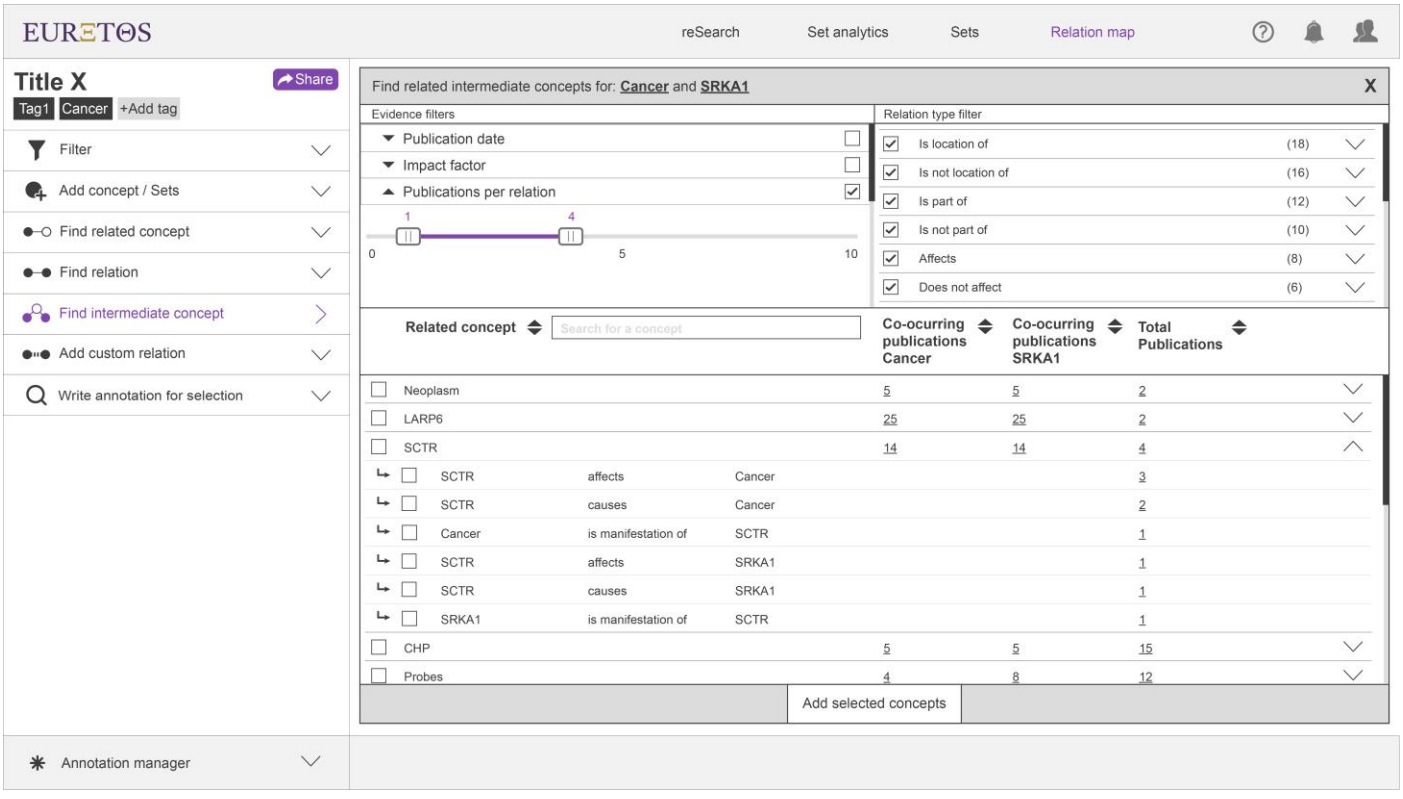


Figure 47: Specific results relations between concepts

Create custom relation

A custom relation can be added to any combination of two concepts for which no relation/link exist. A user can create a custom link, including direction and relation type by selecting the two concepts and clicking on the “add custom relation” button. A screen unfolds where the user can specify the relation, setting a

predicate is however not mandatory (Figure 48). The custom relations are local relations which are only available in the current project. This means that the relations will not be added to the general database of Euretos to ensure that no relations are added with supporting evidence in the form of publications. To make a distinction between custom relations and evidence supported relations, the link will be in the form of a dashed line (Figure 49).

