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CapExBio

A Knowledge Capitalizing, Cooperative Environment for the Genomics Community

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Abstract

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Much focus within biological research today is on genomics and post-genomics. A huge amount of scientific data is produced every day. Hence, there is a need for environments that offers simplified access to resources, is freed from computational barriers, and where the various actors within the field of biology can be given room to develop and improve their processes and enrich their knowledge within their field of study. While this paper is being written, during the summer of 2008, there is yet no single workflow environment that supports cooperation among the primary actors within the field of genomics and that fully supports the necessary capitalization of knowledge within that same community. The aim of this diploma work is to initialize the system design process of this specific cooperative, knowledge capitalizing, workflow environment.
As the project progressed, scope creep management had to be performed in order for the development process to align with the new chosen design method, the User-Centered Systems Design approach. This design approach was chosen based on learnings from the two main fields of systems design, Usability Engineering and Interaction Design. Lack of solid project management and user participation proved to be the biggest challenge when the project was to be initialized. The team's sense of good usability and usefulness proved to be the least of the concerns. The result of this diploma work was a bigger awareness of the importance of sound project management and an initial design proposal for a cooperative, knowledge capitalizing workflow environment.

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TELECOM Bretagne

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Sammanfattning

Mycket fokus inom biologisk forskning är i dag på genomik och postgenomisk forskningen. En stor mängd vetenskaplig data produceras varje dag med hjälp av ett brett spektrum av olika bioinformatikprogram. Det finns därför ett behov av miljöer som erbjuder förenklad tillgång till resurser, som är befriade från beräkningshinder, och där de olika aktörerna inom området biologi kan ges utrymme att utveckla och förbättra sina processer och förbättra sina kunskaper inom sitt utbildningsområde. För närvarande finns det ännu ingen miljö som samtidigt främjar samarbete mellan de främsta aktörerna inom genomik och som fullt ut stöder nödvändig kunskapskapitalisering inom samma område.

CapExBio projektet är ett projekt som försöker ta fram en sådan kooperativ, kunskapkapitaliserande, arbetsflöde-miljö. Syftet med detta examensarbete är att initiera designprocessen av denna specifika miljön och målen är att:

1. Titta närmare på de begränsningar av projektplan och vid behov utföra så kallad scope creep managment
2. Utvärdera systemdesignsstrategier och inrätta en uppsättning metoder som designprocessen kan ses
3. Initiera designprocessen

Allteftersom projektet framskred var scope creep management tvunget att utföras för att anpassa projektets utformning till vald designmetod, Användarcentrerad systemdesign. Valet av metodik gjordes baserat på kunskap om de två största och viktigaste inriktningarna inom systemdesing, Usability Engineering och Interaction Design. Projektgruppen utvecklade en första uppsättning av modeller baserade på djupa litteraturstudier. Bristfällig projektledning och brist på användarmedverkan visade sig vara den största utmaningen för forskningsgruppen när andra iterationsomgången skulle inledas. Användbarheten och nyttan av slutprodukten kan säkras och stödas till fullo, och projektets framgång maximeras, om projektgruppen sätter mer fokus på projektledning och användarnas medverkan. God användbarhet och nytta kommer att ge den bästa effekten på marknaden och bland dess framtida användare, och programvaran kommer att fungera som en stark marknadsförare i sig via ryktesvägen.

Nyckelord

Användarcentrerad systemdesign, bioinformatik, datorstödt kooperativt arbete, genomik, intresse-community, kunskapskapitalisering, människa-dator-interaktion.

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1 Introduction

This section contains the introduction to this diploma work. Here you will find a contextualization of the CapExBio project, as well as a brief description on why how and why this diploma work and the CapExBio project are relevant for developing and facilitating work within the genomics community. In the final paragraphs of this chapter I will put my diploma work and the objectives of my research in context.

1.1 Life Science and Bioinformatics

Much focus within biological research today is on genomics and post-genomics characterized by mass production of scientific data. Research centers and institutions, as well as small local, and big international companies, are driven by the scientific and/or the monetary aspects of this specific field of study. Data and results are produced within genomic projects everyday thanks to increasingly powerful, innovative and fast computers and software. Furthermore, the genomics community is, at the same time, faced with a proliferation of bioinformatics programs. Hence, there is a need for environments that offers simplified access to resources, is freed from computational barriers, and where the various actors within the field of biology can be given room to develop and improve their processes and enrich their knowledge within their field of study. There are several so called workflow systems[1] providing these services. However, as of now, there is yet no single workflow environment that supports cooperation among the primary actors within the field of genomics and that fully supports the necessary capitalization of knowledge within that same community. (Tiwari and Sekhar)

1.2 CapExBio

CapExBio, an abbreviation for Capitalization of Experimental Bioinformatics Knowledge, is such a cooperative, knowledge capitalizing, workflow based framework being developed in a joint venture between TELECOM Bretagne (former ENST Bretagne) and Station Biologique de Roscoff. Previous cooperative work between these two institutions and the OUEST-genopole group resulted in the workflow environment BioSide which federate and access bioinformatics programs, and BioDescription which helps bioinformaticians to describe their programs. However, BioSide and BioDescription are is not cooperative environments and do not support the sought for capitalization of knowledge.

Thus, the two main objectives of the CapExBio project are to create an environment that can:

1. Support the actors when cooperating in developing workflow processes for analysis of their data

[1] "A workflow system … is a holistic unit that defines, manages, and executes workflow processes aided by software" (Tiwari and Sekhar 306)

2. Help the users to capitalize and share learning of workflow process creation and the programs available within the field of genomics by describing them in terms of their field of work.

1.3 Problems, Aims, Questions and Goals

However, in order to fulfill these two objectives the CapExBio project team must overcome some obstacles. These obstacles can be both scientific, such as description templates and aspects of cooperation, as well as technical, like analyzes of ownership patterns or rejections of mediation tools.

The project spans over three years and this diploma work is taking place in the second half of the first year. The aim of this diploma work is therefore to initialize the system design process of a computer supported cooperative work environment that supports the users, independently of their work domain, when analyzing genomics data and capitalizing knowledge.

In order to fulfill that aim one must ask oneself: What are the constraints posed on the project? How does the diploma work fit in to the CapExBio project? How does one approach system design in order to increase the possibility of having a successful project and product? What cognitive aspects influence the actors within the genomics community in their work? Thus, the goals for this diploma work are to:

1. Look more closely at the constraints of the project plan and, if necessary, make alterations
2. Evaluate system design approaches and set up a set of methods with which the design process can be approached
3. Initiate the design process

1.4 Disposition

Since this paper is all about initiating the design process of the CapExBio a good starting point is to look more closely at the project plan and what risks it pose on the design process. This will be discussed in the second chapter. In the third chapter, the two main approaches to system design, Usability Engineering and Interaction Design, are discussed. The User Centered System Design process, which is based on a combination of the two, will also be presented in chapter three. The initialization of the design process based on the learnings from preceding chapters will be dealt with in chapter four. In the fifth, and final, chapter I will discuss the project evolvement and conclude whether I have succeeded or not in attaining my objectives. I will also give some remarks for future work within the CapExBio project

2 The CapExBio Project

It is always important to discuss the constraints that the project plan pose on the design process. This is especially true for the CapExBio project which was initiated and planned without any concern to system design aspects. Project goals, deliverables, project schedule, user involvement and risk assessment will therefore be presented in this section.