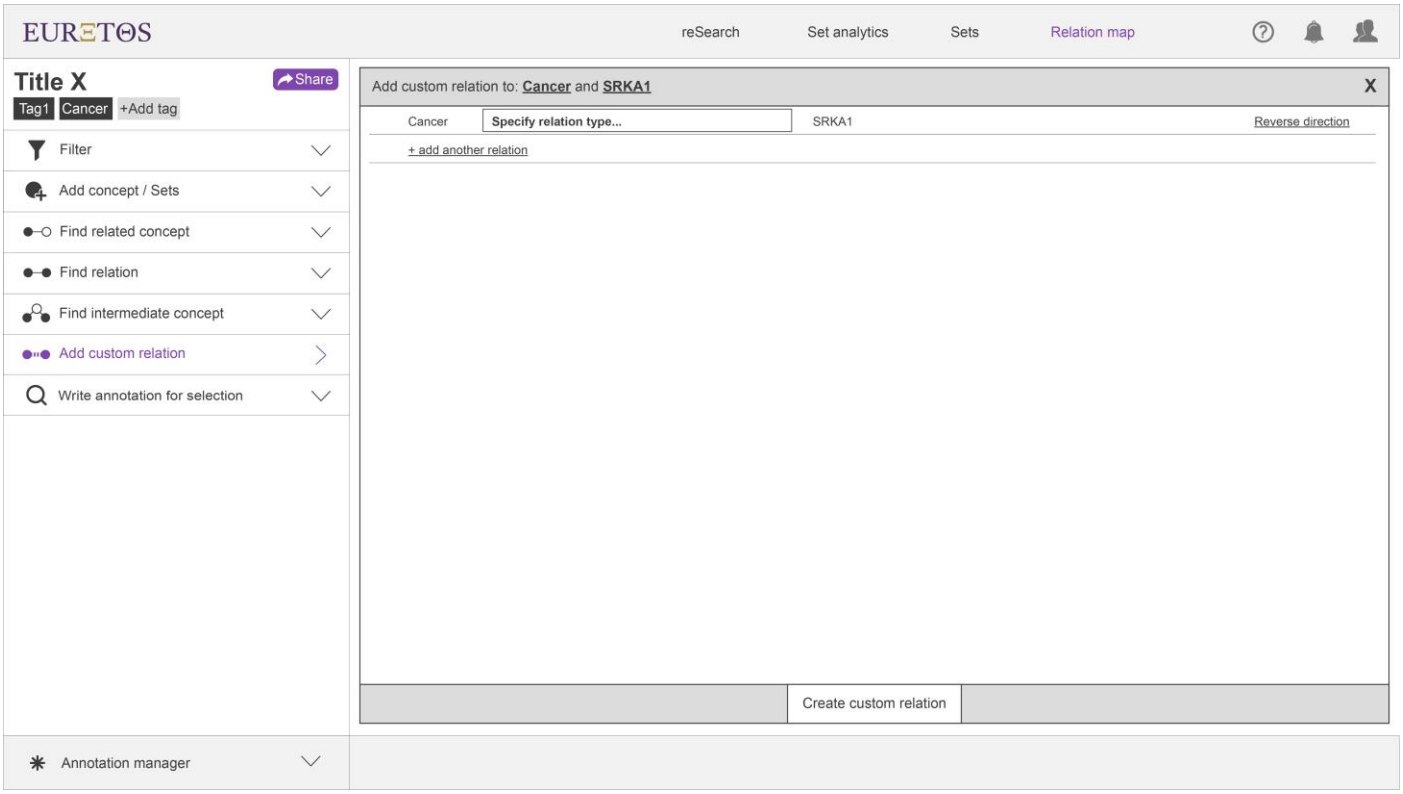


Figure 48: Adding a custom relation to two concepts in the relation model

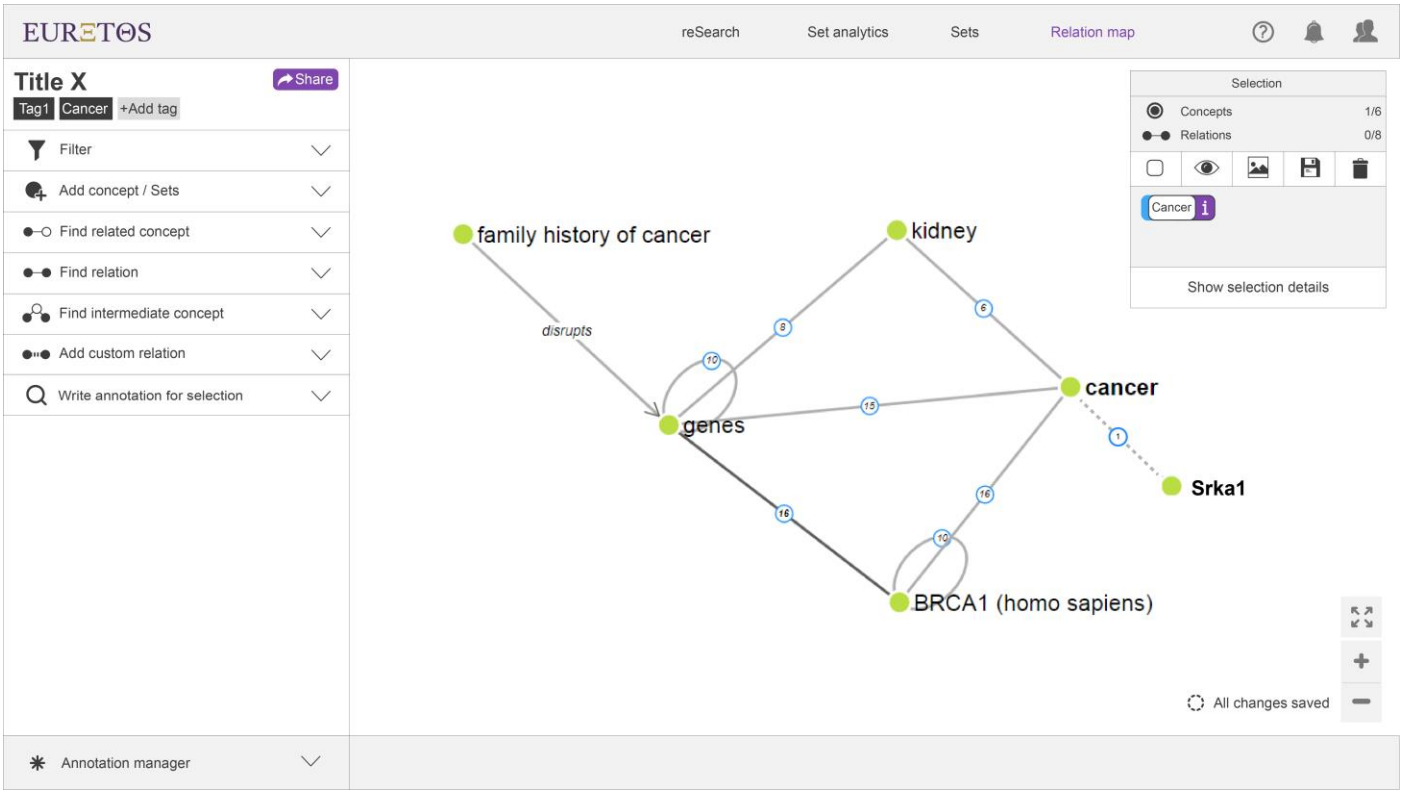


Figure 49: A dashed line representing a custom relation in the relation model

The annotation panel

The annotation panel is a special section where relations between concepts can be annotated. Annotating the relations is an important step to gather academic evidence which supports the relation model (Figure 50).

The user can select up to 5 concepts from the model and activate the panel in the left bottom with the button “Write annotation for selection”. This will make the annotation panel pop up with a generated list with all combinations of the 5 concepts for which publications exists that mentions those concepts. Selecting one of those combinations in the first top section will activate the middle section which shows the publications that mentions those concepts. Clicking the “add to references” link will add the article in the references for the annotation of the concept combination in the bottom section. The user then can write his annotation and give the annotation a title.

An introduction to the project can be written on the left panel. The idea is that in later versions the possibility will exist to export the relation model and the annotation in the form of a report which can be used as appendices for publications.

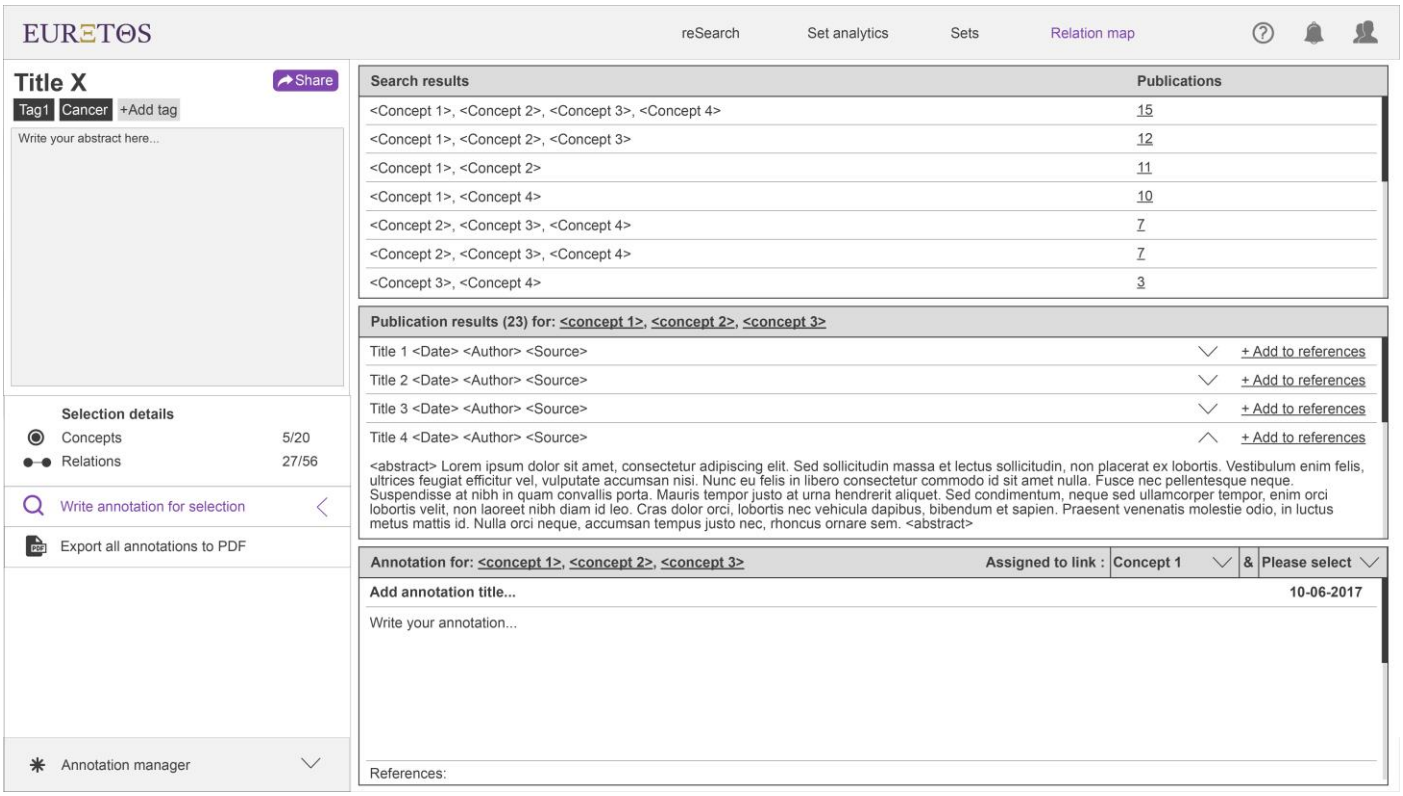


Figure 50: The annotation panel

The Annotation manager

The annotation manager is to give the user an overview of existing annotations and the possibility to edit or delete these annotations (Figure 51).

The Annotation manager shows a list of annotation titles and annotation dates of when it was saved for the last time. When a user clicks on an annotation title, the bar folds out to show the annotation text and references. By clicking on the pencil icon the annotation manager closes and the full annotation becomes visible where the annotation can be edited and new references can further be added.

As the annotation manager is an important mean to keep the overview of all the annotations, it can be accessed from within the annotation panel as well as from the diagram/model view in the left panel.

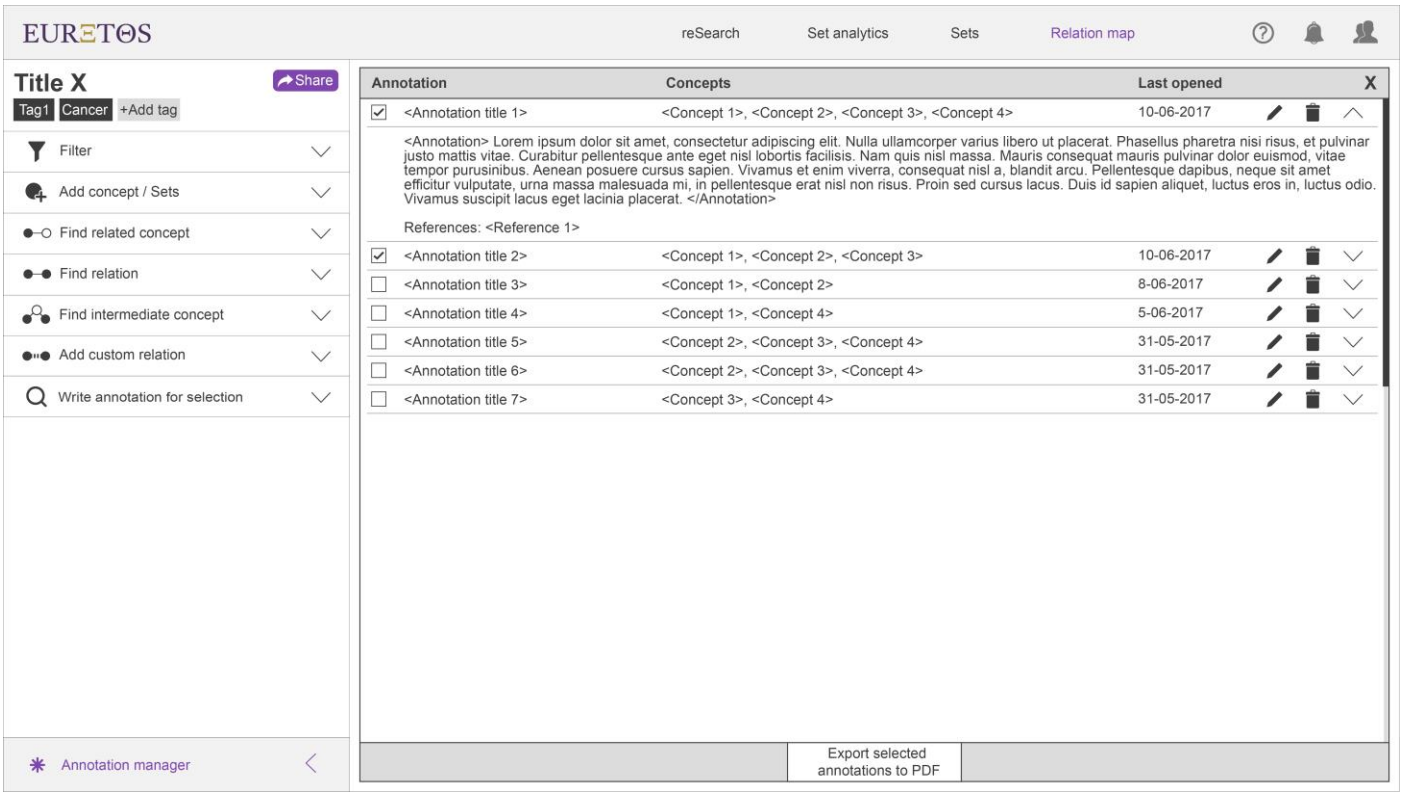


Figure 51: Annotation manager from within the annotation panel

Selection detail screen

To give the user more control of all the elements in the relation model, an option is available to further specify the selected concept and relations (Figure 52 & figure 53). The selection detail screen can be activated by pressing the “Show selection details” button in the top right window. For all the selected concepts and relations, the number of publication are shown with the familiar filters. Here is the possibility to delete specific relations, all relations with a concept or the whole concept. If a concept is deleted for which an annotation is written, the user will first get a warning with the question to confirm to delete concept as well as the annotations in which it is mentioned.

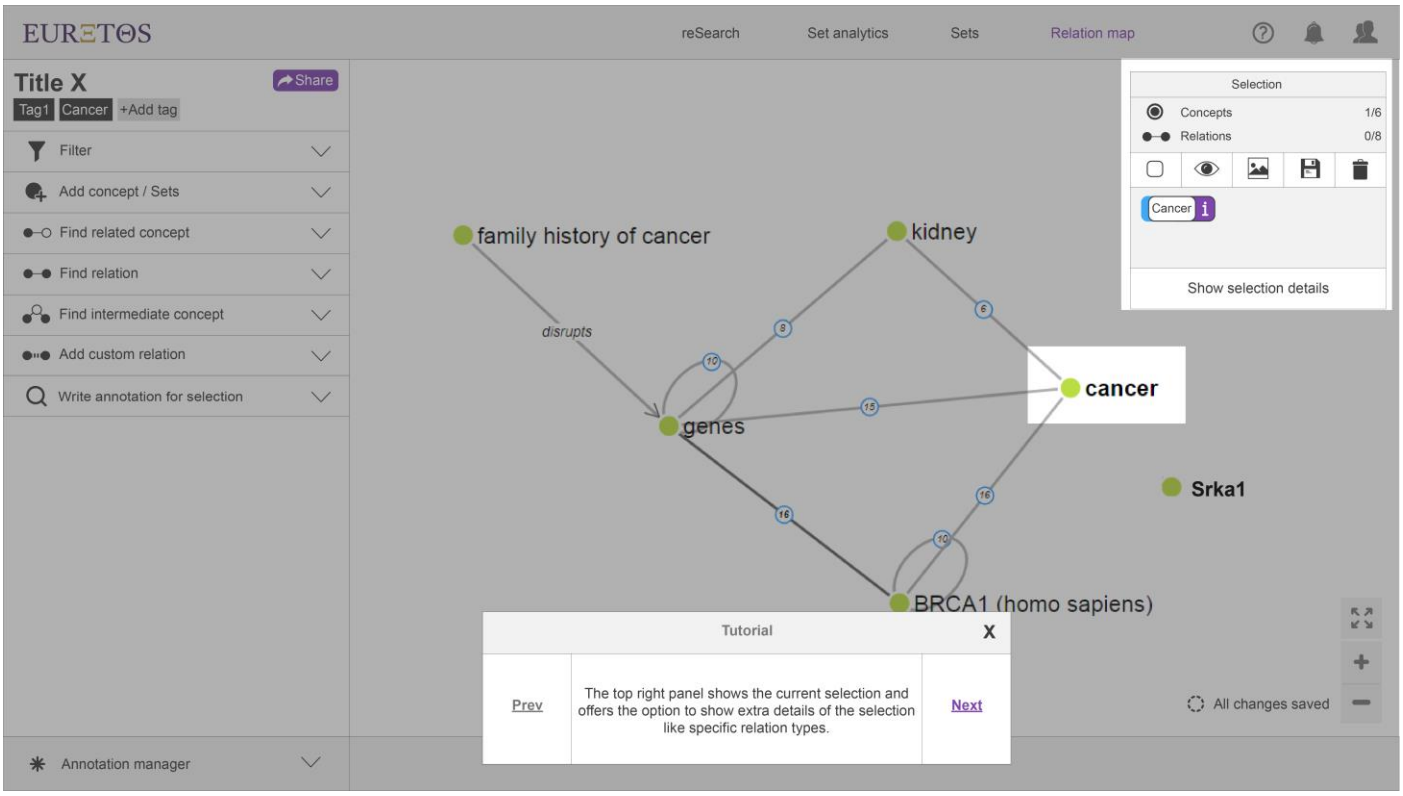


Figure 52: Tutorial screen showing the selection detail window in the top right corner

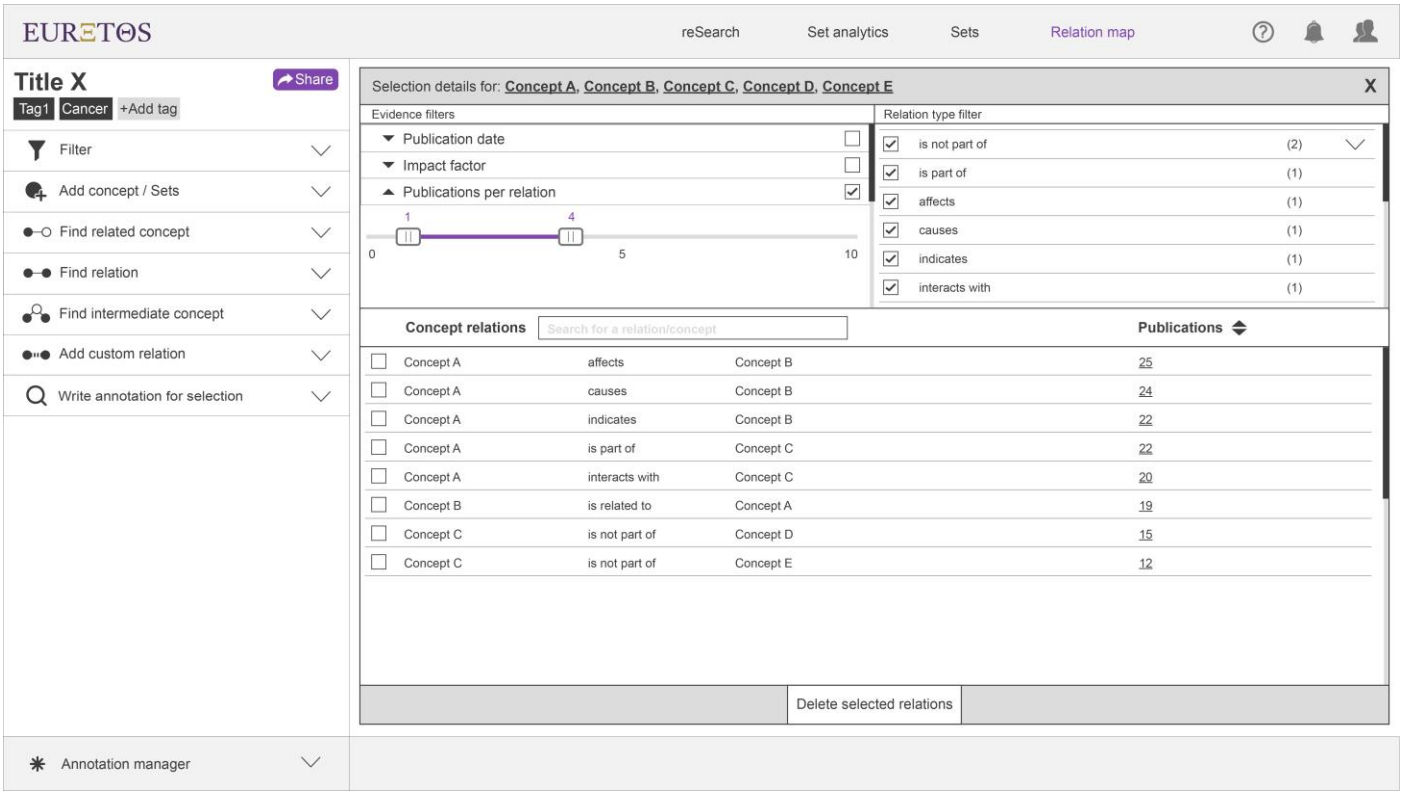


Figure 53: Selection detail screen

Tutorial walkthrough

Completely intuitive user interfaces are difficult to design as not all the users will have the same level of tech savviness. Therefore a tutorial which walks through the most important functions can give guidance to show what is possible. Especially applications that are designed for professionals can have extensive libraries with tutorials how to work with their application.