2.1 Positioning

The intention of launching the CapExBio project is not to become yet another typical workflow system provider. As mentioned earlier, there is yet no single tool that supports cooperation and knowledge capitalization among the primary actors within the field of genomics and workflow processing. This opens up for this project to give the users added value and a richer user experience. However, in order to be able to successfully provide these new functionalities on top of the general workflow system setup, the development team needs to study previous research within the field of cooperation and knowledge capitalization and perform extensive user studies.

2.2 Sponsor

The CapExBio project is a part of the regional priority “Génomique et post-génomique, bioinformatique”[2] (Thematic Sciences and Emerging Technologies and Interfaces) sponsored by the OUEST-genopole® and Brittany Regional organism.

2.3 Scope

The Canadian hockey player Wayne Gretzky once said: "A good hockey player plays where the puck is. A great hockey player plays where the puck is going to be." It shows the importance of defining ambitious and valid goals towards which the team can work. It is a quotation applicable on system design as well as on ice hockey. The goals define the focus of the project and without clear goals the system design will never be fulfilled, or, preferably as Gretzky tries to put it, exceed the expectations of the sponsors and stakeholders.

The CapExBio project has five separate goals stated in the contract. However, these goals should rather be interpreted as a critical path of the project; they are milestones in chronological order. The goals are:

1. Defining and producing patterns adapted to the various metadata types of actors in the field of biological data treatment.
2. Studying and modeling of political cooperation between different actors working with biological data processing studies. This study includes two parts; a computer

[2] “Genomics and post-genomics, bioinformatics” (English translation)

component and a sociological component. These studies should lead to both models, as well as to the production of reusable software components that offer services corresponding to indexing and collaboration.

3. Production of a new environment that implements / use the indexing and collaboration schemes established above. The aim is to have at the end of the project:
    a. A means of describing multi-views of bioinformatics resources for each category of actor;
    b. A cooperative platform design and treatment of these resources.
4. Evaluating the new environment as part of a study conducted at CNRS in Roscoff within the field of molecular phylogeny. The sociological aspect of the evaluation will focus on analyzing the process of appropriating the tool by researchers.
5. Promoting the work from both a scientific and a technological point of view.
    a. From a scientific point of view, the project should lead to recognition of partners on an international level, as well as its ability to bring the new concept of a bank of experimental protocols.
    b. Technically (or industrially), it should allow a wide diffusion and exploitation of the platform produced within the studied community. (Picouet 10-11)

2.3.1 Scope creep management

The lack of a well defined scope with one defined goal and clear management has led to dispersed focus within the project team. Problems with getting the necessary focus on the design process and the importance of usability[3] and real user involvement is problematic. The risks posed on the system design process and the overall success of the project will be discussed in section 2.7 Risk Management. Made alterations to the initial project plan due to risk management will also be discussed in section 2.7.

2.4 Project Schedule

In order to accomplish set goals the project was divided into three different phases, each of them spanning over one year. The purpose of the first phase is to locate and evaluate mechanisms for indexing and publishing software resources in accordance with the genomics community. The focus of the second phase is on modeling and implementation of mechanisms for representation and design of cooperative processing of workflows. Finally, in the third phase evaluation of the second prototype is to be performed and finalization of the production of a robust software tool, deployed within the OUEST-genopole group.(Picouet 11) For a more detailed project schedule see Gantt chart, Appendix 1: Initial

[3] In this thesis usability will be referred to as "the extent to which a product can be used by specified users to achieve specific goals with effectiveness, efficiency and satisfaction, in a specified context of use" (ISO 9241-11)

Project Schedule. The task description is in French and note that the project start has been postponed six months.

The initially proposed project schedule creates, from a system design point of view, several problems due to its incremental design process. In its original form the project schedule was function based with parallel increments, which could be interpreted as a heritage from the preceding BioSide project where the different parts of the system is strictly function based. One of the first things to address within the CapExBio project was how the initial project schedule and system design method could be merged with each other. Some small adjustments to the project schedule could be done to make the project's evolution more compliant with the system design process

2.5 Available Resources

The project organization and available resources creates the play ground on which the CapExBio environment is to be created. It sets the limitations of the project and affects the risk perception and system design. The team of researchers participating in the CapExBio project is localized at TELECOM Bretagne and Station Biologique de Roscoff. Short descriptions of the team members' history and field of study, as well as role within the CapExBio project, can be found in the following two sections. Note that all team members have other commitments on top of this project.

2.5.1 TELECOM Bretagne

Philippe Picouet is associate professor at TELECOM Bretagne and project manager for the CapExBio project. Picouet is specialized in the area of databases, and is the initiator of the BioSide draft. Philippe Picouet focuses on models of representation of meta-data in collaborative environments.

Philippe Tanguy is research engineer at TELECOM Bretagne. Tanguy has a MSc. in Information Technology Engineering and focus on computer languages, such as java and html. He is also specialized on database based software development. Philippe Tanguy is, together with Sébastien Bigaret, responsible for the software development within the CapExBio project. Tanguy is also responsible for students taking part in projects connected to the CapExBio project.

Sébastien Bigaret is together with Philippe Tanguy responsible for the software development within the CapExBio project. Bigaret has a MSc. in Computer Science and Information Technology Engineer and holds a position as Research Engineer at TELECOM Bretagne. Bigaret is specialized on software development and architecture. Main languages are C, Python and Java. Beyond the CapExBio project Sébastien Bigaret is also responsible for the ATOL (Aeronautics Technical Operational Laboratory); a joint venture between TELECOM Bretagne and THALES Airborne Systems.

Frédéric Cadier is post-doc at TELECOM Bretagne. Cadier has a MSc. in Information Technology Engineering and he finalized his PhD. on “Cognitive models for decision support systems” in late 2007. Frédéric Cadier is specialized on how to integrate cognitive constraints into support systems. Within the CapExBio project, he has focused on establishing models of activity and resources. Cadier will be the responsible for future user and work task analyses within the CapExBio project.

Magnus Larsson is finalizing his MSc. in Socio-Technical Systems Engineering at Uppsala University, Sweden, with this diploma work at TELECOM Bretagne, France. He also has a BSc. in Business Administration from Uppsala University. Larsson has focused his studies on Human-Computer Interaction in general and system design in particular. Within the CapExBio project, Larsson is responsible for the initialization of the system design process.

2.5.2 Station Biologique de Roscoff

Xavier Bailly is biologist and researcher in molecular genetics and evolution at Station Biologique de Roscoff (SBR). He is actively involved in the production and application contexts expertise used in the specification and valuing of BioSide.

Erwan Corre is working with bio-analysis at IMIS, SBR, and is responsible for the deployment of the CapExBio platform at SBR.

Gildas Le Corguillé is a bioinformatics engineer at SBR. He has a Master 1 in Biochemistry and a Master 2 in Bioinformatics and Biotechnology. Gildas works at SBR’s bioinformatics service as bio-analyst. Within the CapExBio project Gildas is in charge of the development of the BioSide community and acts as a consultant within bio-analysis.

2.6 User Involvement within the CapExBio project

Google Inc., the world’s most recognized brand, states on their homepage: “Focus on the user and all else will follow” (Google, Inc.). Even though there is a lot more to it, they have nailed down the fundamental aspect of a success. It is important for the CapExBio project to find ways to involve users at all levels of the development/design process in order for the project to be successful.

According to Gulliksen and Göransson it is important to try to maximize the diversity within the group of user participants. (Gulliksen and Göransson, Användarcentrerad systemdesign 291) Additionally, one would also want to have at least two user participants present at any one time throughout the system design process. The users will then be given the opportunity to discuss features, solutions and tasks among each other. However, due to external constraints, such as time, distance, politics, et cetera, the group of user participants is very limited.

Furthermore, Frédéric Cadier's studies have also shown that one person can have knowledge within more than one of the mentioned work domains. Thus, some of the users will represent more than one user group. This could be seen as posing a risk on the design process due to conflicts of interests between the different work domains. Nevertheless, it is a part of the users everyday work life and should therefore not be considered troublesome but rather important to take into account.

Thus, the biggest problem, as far as the CapExBio project is concerned, is the degree of user involvement. The lack of representative users creates a set of risks that needs to be addressed. More about these risks in section 2.7, below. The initial iteration will therefore be based on more general theories on cooperation, knowledge capitalization and community structures, where as the second iteration will be focused on the genomics communities preferences within the mentioned areas.

2.7 Risk Management

According to the Standish Group, the majority of information system projects never reach their goals. The 2007 "First Quarter Research Report" show that "35% of projects are successful, 46% are challenged[4], and 19% fail." (The Standish Group) . The lack of user involvement and top management support is pointed out as the two main sources for these high failure rates. (Aidemark 5) However, the risks can also be everything from time/space issues to external, such as politics. Thus, when working with IT projects it is always of outmost importance to take risks into account. Ignoring the risks will not make them go away.

The CapExBio project is without any defined project management structure and the lack in communication thereof is evident, and so is the lack of user participants. These problems as starting position do not bode well for the system design process and the overall progress of the project. In this section the different risks will be discussed.

2.7.1 Contractual issues

The contract is based on expectations on academic results rather than software development which give the system design process a set of limitations. These limitations will be discussed in this section.

2.7.1.1 Time, milestones and deliverables

The deadline for the CapExBio project is set to late June, 2010. Before the due date the project team needs to fulfill set milestones and deliverables. The Standish Group stated in their 1994 CHAOS report that the biggest key to project success is user involvement. (The Standish Group) Even though criticism towards the criteria of what makes a successful

[4] By "challenged" the Standish Group refers to projects that exceed time or budget, or that do not have the right features.

project has been discussed on internet forums and blogs, the Standish Group's research is still valid for the CapExBio due to its strict funding and time restrictions. However, the user involvement is something that the project team can affect. Thus, in accordance with the UCSD model and recommendations from both the Usability Engineering and Interaction Design communities, only relying on theories and models when designing the system is not the right way to go. The models should only be considered as a starting point, and nothing else. Due to the academic approach to the project too much focus is on the models, which pose a risk to the environment's usability and user focus, and sequentially, its success.

As of now, the main focus within the project team is to finalize the beta version of BioSide, the predecessor to CapExBio, and to produce models for the academic community. The strict focus on finalizing models and publishing papers have to some extent alienated interested parties from the main objective; to produce a scientific workflow management system for the genomics community. The strict focus on these deliverables has led to dispersed objectives and lack of communication. Crucial user and domain expert participation have gone lost due to this. The models, the cooperation, the resource and the workflow model, will be the basis for crucial decisions on design propositions in accordance with the contract. The design process is therefore dependent on the models and a delay in the production of the models will affect the system design process. However, the lack of project management, user participation and a big focus on models does not bode well for the success of the project. The project will not exceed its budget or time frame, but the risk of not delivering a system with the right features is of concern.

In order to minimize this risk of delays it is very important to minimize the risks of absent users and team members as discussed earlier. Furthermore, a good idea is to introduce short meetings of half an hour/one hour every Monday morning. The focus of the meetings should be on what each team member have planned to do that week. This way it is easy for the project manager to keep track on the progress, the other team members can get an understanding for his part in the project and how his work relates to the others' work, constructive criticism and expertise sharing can be shared and it is easier to streamline the project towards one major goal.

2.7.1.2 Funding

The funding of a project is always a big issue. In this case the budget is very limited and as a result it is impossible to tie additional team members to the project. However, by introducing the concept to potential investors and stakeholders it is possible to expand the projects budget. Hence, introduce new project members to the CapExBio project team. Furthermore, no discussions related to administrative issues of the environment after rollout have been held either. One approach that could solve the problems with funding and administration after rollout, as well as some difficulties with the system design, is a partnership with, for instance, Google, Inc. Google invests time and money in new innovative projects, such as bioinformatics projects. They would be a suitable partner for the project and could help with funding and more man-hours devoted to the project. Furthermore, Google produces state of the art information systems technology and solutions, such as the PageRank Technology and Hypertext-Matching Analysis. (Google, Inc.) No one in the CapExBio team has any knowledge in search construction and appropriate contextualization of information. Thus, setting up a series of partnerships with companies, like Google who can contribute not only with monetary value, but also with knowledge in search, scalability, server capacity, security, et cetera, the funding of the project could be secured before and after rollout of the environment.

2.7.1.3 Legacy and brand-identity issues

The CapExBio project was meant to be an extension of the BioSide project, and inherit several features from the preceding development process. However, there are some legacy and brand-identity issues surrounding this approach. On the legal side, the name BioSide is trademarked since 2003 which means that the environment no longer can go under that name. Due to this, it is important that a new name, which must be compliant with the intended brand identity, is proposed. It is also important that the brand identity complies with the way the users want to be perceived and the feel they want to get when using the environment. The name needs to be internationally marketable as well. One proposition that stand out among the others is BioDesktop. More time needs to be put on trying to create a good brand identity. Furthermore, the branding of the new application is held back by the previous BioSide project. When discussing the project, the majority within the project team refer to BioSide, which creates unnecessary confusion. The strong linkages to the previous project and its design create unnecessary limitations to the creative thinking of the group. This is especially a big problem because the previous design is not based on any user input.