The tutorial walkthrough can be activated through the question mark icon in the header. A pop up will provide the navigation to allow the user to cycle through the various functions of the relation map tool (Figure 54 & figure 55).

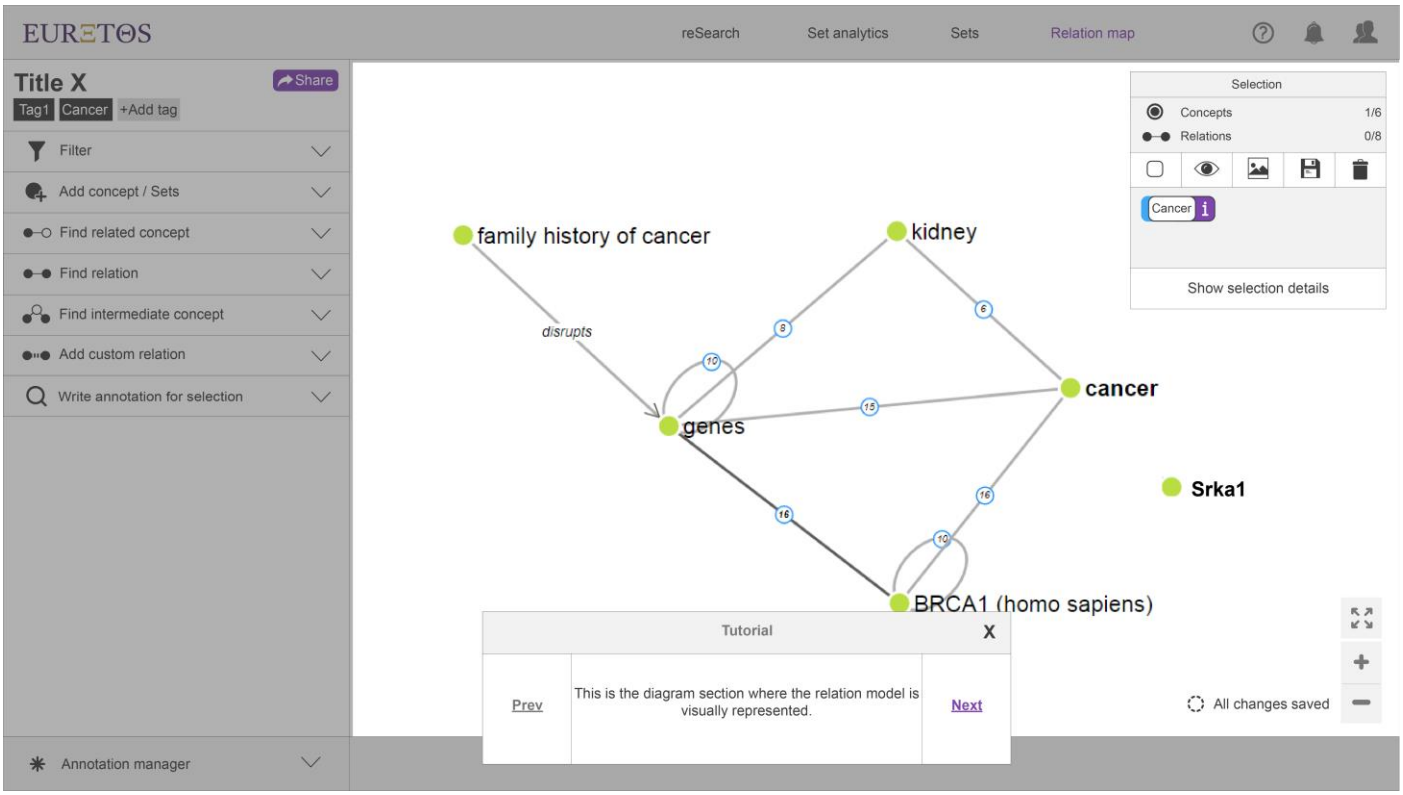


Figure 54: Tutorial walkthrough screen explaining the diagram section of the relation model

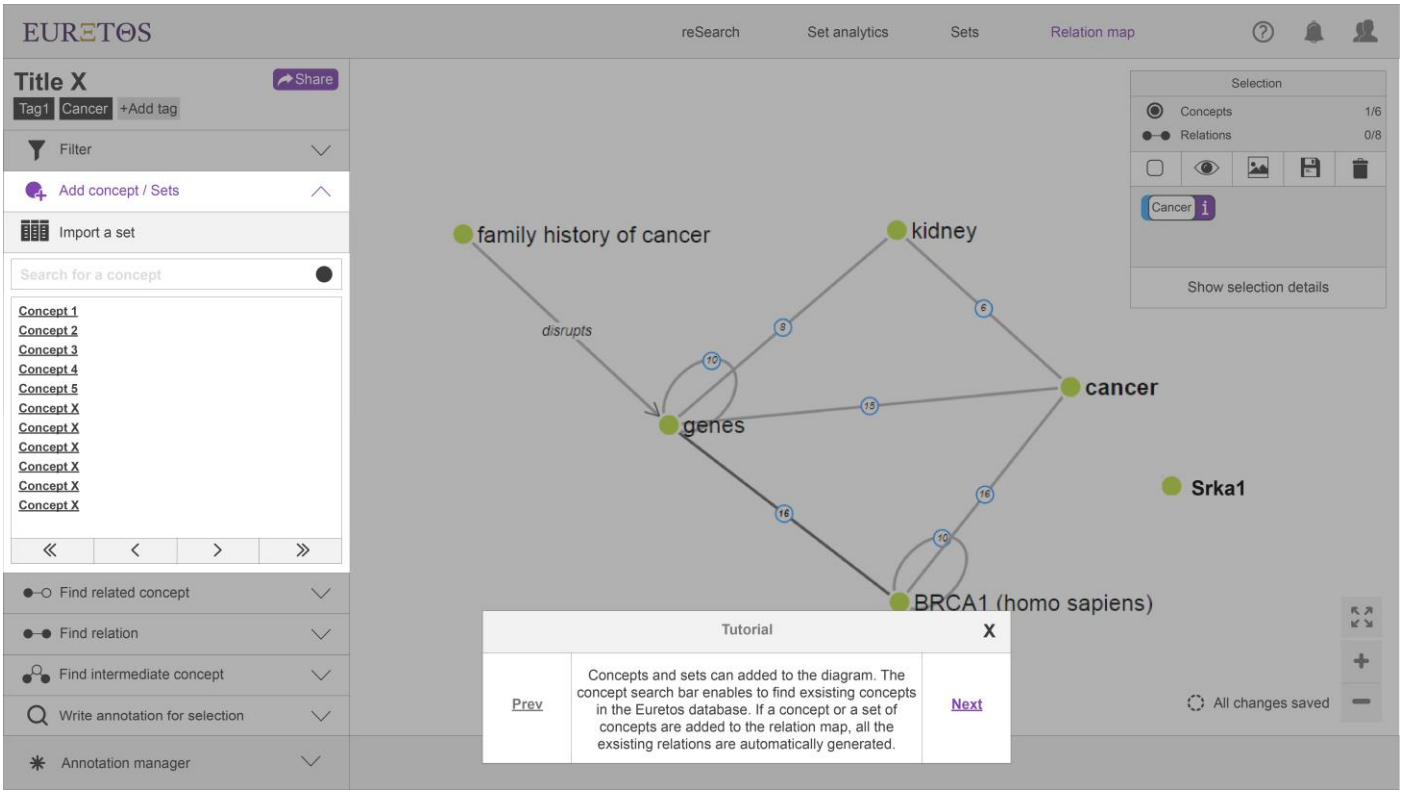


Figure 55: Tutorial walkthrough showing where concepts and sets can be added

Share your relation map project

To support collaboration between researchers with the Euretos platform. A new share option has been designed. The current project can be shared by filling in an email address (Figure 56). If the receiver has a Euretos account, the project can be directly accessed and constructed further. If the receiver does not have an Euretos account, the receiver will get the possibility to create a trial account. This way researchers will still be able to collaborate with each other as well as it is a form of attracting new researchers who might be interested to also start working with the platform. An extra benefit is that the researcher who does not have an Euretos account yet, immediately has a reason to use the platform and has the collaborating researcher to help with the initial use of the platform.

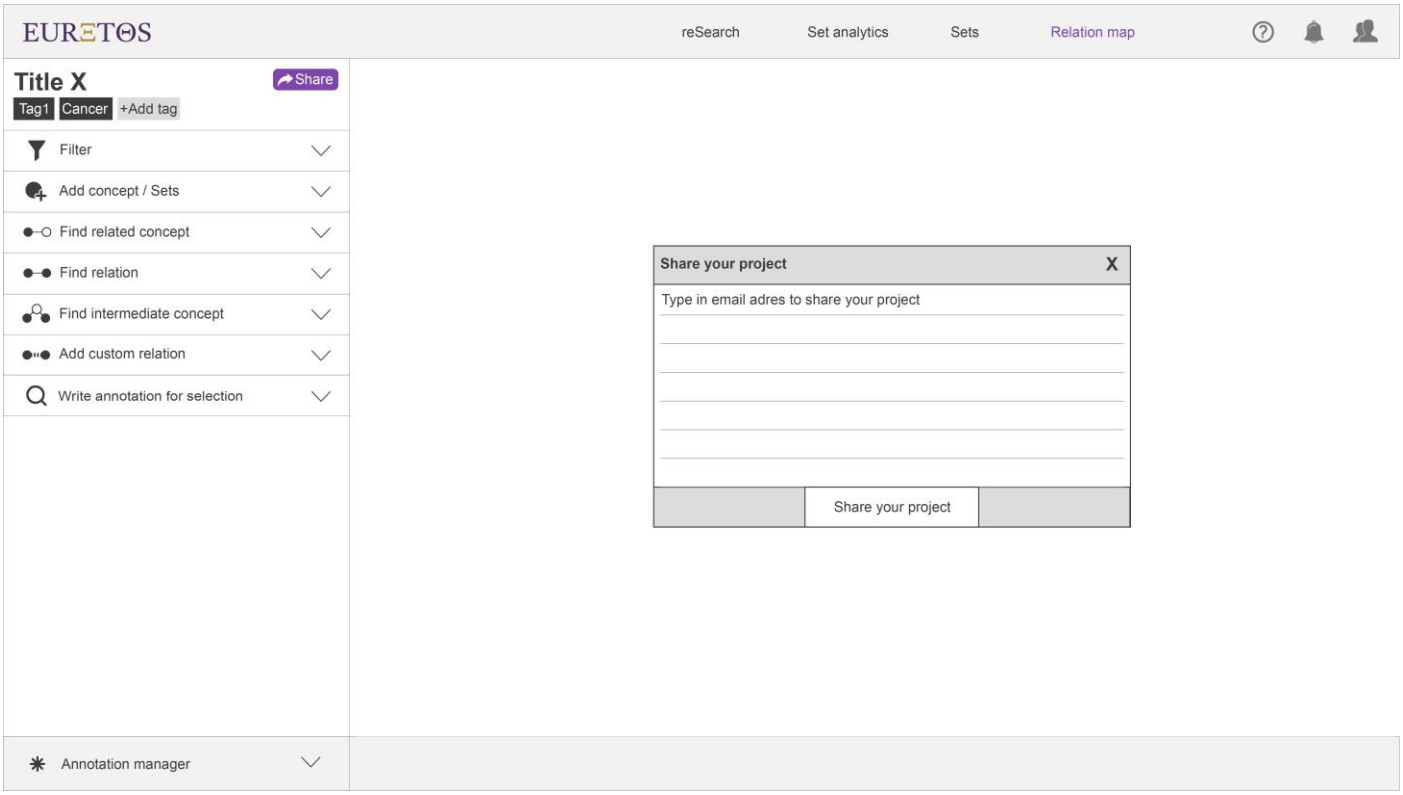


Figure 56: Share your project

8. User validation

The final concept was evaluated to verify whether most requirements from the design brief were fulfilled or not. As user research has shown that navigation has been an issue with previous versions of the knowledge platform, a small user test study was conducted to find issues on a practical level. Although some users have been consulted during the development phase, this has only been on a functionality level to determine if the ideated functions would fit the needs of the target groups. For the user validation, the main focus is on the how these functions have been translated into designs and if the user interface has the wanted level of intuitiveness and usability.

Method

To conduct the small user test study, participants have been selected based on the most common groups of users, the molecular biologists and the bioinformaticians. The user test study was conducted with in total of ten participants from two user groups.

Three molecular biologists, two from the LUMC, male and female and one female molecular biologist from the Dutch Techcentre for Life sciences with an age range of 25 to 45, with one molecular biologist having more than 15 years of experience in her field.

Seven bioinformaticians from the LUMC, four males and three females with an age range of 20 to 45, with three bioinformaticians having more than 15 years of experience in the field of bioinformatics.

Simple task-based scenarios were ideated to simulate the real goals of the user. This helps to uncover their method of progressing towards the final goal. By encouraging the participants to think-aloud, their considerations were uncovered to gain an understanding on how they experience the new platform. Next to taking notes, the user tests were audio recorded for later reviewing.

As the platform was still in development, a mock-up prototype was used to simulate the platform. Simple navigation with this mock-up was possible to test if the new platform was an improvement on the current platform of Euretos. The mock-up prototype was created with Invisionapp, a prototyping tool which transforms static screens into clickable, interactive prototypes. Invisionapp was chosen as it is straightforward to use, free and it is used by companies like Netflix, Airbnb and Evernote to evaluate their digital designs.

Before the start of the simulation and the task-based scenarios, the goal of the user test, to test the user interface, was explained to the participants and they were asked to think-aloud while using the prototype. They were asked to complete following tasks:

1. Follow the tutorial
2. Add 3 concepts to the relation map
3. Apply a filter
4. Show selection details of the selected concepts
5. Add a custom relation
6. Write an annotation
7. Share your relation map project

After each completed task, a short discussion followed to evaluate which design elements were helpful and which were distracting or not clear enough. Also the tasks were discussed afterwards to evaluate if it matches the needs of the participants when executed during research and if they were missing specific functions.

Results

In this part the results of the concept evaluation will be described. The results are presented in the order of the task scenarios

Summary of the results

- The tutorial walkthrough is essential to explain the use of the relation map for new users of the Euretos platform as well as for more experienced users
- Not all elements of the tutorial are visible enough to draw immediate attention
- Adding concepts is straightforward, clear and simple
- The new filter panel offers a powerful tool to explore relation models
- The new filter panel increases the trust in the presented results
- The use of tooltips should be increased as it helps to give ad-hoc information
- How to add a custom relation is not always initially clear
- Writing annotations is an extra step which changes the way researchers could be collaborating, the explanation of the annotation tool and how it changes the workflow needs to be much more emphasized
- Sharing relation map projects probably will improve collaboration between researchers
- Navigation has been improved significantly; easy navigation
- The overall design, functionality and usability has received positive feedback

1. Follow the tutorial

The participants mentioned that the tutorial walkthrough is an effective method to introduce new as well as experienced users to the all the functions of the relation map. Especially for new users the walkthrough setup helps to guide the user which steps are commonly used after each other to construct a relation model. The method of highlighting specific parts of the user interface to draw attention to the part that is being explained is text has overall been experienced as effective, although the changes between steps are not always visible enough (Figure 57). The suggestion to make the changes more visible by making use of animations could enhance the visibility.

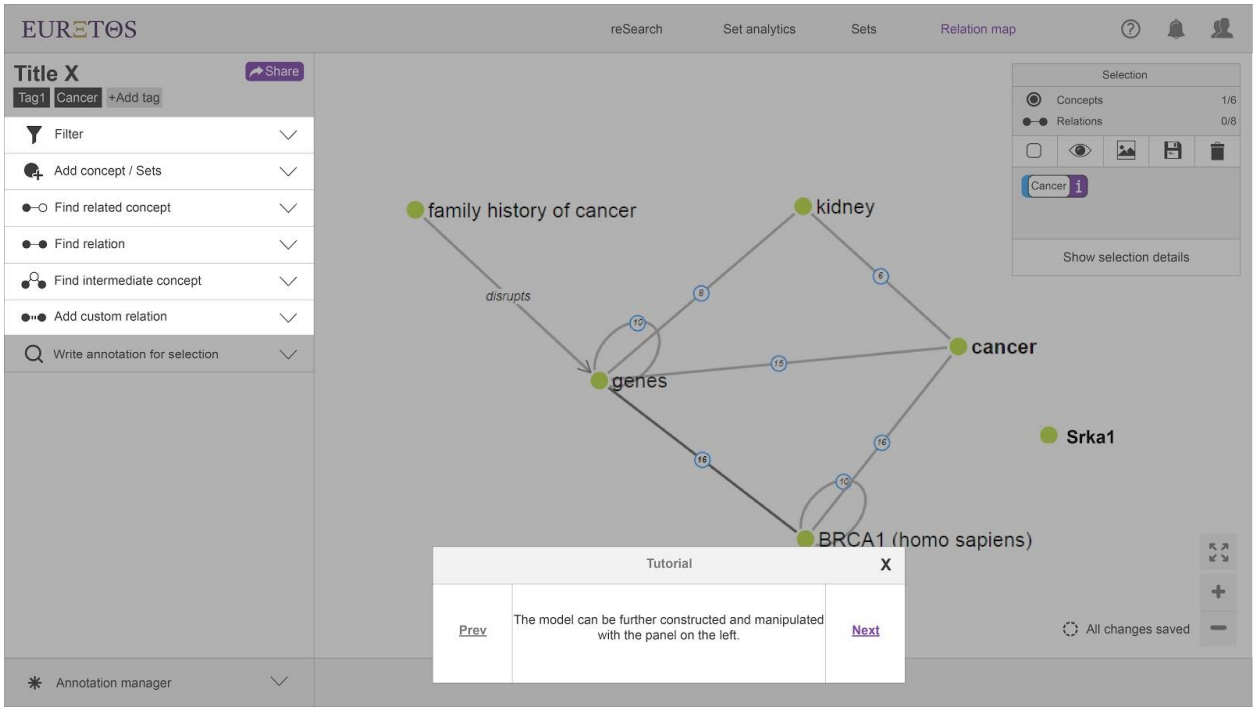


Figure 57: Walkthrough tutorial

2. **Add 3 concepts to the relation map**

Adding concepts is the most important step to construct a relation map and the participants had no trouble to find where concepts could be added to the relation map. Although the mock-up prototype did not allow the participants to actually type in and search for concept they wanted to add to the relation map, the navigation of the add concept/set functionality was straightforward, simple and clear.