2.7.1.4 Usability versus Functionality

There are not only contractual issues that affect the degree of usability. Finn Kensing, IT University of Copenhagen, Denmark, has been quoted saying:

> *"One reason so many large, important systems are not being used, or that users h*ave to work around the system to get the work done, is that the programmers didn't understand what the *users were doing. They develop the application according to their own interpretation."*
> (Usability Professionals' Association)

The same concern is brought up by Gulliksen and Göransson. They suggest that the system designer should be present throughout the whole life cycle of the software and secure the users' needs and the usability of the system. Furthermore, they suggest that the developers should spend time with the future users, and participate in the design process and contribute with input and gain new knowledge about the users and their needs. It is not uncommon that new functionalities enabled by new technology get more focus than the actual needs of the users during development processes. When time and money become an issue, functionality often become more important than usability, which is very unfortunate. Recent studies have shown that a solid focus on usability lead to "increased productivity, decreased training and support costs, increased sales and revenues, reduced development time and costs, reduced maintenance costs, [and] increased customer satisfaction“ (Usability Professionals' Association). One should therefore not be too hasty to disregard the usability aspects when time is running short. It is the easy way out for a development team to focus strictly on functionality.

2.7.2 Project team

Even though the users make up the biggest risks, the team members also pose a set of critical risks on the project’s evolution and success. In the following subsections will the major risks related to the project team be presented and discussed.

2.7.2.1 Absence of team members

Financial constraints as well as the team members additional work obligations outside the CapExBio project make the project very sensitive to any kind of absence. Every team member has a key role within the project, which creates problems with long holidays, illness, or if the members’ other obligations takes too much time into account. As of now, there are no evident solutions to these problems. However, the team members are well aware of the situation and work to minimize any absence. Nevertheless, the time aspects can be seen in the lack of team meetings and briefings due to lack of time on everyone’s behalf. This affects the quality of the projects execution and any further absence will create big problem for the already strained project.

2.7.2.2 Dispersed project team

The fact that the project team is dispersed elongates the design process even though we live in a highly digitalized world; the domain experts are located in Roscoff and the development team in Brest. Due to problems with getting user participants for the different steps of the design process, the domain experts input are more and more important. It the only connection to the work domain the CapExBio project tries to aim.

2.7.3 Users

In the CapExBio project one of the biggest risks involve the users and their participation. It has become clear as the work progresses that the project’s success mainly depends on how the users and their involvement are being handled. This finding complies too well with the research of the Standish Group.

2.7.3.1 Absence of user participants for the different iterations

Due to the small number of users there is a major concern whether or not absence of end users can be handled. Holidays, illness as well as the end users own work load are issues the CapExBio project team do not have control over. The fact that the end users and project team are dispersed adds further complexity; end user participants have been sought at

Station Biologique de Roscoff and at IRISA[5], Rennes. Additionally, according to the project plan the actual specification parts are very short and intense, which increases the risk of delayed deliverables if the user participation is not dealt with. The strong linkages to an incremental design approach add further complexity.

User feedback can be summarized as:

- The end users do not see how they would get the time for another involvement on top of their other commitments.
- The end users do not see how their participation would alleviate and enrich their work situation in the long run.

Therefore, it is important for the CapExBio project team to find alternative ways of approaching the end users. It is imperative for the projects progress to get the vital user participation.

One approach that could be of interest is to make greater use of the domain experts at Station Biologique de Roscoff when collecting data on the end users and their work tasks. It has shown to be easier for the domain experts involved in the project to approach and get the necessary help and involvement from the end users than it has been for the TELECOM Bretagne team. The differences in background and language discrepancies, as well as the understanding for each other's work may be the root for this change of attitude by the end users. Thus, by making use of the relationship between the project team's domain experts and their relation to the end users a maximization of user participation is possible.

This approach opens up for several opportunities as well as potential problems for the project's success. On the one hand, the domain experts speak the same language as the users and can set up a common ground with the interviewee. They can also find things that might not come up for discussion if one of the TELECOM Bretagne team members performed the interviews. Furthermore, the domain experts work closer to the end users and can observe them as they work more closely and in a more informal setting. This can have positive effects on the collection of data for the design process. On the other hand, they do not possess the knowledge of software development and the methods used within the project. This might lead to information disequilibrium. There is also the risk of the interviewee modifying their answers to what he/she believes the interviewer is looking for if they know each other. However, that risk is very small compared to the risk of not having any end user participation at all. The domain experts have been given a hand-out in order to learn more about the development process. They have also been asked to monitor their fellow colleagues as they work and report back in accordance with the given instructions

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[5] IRISA is a research unit working within information and communication science and technology. <http://www.irisa.fr/home_html>

(see Appendix 3: Hand-out to Domain Experts at SBR). However, due to vacations no results from this approach have been reported back and evaluated. It will be up to the development team to look closer at this when the vacation comes to an end.

Another interesting approach is to try to make use of research institutions closer to the development team; think global, act local. There are several institutions conducting biological research within the Technopôle Brest-Iroise area that could take part in the design process. Examples are Ifremer[6], ESMISAB[7] and ENIB[8]. The idea is to create an environment for expert scientists which make it important to find representatives from that group of future end users. However, domain experts have also pointed out the importance of being able to use the environment to educate future expert scientists. Consequently, even though the interest is on keeping a strict focus on the present experts and their work, the use of novices within the workflow field should also be considered. According to user studies prior to the CapExBio project, the end users, even though they are considered experts within their field, are lacking in workflow related computer skills. This is especially evident for the pure biologists. (Cadier, The CapExBio project) Thus, by combining study of expert scientists and novices the project can exceed its goals and like Gretzky would have put it: Play where the puck will be.

2.7.3.2 Degree of project involvement

It is important to keep a distance between end users, work domain experts and team members. According to Gullikesen and Göransson, it is easy for an end user, participating extensively in a project, to go from supporting and protecting the needs of his/her peers to consider him-/ herself as a part of the development team. (Gulliksen and Göransson, Användarcentrerad systemdesign 221) The combination small amount of user participants and a project spanning over three years might lead to the user participants identifying themselves with the team members. This will create problems trying to gain relevant and valid information from the end users. Furthermore, the work domain experts involved have strong linkages to the CapExBio project and project team which creates further complexity when trying to keep a solid user focus.

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[6] Ifremer is an abbreviation for "Institut français de recherche pour l'exploitation de la mer" (eng. "French Research Institute for Exploitation of the Sea". < http://www.ifremer.fr/francais/index.php>

[7] ESMISAB is an abbreviation for "Ecole Supérieure de Microbiologie et Sécurité Alimentaire de Brest" and is a part of University of Brest, Western Brittany. <http://www.univ-brest.fr/esmisab/esmisab/>

[8] ENIB is an abbreviation for "Ecole Nationale d'Ingénieurs de Brest". < http://www.enib.fr/>

3 System Design

Within system design there are two main approaches for securing the usability of a system. The first, Usability Engineering, focuses on evaluation of the usability of systems, and the second, Interaction Design, is a process description with the purpose of showing the key activities of the development process. Under the following two subheadings a brief description of the two approaches to usability will be given. These two approaches are often, more or less, combined in different user centered system development methods. In Jens Rasmussen's Cognitive Work Analysis (CWA) strong connections can be made with Usability Engineering, while in Hugh Beyer and Karen Holtzblatt's Contextual Design Process strong links can be done with Interaction Design. However, in this project the User-Centered System Design approach will be used. It is based on both Usability Engineering and Interaction Design and it can be seen as a bundle of different methods whose purposes are to secure the user focus and usability of the system to be developed. The user-centered system design process will be discussed in the method description, section 3.3. In the following two sub-sections, we will look more closely at Usability Engineering and Interaction Design, and their characteristics. This will give a bigger understanding to usability and the usefulness of User-Centered System Design, which will be discussed under the third and last sub-sections.