3. **Apply a filter**

The filter panel functionality has been increased to give the user more control over the results shown in the relation map in the form of relations between concepts and therefore is an essential part of the relation map tool. Especially in a big data environment where there is a lot data, filtering is essential to make the data comprehensible.

The participants were quickly able to find the filter panel and were impressed with the new filter options which did not exists in the previous version of the knowledge platform. Especially the option to filter out relations based on the number of publication was seen as a welcome addition. They mentioned that while doing research and constructing models, it is essential that they can trust the results they are seeing on their screen. The possibility to only see relations that are supported by a minimum number of publications can help to improve their trust in the results. One participant mentioned that one publication is as good as no publication and that she preferred to see at least four publications as this improves the reliability of her own research.

In addition, some participants mentioned that the possibility of filtering relations on publication date also increases the trust in the results as the field of life science is a fast moving field and that older publications are not always completely correct. An extra benefit of having the possibility to set a range of publication dates is that the development of a specific pathway or model can be seen developing over time. A function which the publication date filter was not necessarily designed for but nevertheless a valued extra possibility to use this particular filter for.

4. **Show selection details of the selected concepts**

The selection detail screen is to show more in-depth information about relations between concepts. The reason that there is a special screen is because it otherwise would not fit in the main diagram view with the relation model.

Three participants however had initial difficulties to understand that to activate the selection detail screen, some concepts and relations needed to be selected to activate the selection detail screen. This could be solved by giving the button to access the detail screen a hover state with a tooltip box with the text why this function is currently unavailable (Figure 58). After discussing this matter with participants who were able to successfully find the selection detail screen, the main consensus was that the use of tooltips should be increased to give ad-hoc explanation what a specific button does and if applicable why it is not available.

All the participants did value the selection detail screen as it offers a textual version of the relation map with the same publication evidence filters as opposed to the filter panel of the main diagram view which is a graphical view. The participants mentioned that the multiple options to filter evidence helps to gain trust in the viewed results.

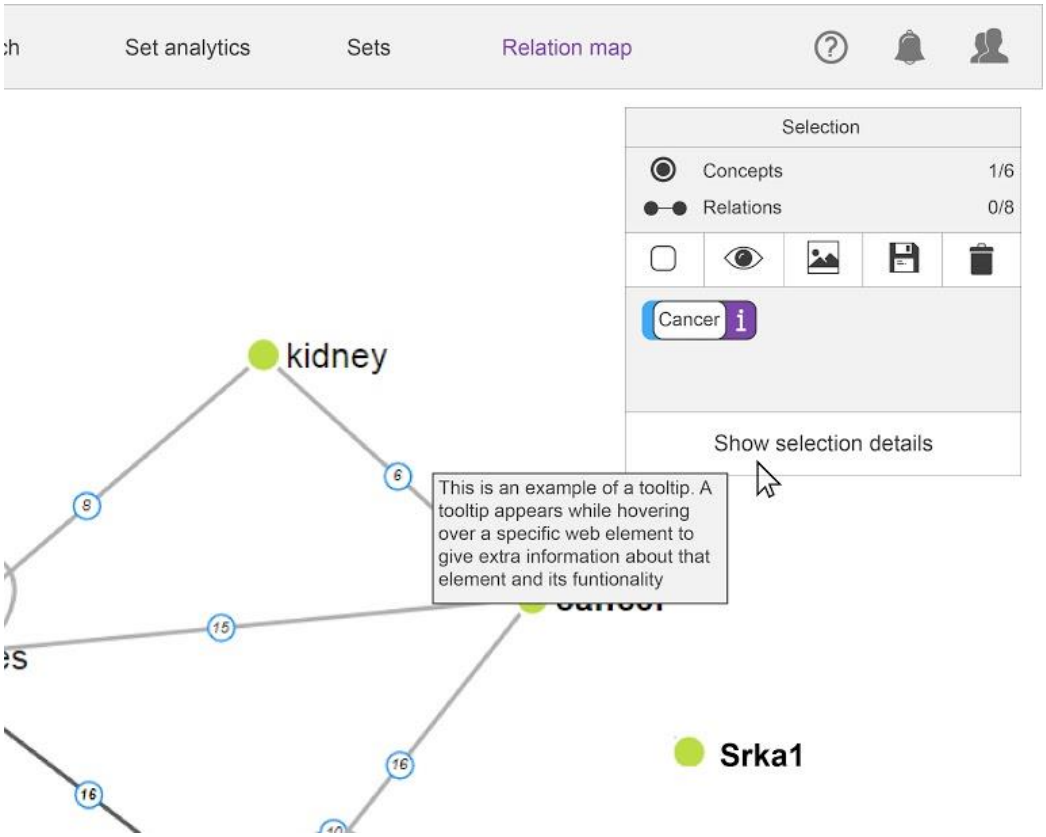


Figure 58: An example of a tooltip

5. Add a custom relation

The task of adding a custom relation is based on the need to visually construct a relation model and incorporate own findings from a recently executed research which is not yet published and therefore not yet incorporated into the Euretos database.

As with the selection detail screen, the first step is to select two concept for which a custom relation needs to be created. This was not always clear enough for most participants. The expected behaviour was that they could also add a concept for which a custom relation needed to be established. The current workflow is to first add a concept via the add concept panel, then select two concept for which a custom relation needs to be established and then activate the “add custom relation” function to create the custom relation. After being explained the workflow, the participants said that this should be mentioned more explicit in the tutorial which steps are needed to add a custom relation.

The participants also asked if the custom relations added to the relation map are also added to the Euretos database. As this is not the case and all custom relation are only connected to the model in which they are present, this should also be mentioned more explicit.

6. Write an annotation

Writing annotations is something completely new for the relation map tool. Annotating means that for each relation that exists between concepts in the relation model, an explanation with references are added. Although there is a dedicated tutorial walkthrough for writing annotations. The main goal was not clear from the start and only after personal explanation, the use of writing annotation became clear. One participant said that writing annotations can definitely be of value when collaborating with other researchers as it offers the possibility to explain each relation of a relation model. The method to write annotations does need some

training or at least be more explicitly mentioned that it is an important step to improve collaboration between researchers.

The steps of constructing a relation model, writing annotations and sharing the project need to be much more emphasized as it is a new method of working. Some participants were not sure if they would be using the annotation functionality but they did see the added value for other researchers.

7. **Share your relation map project**

The last task is to share the relation map project with other researchers. It is a simple step to send the complete project via an email address. The participants all were positive about the possibility to share projects and to collaborate with other researchers. Especially the fact that the receiver without a Euretos account can directly start a tutorial account and start collaborating was received with positive feedback.

8.1. Discussion

The results of the evaluation could have been different if the prototype would be fully functional. Unfortunately the development of the beta version of the Euretos platform was not yet in a phase that it would be presentable to potential users. Therefore the use of the Invisionapp was the best quick solution to still have a somewhat interactive prototype to test specific functionality like navigation. Some parts, like searching for concepts in the database to add to the relation map, could not be completely experienced by the user as it is to interactive to create mock-ups for. The same goes for writing annotations, which makes the new functionality feel a bit abstract. For the next user test, a fully functional service should be available to give task-based scenarios which range further than performing simple navigational tasks and should be more close to performing actual research with the platform.

The user group that participated was relatively diverse and let to useful feedback. The participants with prior Euretos experience were more proficient with the new platform and therefore making new user groups with and without experience for the next user validation might lead to more rich insights. Also a more quantitative approach regarding the next user test is recommended as the smoothness of the user experience, trust and confidence need to be expressed in quantifiable measurements. The current version of the knowledge platform should also be taken into account during this quantitative approach to be able to validate quantifiably that the improved platform is indeed an improvement.

8.2. Conclusion

Overall the small user test study received positive feedback and the user group was excited about the new possibilities for the relation map tool. The relation map tool was accepted by the participants as a model exploration and model construction tool with a lot of user control. Especially the new evidence filters help to gain the trust of the user for the results that the Euretos platform shows. The current problems of the concept mainly focuses on the way functionality is explained, especially the new option to write annotations and create a more interactive model.

The main conclusion is that the relation map tool offers a lot of possibilities to perform research and collaborate with other researchers. The smoother user experience compared to the current version of the knowledge platform, helps to give the user confidence in using the improved platform and resulting in a high level of trust in the results. The found issues around the tutorial and the annotation functionality however need to be solved and reassessed together with a fully functional beta version of the relation map tool, before the full version can be released.