3.1 Cognitive and Usability Engineering

When a human wants to perform a task her goals are expressed in psychological terms, whereas the computer's current state, the one to be manipulated, is expressed in physical terms. Evidently, these two states differ both in form and content. The innate discrepancy between the psychological and physical variables is thus of major concern when designing usable systems. (Norman, Cognitive Engineering 38) According to Donald A. Norman there are two ways one can shorten the gap between the user and the system, and that is to either move the user closer to the system or move the system closer to the user. (Norman, Cognitive Engineering 43) Shorten the gap between the extremes is done, in the terminology of Cognitive Engineering, by "providing a good, coherent design model and a consistent, relevant system image" (Norman, Cognitive Engineering 45) The design model should be based on the user's task, requirements and capabilities, as well as the user's background, experience and cognitive powers and limitations. (Norman, Cognitive Engineering 47) The user's mental model is based on how the user interprets the system image, so by manipulating the system image it is possible to make the design model and user model approach each other and at the same time make the user understand the system she manipulates. For an illustration of Norman's viewpoint, see Figure 1, below.

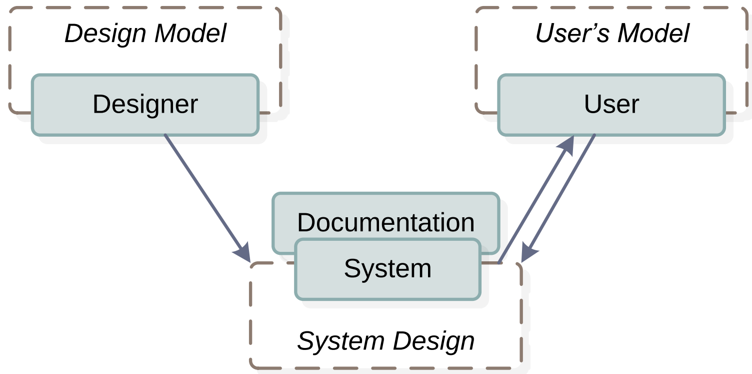

Figure 1: Abstraction of Human-Computer Interaction (Norman, Cognitive Engineering 46)

Thus, in order to make the system enjoyable the deliverance of a powerful tool is of the essence. By facilitating the user's skills and control over the work performed, and not turning it into a "systemized workplace", the system will gain attractiveness and make it more usable and useful. (Norman, Cognitive Engineering 52-53) This statement by Norman also complies well with Activity theory's look upon a system. That is, not as a container of the activity, but rather as a participant of that same activity.

Two important prescriptions for design stated by Norman are to "[s]eparate the design of the interface from the design of the system" (Norman, Cognitive Engineering 60) and to "[d]o user-centered system design: Start with the needs of the users" (Norman, Cognitive Engineering 61). This described way of approaching usability, Cognitive Engineering, is the foundation of Usability Engineering, in which field Norman and his well recognized colleague, Jakob Nielsen[9], are authorities. Today advocates of Usability Engineering "engage in task analysis, then prototype interface designs and conduct usability tests". (Gulliksen and Göransson, Användarcentrerad systemdesign 121-122) Thus, what Usability Engineering boils down to is quantified analysis and assessment of usability. It is however important to recognize Norman's recommendation to look into user-centered system design when developing systems. Another related field of study, Interaction Design, looks more at processes and practices for developing interactive systems, therein included computers.

3.2 Interaction Design

Interaction Design is an approach that aims to "reduce frustration and increase productivity and satisfaction" (Wikimedia Foundation, Inc.) for the users when using the technology to be produced. The foundation of Interaction Design is based on cognitive psychology and

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[9] Jakob Nielsen holds a Ph.D. in human-computer interaction from the Technical University of Denmark in Copenhagen. Nielsen founded the "discount usability engineering" movement for fast and cheap improvements of user interfaces and has invented several usability methods, including heuristic evaluation. He holds 79 United States patents, mainly on ways of making the Internet easier to use.

iterative cycles of user research. Through these surveys and knowledge in human cognition the designers can understand the user's needs, goals and work experience.

The general steps in an Interaction Design process are:

1. **Design researches** where observations, interviews, questionnaires, et cetera are used to investigate the users and their environment.
2. **Research analysis and concept generation** where the designers through brainstorming, discussion and refinements based on knowledge drawn from user research, business opportunities and technological possibilities try to create concepts for new software, for instance.
3. **Alternative design and evaluation** is the phase in which the designers put together crude prototypes on paper of alternative solutions to the problem space. Tools such as wireframing (also known as "schematics") and flow diagrams are popular. The solution should not be the final solution, but a solution that for the moment solves as many of the user requirements as possible.
4. **Prototyping and usability testing** is one of the most useful ways to test usability and see whether the design fulfills the requirements. Iterations with the users help to trim the system and the role of the artifact, its look-and-feel and implementation can be evaluated.
5. **Implementation** is a phase where the interaction designer needs to be present as well as ensure that what was designed is implemented correctly. Furthermore, if changes need to be made during the building process the interaction designer should be involved.
6. **System testing** is often done in order to catch bugs, but also for testing usability. It is preferable if the designer is a part of this process as well as order to make modifications to the system if it is needed. (Wikimedia Foundation, Inc.)

Due to the fast evolvement and diffusion of technologies, advocates of Interaction Design have realized the importance of broadening their horizon. The insight that it is not enough to "just" make faster and more reliable systems, but that the systems nowadays also must satisfy desires and needs of the user, have resulted in a series of attempts to approach the fields of Usability Engineering, human cognition and psychology. UCSD, as mentioned earlier, is such an approach. It has the thought through process that secures the user involvement in the project development, but also the focus on evaluation and iteration that is needed to get a sound balance between system functionality and system usability.

As mentioned earlier Norman, one of the big authorities within the field of Usability Engineering, advocates a user centered system design approach. He claims that only relying on Usability Engineering is not sufficient enough for delivering usable and useful systems. According to Jan Gulliksen and Bengt Göransson, one cannot only rely on Interaction

Design either; hence a deeper understanding for the usability aspects is of importance when designing systems.