9. Corporate entrepreneurship

This graduation project has been primarily focused on research, strategy development and concept development. All these phases are important for successful business development and market growth. But having a sound strategy with a sound product portfolio does not necessarily mean that the company will grow. Every starting company is developing product or services and almost all failed start-ups have a product or service. The reason why start-ups might fail is that they don't have enough customers. Weinberg & Mares (2015) argue that for companies especially start-ups and scale-ups, it is essential to create traction with new customers.

Just starting with marketing/traction channels might prove not efficient and expensive. Therefore it is important to set goals which are quantifiable and measureable. For instance a google ads campaign with the goal to attract more traffic to the company's website which eventually will lead to more customers. The number of website visitors can be measured and the costs for the ads campaign are known. This means that a simple calculation can be made to express how much money equals one new paying customer. But a large ads campaign can be very expensive. Therefore choosing the wrong traction channel can be a costly mistake which even can mean the end of a start-up as investors might interpret this as no interest from the target group. Therefore the selection of the right traction channels are an important step in scaling up a starting company.

Making a decision which traction channels to use can have a big impact. It can be compared with buying a car. Almost nobody buys a car without having a test drive. A test drive is a mean to determine if the car fits the needs of the buyer, therefore reducing the risk on bad purchase. The same goes for traction channels, small experiments can reduce the risk and give an indication of how efficient that specific traction channel will be for reaching the traction goal.

Weinberg & Mares (p41, 2015) have determined three important questions which need to be taken into account when designing traction experiments.

1. How much does it cost to acquire each customer through this channel strategy?
2. How many customers are available through this channel?
3. Are the customers you are getting through this channel the ones you want right now?

The first traction channel strategy tests should be cheap and short to give quick insight on how well these channels are working to reach the traction goal. Effective tracking and reporting is important to evaluate the efficiency of these traction channels. The cost to acquire a new customer needs to weigh up to the lifetime value of a customer. Otherwise acquiring a new customer could even cost more money than it brings in. In the case of Euretos, this will not likely be the case as it is focused on the academic/business market with a subscription service and not on consumers with a fast moving product with low profit margins.

There 19 different traction channels that could be used to gain traction. Some of them are easier applicable than others but this all dependent on the context. The 19 traction channels are:

1. Targeting blogs: building relationships with bloggers that write about the field in which the company is active.
2. Publicity (PR): Spreading the word about the company via traditional media outlets like newspapers, magazines and television.
3. Unconventional PR: Doing something special to draw media attention like publicity stunts.
4. Search engine marketing (SEM): Paid advertisements for search engines like Google.
5. Social and display ads: Display ads like banners on websites or ads on social network sites like google and twitter.
6. Offline ads: Television/radio commercials, billboards, newspaper ads, flyers and other local advertisements.

7. Search engine optimisation (SEO): Optimising your website to make sure it shows up for key search results.
8. Content marketing: Creating own content like blogs or news sections to draw people to the company's website
9. Email marketing: Converting interested potential customers while retaining and monetising existing one.
10. Engineering as marketing: Building an web service, app or free tool for the target market for little to no cost to draw new users or customers to the company's website.
11. Viral marketing: Encouraging users to refer to your product while every new acquired user brings in at least on more user, preferably more.
12. Business development: Establishing partnerships and agreements with other companies to promote each other's' product or services.
13. Sales: Directly reaching out to potential customers in order to convince them to buy the product/service, like cold calling.
14. Affiliate program: Rewarding existing users with money or extra services for referring the product or service to new customers.
15. Existing platforms: Using existing platform to help promote your product, like using the app store or android's play store.
16. Trade shows: Using industry specific shows to show and promote the latest products and services.
17. Offline events: Sponsoring or organising events from small meetups to large conferences.
18. Speaking engagements: Performing speeches/presentations at industry specific events.
19. Community building: Investing in the creation of relationships between customers and helping them to bring in more people, like Wikipedia or Stack Overflow.

Most of these traction channels are not interesting for Euretos as it will be difficult to reach the target group efficiently. The chance that a bioinformatician will see the commercials before the 8 o'clock news is quite high but these commercials are very expensive because it reaches many more audiences. This makes it a bad choice for Euretos. The same goes for viral marketing, offline ads, social ads and display ads. The more interesting traction channels are the channels that are target group specific especially because the Euretos knowledge platform is targeted at a specific niche.

With traction channels like speaking engagements, engineering as marketing, sales and email marketing, it is much easier to control whom would be reached with these channels. While engineering as marketing would still require some investments, the others require much less resources.

By creating an overview of the traction channels with a few simple selection criteria, direction can already be set for interesting traction experiments (Table 1). The most interesting traction channels are:

- Targeting blogs
- Search engine marketing (SEM)
- Search engine optimisation (SEO)
- Content marketing
- Email marketing
- Business development
- Speaking engagements

Traction channel	Target group specific	New customer reach	Costs	Trackable
Targeting blogs	yes	Medium	Low	yes
Publicity (PR)	no	Low	High	no
Unconventional PR	no	Low	High	no
Search engine marketing (SEM)	yes	High	Low	yes
Social and display ads	no	Low	High	yes
Offline ads	no	Low	High	no
Search engine optimisation (SEO)	yes	High	Low	yes
Content marketing	yes	Medium	Low	yes
Email marketing	yes	Medium	Low	yes
Engineering as marketing	yes	Medium	Medium	yes
Viral marketing	no	Low	High	no
Business development	yes	High	Low	no
Sales	yes	Medium	Medium	yes
Affiliate program	yes	Medium	Medium	yes
Existing platforms	no	Low	Medium	yes
Trade shows	yes	Medium	Medium	yes
Offline events	yes	Low	High	no
Speaking engagements	yes	High	Low	no
Community building	yes	Medium	Medium	no

Table 1: Rating traction channels for Euretos

With the business model canvas analysis, it was already established that Euretos already is using some of these channels like speaking engagements on conferences. Also business development is an important activity as Euretos is actively collaborating with academic institutes to promote their software. The goal to be mentioned more in academic publications can be an appropriate method to reach the target group and also to gain trust with the target group as it is already trusted by other scientific researchers.

Traction channels can also be combined to strengthen both channels. Combining content marketing, email marketing, targeting blogs with the business development by actively promoting new published researches that have been executed with the use of the Euretos knowledge platform might prove to be an effective strategy to gain more traction. When present on conferences for speaking engagements, using the previously mentioned channels could also strengthen each other. As these channels are also low cost, it poses almost no risks at all and therefore should be considered to be used as traction channels.

10. Overall conclusion

Researchers in the field of life sciences all believe that computer applications will become more important for performing efficient research. Euretos has a unique positioning compared to its competitors as it has a large knowledge database which can be used to accelerate the research process. Complex disease mechanisms can be better understand with the use of the Knowledge platform. However, there are some researchers who are not able to fully access the knowledge stored in the database as the user interface does not completely offer the user experience they are looking for. This graduation project was about improving the user experience of the target group through designing a new user interface for the Euretos knowledge platform. The first step however was analysing the positioning of Euretos to verify that an improved user interface would lead to a strengthening of the unique positioning of Euretos.

The database size and quality which lead to unique knowledge exploration and expansion combined with the relative low price compared to competitors in the same product form category, gives Euretos a strong positioning. The text mining algorithm to create data which is organised in a model framework, makes the database unique. Competitors are not likely to be able to recreate a similar database as algorithm development and building the database take time. The usability of Euretos knowledge platform offered the opportunity to differentiate even more from the competitors, while also creating the possibility to appeal to a larger group of users.

As validity is an important factor for life science researchers to trust results from software applications. A smooth user experience helps to gain trust from the user as a it gives the user more confidence to be able to control the platform. There are indications that user experiences that are designed with care induce the feeling of trustworthiness. The wanted result is that a higher level of trust will lead to researchers citing the Euretos knowledge platform in their research publications. The more publications mention the platform, the higher the trust will be from other researchers and therefore results from the knowledge platform will be considered more valid.

User research indicated that a smooth user experience could lead to the user having a higher feeling of trust. This trust is largely gained by giving the user control over the outcomes of their search queries and by preventing unexpected behaviour by making a predictable user experience, which in turn could lead to more confidence of the user for using the platform. In addition, multi-disciplinary collaboration between molecular biologists and bioinformaticians should also be supported as it helps to share knowledge but also to have a positive effect on the efficiency of a collaborated research.

Research how to design smooth user experiences indicated that it is important to give the user the sense of being in control. This means that for user interfaces, it has to be simple, clear, consistent and predictable. If the user is unable to answer the questions: Where am I now? Where can I go? What will I find when I get there? Then the user interface is not designed with simplicity, clarity, consistency and predictability in mind.

Another important aspect for a smooth user experience is that it needs to fit the expectations of the target group. There is a balance between the level of intuitiveness and the level of training needed to be able to feel confident to use the platform. The amount of time a user uses the platform dictates if the user is a sporadic or a professional user. As user research indicated that none of the researchers work full time with the knowledge platform, the decision was made that a higher level of intuitiveness was preferred over extensive training. This resulted in a trade-off that the number of functions needed to be reduced to be able to design a more intuitive user interface. The trade-off was made based on the 80/20 rule of thumb, that 80 percent of the time, 20 percent of the functions are used. In consultation with Euretos management, the most essential features were chosen which lead to the design brief.