A more result oriented approach is needed – a method for combining the two doctrines. This approach could be called User Centered System Design (UCSD) to which Usability Engineering contribute with knowledge about quantified analysis and assessment of usability, towards which the system then can be engineered (Gulliksen and Göransson, Användarcentrerad systemdesign 121-122), and to which Interaction Design contribute with "navigation, representation and information structuring of graphical user interfaces" (Gulliksen and Göransson, Användarcentrerad systemdesign 155).

3.3 User-Centered System Design

The UCSD process is an iterative process and the idea is not to come up with a one best solution, but rather to co-develop the environment together with the users in a series of iterations. Gulliksen and Göransson set up twelve principles for securing usability and user focus based on ISO standards and acknowledged research on the subject. These principles are:

1. **User focus** – the goals with the activity, the users' work tasks and needs shall be indicative throughout the development process.
2. **Active user participation throughout the development process** – representative users shall actively participate, early and continuously, throughout the systems whole lifecycle.
3. **Evolutionary development** – the system shall be developed iteratively and incrementally.
4. **Mutual and shared understanding** – the design shall be documented with a for everyone involved easy to understand representation.
5. **Prototyping** –prototypes shall be used early and continuously to visualize and evaluate ideas and design solutions with the end-users.
6. **Evaluate real usage** – measurable usability goals and criteria for design shall as long as possible control the development of the environment.
7. **Explicit and outspoken design activities** – the development process shall involve dedicated and conscious design activities.
8. **Cross disciplinary teams** – the development shall be executed by effective teams with broad range of competencies.
9. **Usability advocates** – experienced usability advocates shall be involved early and continuously throughout the development process.
10. **Integrated systems design** – all parts affecting usability shall be integrated with each other.
11. **Adapt the processes to local conditions** – the user centered process shall be specified, adapted and implemented locally in every organization.

12. **A user centered attitude** – a user centered attitude shall always be established. (Gulliksen and Göransson, Användarcentrerad systemdesign 110-113)

The principles are also summarized in Figure 2, below.

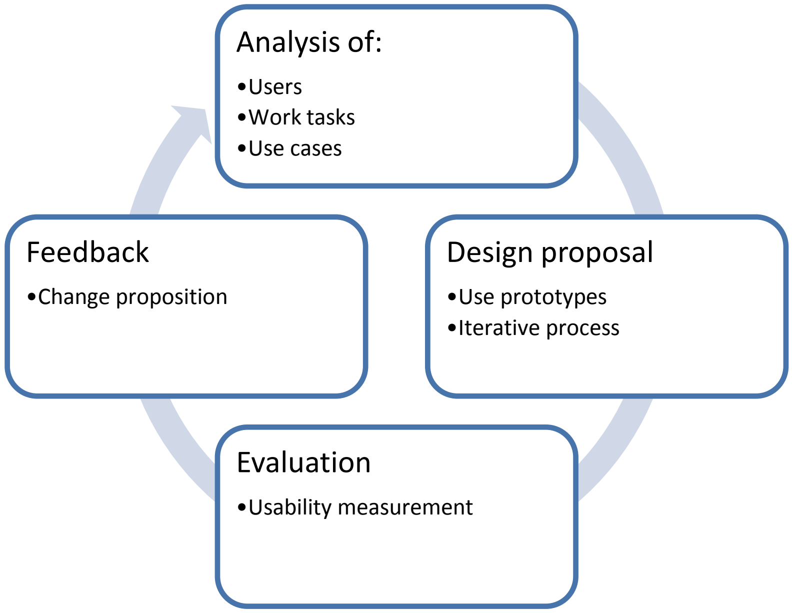

Figure 2: Iterative user centered process (Gulliksen and Göransson, Användarcentrerad systemdesign 109)

In the following sub-sections useful methods for analysis, design and evaluation will be presented. All these methods are appropriate for the CapExBio project. A more thorough description of these methods can be found in the book Användarcentrerad systemdesign by Jan Gulliksen and Bengt Göransson.

3.3.1 Analysis

In the following sections user and work task analysis, and the information usage analysis, will be discussed. These analyses help keeping the focus on the users and their work tasks.

3.3.1.1 User and Work Task Analysis

To begin with, it is important to understand that the system designer, or even the domain experts, is not the typical users of the system. The domain experts can supply important and vital information on the domain and field of application, but the most important information is the one retrieved from the users. To get an understanding of the users and their work tasks, one need to do user and work task analyses. There are different ways this can be done. For instance, Karen Holtzblatt[10] developed the Contextual Inquiry method which has gained a great deal of respect within the usability community. This method is a part of the Contextual Design Process and calls for "one-on-one observations of work practice in its naturally occurring context"(Wikimedia Foundation, Inc.). By participating and watching how the user does his/her work the researcher can get an understanding for the work to be done. Jakob Nielsen puts it this way: "[D]on't listen to what they [the users] say; look at what they do" (Nielsen, Extreme Usability: How to Make an Already-Great Design Even Better). This method is very well suited for the CapExBio project as it provides an insight into the users work conditions, user categories, informal organization structures, "tacit knowledge", use frequency, et cetera.

However, if it is not possible to take part in the users' everyday work life questionnaires can be used. (Gulliksen and Göransson, Användarcentrerad systemdesign 219-220) Nevertheless, using questionnaires increase the risk of missing out on valuable knowledge about the users and their work. Thus, questionnaires should not be used within the CapExBio project. Questionnaires are too formal and restrictive to capture the cooperation and knowledge capitalization within the genomics community. Furthermore, the work of developing reliable and usable questionnaires demands knowledge within behavioral science and neither of the project team members have the pertinent knowledge to produce such questionnaires.

3.3.1.1.1 User analysis

When doing the user analysis one needs to answer the questions: "What are the user categories, for whom is the system developed and what characteristics do these categories have?" (Gulliksen and Göransson, Användarcentrerad systemdesign 220) Gulliksen and Göransson propose some relevant questions, such as:

- What is the user*s' level of experience of the task to be performed?*
- *What is the users' educational background?*
- *What is the users' experience level with computers?*
- How much effort will be spent on training?
- Use frequency?
- In what environment will the system be used?
- Will there be users with physical disabilities? (Gulliksen and Göransson, Användarcentrerad systemdesign 221)

The result of a user analysis could be presented as user profiles or design recommendations, or act as a foundation for a requirement specification.

[10] Karen Holtzblatt is co-founder of Contextual Design and is CEO at InContext Enterprises that sell and develops the Contextual Design Process. She holds a PhD. in Applied Psychology (University of Toronto). Karen Holtzblatt has more than 20 years teaching experience both professionally as well as at University.