The three main functions of the improved knowledge platform, where the ReSearch tool, the Set analytics tool and the relation map tool. Because of time restraints and that the relation map tool is the most interactive functionality of the platform. The scope was set to design the relation map tool. The features of the relation map tool were inspired on the previous version of the relation map tool but with a focus on

increased user control. Also more trust in the relation map tool from the user should be gained and collaboration between researchers should be supported. In consultation with Euretos management, high profile users and the development team, the most important actions were determined in the design brief.

The design of the relation map tool has a straightforward layout with a distinctive sections. The manipulation panel is used to add concepts to the diagram/model view and to filter concepts. The filters available were designed to give the user more control over the resulting concepts in the relation model. The parameters for the filters were a direct result from the user research, as was determined that to gain trust in the results, the user needs to be able to filter on publication date, impact factor and the number of publications supporting a statement.

For the user validation a small user test study was conducted. From the study it was learned that the target users' basic needs were fulfilled. The relation map tool was accepted by the participants as a model exploration and model construction tool with a lot of user control. Therefore, it can be said that overall the relation map tool is found to be an appropriate solution to perform research, construct models of disease mechanisms and to collaborate with other researchers. However, there were important comments and recommendations as well which can help further improve the relation map tool and the user experience of the research process. These comments and recommendations should be taken into consideration for further development of the concept.

In conclusion, the studies and user research that have been conducted helped to unveil the users' needs and desires and to some extent the problems they were facing with the current platform. The research about the positioning of Euretos strengthened the idea that improved usability would lead to a better user experience as well as a better positioning for Euretos. To consolidate the opportunities to improve the current situations and problems, the relation map tool was developed as part of the improved knowledge platform. Through user validation, it was indicated that the application is a helpful tool in performing research by constructing relation models for disease mechanisms and that the application probably will offer a smooth user experience. Therefore, the relation map tool will be used as a starting point to redesign the knowledge platform into a user-centered life science research application.

11 Reflection

This graduation assignment has been initialised by Euretos. During the assignment formulation, it was already clear that Euretos' goal was to develop an improved version of the Euretos knowledge platform. To fit the graduation requirements for the master of strategic product design, extra attention was needed for the company analysis, market research and strategy development.

Although Euretos had explicitly addressed their wishes to improve the usability of the platform, first some studies and user research where needed. As the field of life science research is a very complex field, it was very difficult to start the research. During many interviews with molecular biologists and bioinformaticians, the level of prior needed knowledge about life sciences was very high to really understand their needs and problems. This led to a less rich user research than was expected. Fortunately the Euretos management was very helpful into understanding the needs of the user and translating these needs into more concrete statements.

On the level of research methodology, there is room for improvement. The research methods were not always completely suitable for the situation which also led to less rich insights. The use of quantitative research methods could have been an easier way to force the life science knowledge level needed for performing the user research to be lower. As the target group was often quite difficult to reach, a questionnaire could have been a more appropriate method to obtain a larger sample size, which in turn could have led to more generalisations.

Designing the mock-ups to a detailed level was a new experience as well and a lot of knowledge was gained about designing user interfaces. The level of details were to such an extent that the Euretos decided to directly implement the designs in the development of the improved knowledge platform. This resulted in a considerable amount of time being used for the actual development of the application. Unfortunately the development of the application did not progress fast enough to be used for the user validation. Therefore a makeshift mock-up prototype was the only solution to still have some interaction with the users. Given the time constraints, the prototype was the best that could have been achieved while still gaining valuable user feedback. Overall it was a very educational experience to find the balance between personal graduation goals and the goals of the company.

Although this graduation project has not always been an easy process, lots of knowledge was gained which gives the confidence that continuous work does has its achievements. It is very rewarding to see that Euretos has taken this graduation project very serious and to see that the actual mock-up designs are being developed into an application that is going to be used by professionals (Appendix D).

References

Abras, C., Maloney-Krichmar, D., & Preece, J. (2004). User-centered design. Bainbridge, W. Encyclopedia of Human-Computer Interaction. Thousand Oaks: Sage Publications, 37(4), 445-456. Alertbox . Retrieved from https://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/

Barnum, C. M. (2010). Usability testing essentials: ready, set... test!. Elsevier.

Bertram, B. (2005). Commodore 64. retrieved from https://commons.wikimedia.org/w/index.php?curid=133083
Buijs, J. A., & Van der Meer, H. (2013). Integrated Creative Problem Solving: Delft Studies on Innovation. Eleven international publishing.

Creusen, M. E., & Schoormans, J. P. (2005). The different roles of product appearance in consumer choice. Journal of product innovation management, 22(1), 63-81.

de Regt, M. (2017, May 5). Personal interview with the lead UX designer at Philips Healthcare

Djamasbi, S., Siegel, M., & Tullis, T. (2011). Visual hierarchy and viewing behavior: An eye tracking study. Human-Computer Interaction. Design and Development Approaches, 331-340.

EY. (2015). Biotechnology Industry Report 2015, Beyond borders Reaching new heights

EY. (2016). Beyond borders 2016: Biotech financing Bountiful harvest leaves biotech well prepared for financial winter

Fisher, T. (2017). What Is the Command Prompt in Windows, and How Do I Open It? Retrieved May 03, 2017, from https://www.lifewire.com/command-prompt-2625840

Forty, A. (1986). Objects of desire:[design and society from Wedgwood to IBM]. Pantheon books.

Griggs, B. (2011, May 09). The Commodore 64, that '80s computer icon, lives again. Retrieved May 03, 2017, from http://edition.cnn.com/2011/TECH/gaming.gadgets/05/09/commodore.64.reborn/

Hughes, J. P., Rees, S., Kalindjian, S. B., & Philpott, K. L. (2011). Principles of early drug discovery. British journal of pharmacology, 162(6), 1239-1249

Johnson, J. (2013). Designing with the mind in mind: simple guide to understanding user interface design guidelines. Elsevier.

Klein, G. (1997). The recognition-primed decision (RPD) model: Looking back, looking forward. Naturalistic decision making, 285-292.

Klein, G. A. (1999). Sources of power: How people make decisions. MIT press.

Koper, A. (n.d.) Qiagen Sample to Insight [PowerPoint slides]

Krebs, A. M., Mitschke, J., Losada, M. L., Schmalhofer, O., Boerries, M., Busch, H., ... & Brunton, V. G. (2017). The EMT-activator Zeb1 is a key factor for cell plasticity and promotes metastasis in pancreatic cancer. Nature Cell Biology, 19(5), 518-529.

Krug, S. (2005). Don't make me think: A common sense approach to web usability. Pearson Education India.

Lal, R. (2017). Digital design essentials: 100 ways to design better desktop, web, and mobile interfaces. Beverly, MA: Rockport

Langerak, F., Hultink, E. J., & Robben, H. S. (2004). The impact of market orientation, product advantage, and launch proficiency on new product performance and organizational performance. Journal of product innovation management, 21(2), 79-94.

Lawson, B. (2006). How designers think: the design process demystified. Routledge.

Mac History, (1983) Screenshot Apple Lisa. Digital image

macOS Human Interface Guidelines (2016) Retrieved from https://developer.apple.com/library/content/documentation/UserExperience/Conceptual/OSXHIGuidelines/DesignPrinciples.html#//apple_ref/doc/uid/20000957-CH18-SW1

MacOS Sierra. (2016). In Wikipedia. Retrieved May 10, 2017, from https://en.wikipedia.org/wiki/MacOS_Sierra

Multiomics. (2017, June 11). Retrieved June 15, 2017, from https://en.wikipedia.org/wiki/Multiomics

Nielsen, J. (2000). Why you only need to test with 5 users.

Nussbaum, B. (1993) Business Week, Hot Products: Smart Design is the Common Thread. June, 7, 54-78.

Osterwalder, A., & Pigneur, Y. (2010). Business model generation: a handbook for visionaries, game changers, and challengers. John Wiley & Sons.

Phoebe Chen, Y. P., & Chen, F. (2008). Identifying targets for drug discovery using bioinformatics. Expert opinion on therapeutic targets, 12(4), 383-389.

Ries, E. (2011). The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses. Crown Business.

Shneiderman, B. (2010). Designing the user interface: strategies for effective human-computer interaction. Pearson Education India.

Stern, M. (2014). Designing intuitive user interfaces.

Small, R.S. (2013). Retrieved May 15, 2017, from http://harwoodp.people.cofc.edu/YOUTUBEandYOUMainPage.html

Toonen, L. J. A. (2017, March 21). Personal interview

Ukraine Digital News & AVentures capital, (2016) IT Ukraine, IT Services and software R&D in Europe’s rising tech nation

van Arnhem, J. P. (2013). Unpacking Evernote: Apps for note-taking and a repository for note-keeping. The Charleston Advisor, 15(1), 55-57.

Webby awards. (2017). Retrieved June 23, 2017, from https://www.webbyawards.com/winners/2017/mobile-sites-apps/general-sites-apps/productivity/evernote/

Weinberg, G., & Mares, J. (2015). Traction how any startup can achieve explosive customer growth. NY, NY: Portfolio/ Penguin.

Yang, Y., Adelstein, S. J., & Kassis, A. I. (2009). Target discovery from data mining approaches. Drug discovery today, 14(3), 147-154.