3.3.1.1.2 Work task analysis

If the user analysis answers the question of which user categories there are, then the work task analysis should answer what tasks the users perform, and how these are performed. Gulliksen and Göransson propose the following questions to exemplify:

- Why is the user performing a certain task?
- How often is this task performed?
- How long does it take?
- What steps or maneuvers are needed to perform the task?
- Does the user collaborate with another user?
- What tools or artifacts does the user need to perform the task?
- *Are there a lot of critical tasks or "bottle necks", which makes the task more difficult to perform?*
- How can the situation and the information support be improved? (Gulliksen and Göransson, Användarcentrerad systemdesign 222)

By making a thorough user and work task analysis, the amount of functions in the system can be held as low as possible which makes the system more easy to use. In order to have a successful user centered project the work task analysis is of outmost importance and it keeps the size and complexity of the system to a minimal. (Gulliksen and Göransson, Användarcentrerad systemdesign 222-223) Interesting here is the strong connections between the user and work task analysis and Activity theory.

The following best practice will be used when summarizing the data collected from the work task analysis:

- *Formulate the users' goals and milestones.*
- Always formulate a global goal with the whole interaction.
- Formulate the approaches to achieve the goals.
- *Make a breakdown into "width first"* – identify common work tasks.
- Stop the breakdown when the leaves in form of specific work tasks have been reached.
- Using pen and paper can make the work a lot easier, e.g. Post-It Notes. (Gulliksen and Göransson, Användarcentrerad systemdesign 224)

Usability goals, which can be followed up during the evaluation phase, should be formulated.

3.3.1.2 Information Usage Analysis

The information usage analysis is very important to conduct. It is not only necessary to analyze what information is to be used, but also how it will be used. As mentioned in the introduction to this paper, today, a lot of the work performed within genomics research is in some way connected to knowledge management or data treatment. Thus, it is important to create a system that presents information in a relevant way so the user's cognitive capacity is free for the actual work. The analysis can also help showing on functional adaptations that might be of use for the users. "It is an analysis which purpose is to describe which decision and assessment tasks are present in the work and how data is used to solve these tasks."(Gulliksen and Göransson, Användarcentrerad systemdesign 226) Together with one or several users from each user category the following activities have to be performed:

1. Make a general description of the work content.
2. Gather copies of, and describe all sorts of, information carriers that are being used.
3. Describe all management routines used with each information carrier.
4. Describe what decisions and evaluation tasks that are part of the work.
5. Describe what information amounts (variables) that are being used in each of the different decision and evaluation situations mentioned above.
6. Analyze the material for each decision and evaluation situation.
7. Describe concurrency demands on the data.
8. Information amount and variable properties.
9. What must be done, e.g. how the decision/evaluation is being documented.
10. Analyze the material in terms of what decisions and evaluation situations that needs to be done at the same time. This defines work situations. (Gulliksen and Göransson, Användarcentrerad systemdesign 226-227)

One question that arises is how to document the information retrieved from mentioned activities. In a document the following paragraphs should be listed:

- *A description of the work process of a "typical"* day, week, or another appropriate time unit.
- A list over work tasks
- A list over work situations[/contextualized work tasks]
- A list of variables with properties for each variable
- For each decision and evaluation: A list of used variables
- For each work task: What needs to be performed. (Gulliksen and Göransson, Användarcentrerad systemdesign 232-233)

By doing an information usage analysis important information about the users' work can be discovered. The information usage analysis can complement prior data models and can act as a good foundation for future design decisions. See Figure 3, below, for a more illustrative depiction of the relation between the three analyses.

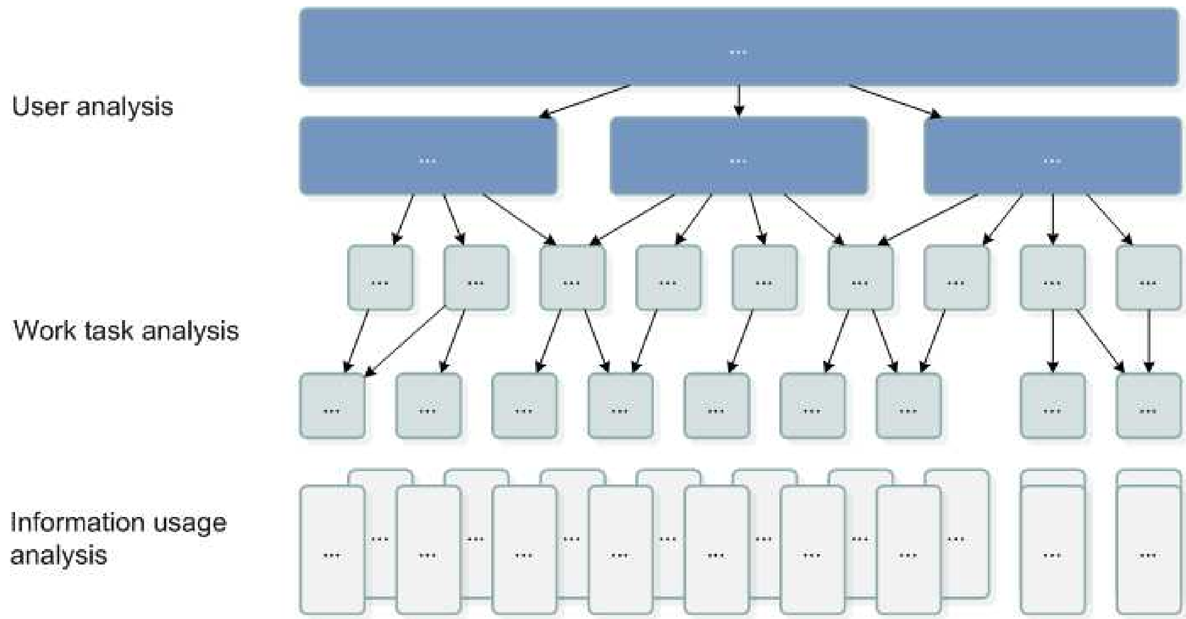

Figure 3: Illustration of the relation between the User, Work task and Information usage analyses

3.3.2 Design

In this section different approaches to design will be discussed. These are separate activities and some of them overlap each other. It is optional to use them, but at least some of them should be conducted during the design step.

3.3.2.1 Scenarios and Storyboards

Scenarios and storyboards are used to visualize design solutions. Scenarios can describe how the system should behave and how the users can solve tasks with the help of this system. The descriptions can be either written or drawn or a combination of the both. In a storyboard a series of scenarios can be combined to describe the work sequence. These scenarios and storyboards can be used as early prototypes and are preferably made with pen and paper. These early prototypes should be used to discuss the workflow with the users. By presenting different solutions, an early evaluation of the system can be made and a lot of time saved.(Gulliksen and Göransson, Användarcentrerad systemdesign 233)

3.3.2.2 Framing and Design

Paul Mijksenaar claims in his book Visual Function: an Introduction to Information Design that a design has three qualities; Reliability, Utility and Satisfaction. These qualities were already stated by the Roman architect Vitrivius over 2000 years ago who claimed that good design was held up by: Firmitas, Utilitas, Venustas. (Mijksenaar 18) This approach is also supported by Norman who points out the importance within Engineering of not only focusing on reliability or utility, but also on emotional values. (Norman and Ortony, Designers and Users: Two Perspectives on Emotion and Design)

Gulliksen and Göransson present five key activities in the framing and design process. These are by no mean sequential, and the designer needs to shift between the different states as the activities affect each other. The five key activities are:

1. **Understanding** – What is going on?
   Usable tools are: Pictures, notes, video clips and structured interviews.
2. **Abstraction** – What are the main parts?
   For documentation one can use sketches, charts, lists, et cetera
3. **Structure** – How are the parts connected?
   See to that the designer's view of the structure equals the one of the users'.
4. **Representation** – How can the structure be represented?
   Usable tools are rough sketches, paper prototypes and interactive prototypes.
5. **Detail** – What attributes should be used?
   Here the system designer might consider hiring an illustrator. (Gulliksen and Göransson, Användarcentrerad systemdesign 239-240)

Within Usability Engineering the advocates believe in the objectivity of design and usability. When working with user centered system design their formalism and structure is very important. However, combining this formalism with free design is the best solution for UCSD. By using the functionality of Usability Design combined with the designers experience the user focus and usability of the system can be secured. This leads us to the next section about Aesthetic Design.

3.3.2.3 Aesthetic Design

Aesthetic design is a topic hard to approach. It is not easy to define why some designs are appealing and others are not. However, areas that fit into the aesthetic design process are color, form, layout, typography, et cetera. For example the knowledge of how colors are perceived by the human eye or which fonts that are easy to read, et cetera. The aesthetic design process is important but making "finalized" prototype proposals too early in the development process might discourage further development. At an early stage the aesthetic design should rather focus on conformity of the system design, and later in the process the focus can be on forms and details. (Gulliksen and Göransson, Användarcentrerad systemdesign 241-242) Within the CapExBio project no use will be made of graphical designers or consultants. Within this project the use of already appreciated design features will be made.

3.3.2.4 Prototyping

Throughout the CapExBio project several prototypes will be made and evaluated. It is a very important part of the user centered system design process and is a place where system designers, programmer, IT architects and users can meet and discuss the system to be developed and by using paper sketches and prototypes to conform the view of what is to be produced. Then why is prototyping so important? Prototyping is a place where:

- New solutions can be explored
- Functionality tested
- Demands found
- Creativity to be trained
- Performance and look-and-feel tested
- Command sequences tried
- System development can be performed (Gulliksen and Göransson, Användarcentrerad systemdesign 243)

Through a series of iterative processes different design proposals can be evaluated and co-designed with the users. Some proposals might be discarded while other might be merged. One can start with notebooks, proceed to Post-It Notes, then drawings and finally try to make computerized working prototype which can be tried in a real setting. Help during this process can be the scenarios and storyboards which can guide and help to set up a series of different prototypes. Criteria lists can be of great help when creating larger systems. They support the design decisions during the prototyping. (Gulliksen and Göransson, Användarcentrerad systemdesign 246-250)

3.3.2.5 Contextual Prototyping

Contextual prototyping is very important, not only to get the users involved in the design process, but also to get the developers closer to the users and their work environment. This can be done by letting the developers participate at the work site; let them do interviews and create their own opinion. It is very important that all participants in the development team at least once have been out and met the users and seen them work. Gulliksen and Göransson recommend that at some time during the development process some of the design work moves out to the users' work site. This creates a mutual understanding and informal and spontaneous contacts between developers and users can occur. By involving users and creating rough prototypes early in the design process the limitations on usability and interface design can be minimized. (Gulliksen and Göransson, Användarcentrerad systemdesign 250-252) One way of optimizing the design process regarding usability could be to:

1. Specify the most common or most critical scenarios in the work process
2. Divide the development team and participating users into groups and let the groups develop mock-ups
3. Present and discuss the different approaches and together create one unified prototype. (Gulliksen and Göransson, Användarcentrerad systemdesign 252)

3.3.3 Evaluation Methods

This phase of the UCSD process is strongly linked to the theories and methods proposed by advocates of Usability Engineering. It is important to start evaluating the system early in the development process; the earlier problems are discovered the cheaper it is to correct them. Furthermore, it is important to involve the users. They can give invaluable input and show on areas of improvement that domain experts could not. Gulliksen and Göransson stress that:

> *"The evaluation process should include empirical measurement in which tests are conducted where users perform real tasks on prototypes. The users' reactions and attitudes sh*ould be *observed and analyzed."* (Gulliksen, Görnsson and Boivie 2)

Additionally, it is of outmost importance that the evaluation phase brings forth constructive criticism that can lead to a change for the better.

There are an abounded of evaluation methods. Gulliksen and Göransson present the following:

- User observation
- Performance related measurements
- Critical events
- Questionnaires
- Interviews
- *"Think loud"*
- Participatory design and evaluation
- Creativity methods
- Document based methods
- Model based methods
- Expert evaluation
- Automatic evaluation (Gulliksen and Göransson, Användarcentrerad systemdesign 256-257)

In the CapExBio project evaluation will be done with the help of user observations, critical events, interviews, "think loud", participatory design and evaluation, and creativity methods. In this way the user participation is kept at a maximum. However, these methods will not all be used at the same time. Depending on where in the development process the prototypes are, different methods will be used. By varying and combining different methods new problems can be found and by repeating previous tests one can validate whether or not errors have been fixed. However, it is of outmost importance that one try to approach the prototypes differently each time with the help of users in order to get a system that supports the users to the fullest.

4 Initialization of the System Design Process

The goal with the CapExBio project is to propose and develop a knowledge capitalizing, cooperative workflow environment for the genomics community. In order to fulfill this goal, the project team will make use of the UCSD process proposed by Gulliksen and Göransson. By doing so, the risks of not delivering a usable and useful system with the right features are kept to a minimum. However, due to extensive problems getting user participants, the design process had to take on a somewhat different approach in its initial phase than proposed by Gulliksen and Göransson.

The design process will begin with literature studies on subjects relating to the projects positioning. A general design proposal, only based on human cognition, will then be evaluated together with the project team and domain experts. The second iteration will then take its starting point in the feedback given by the domain experts and an initial mapping of the user domains made together with the domain experts. Future iterations should thereafter be solely based on the input from users and domain experts. (See Figure 4)

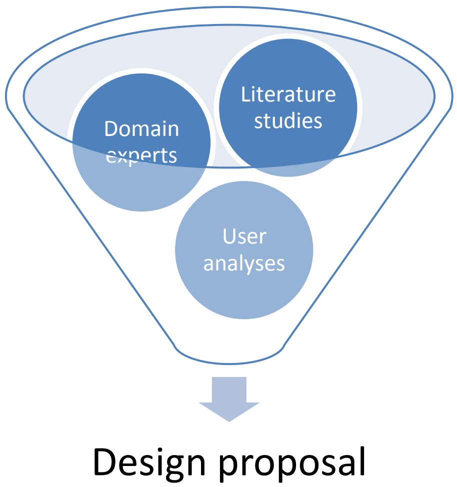

Figure 4: The three parts that make up the design proposal

This approach will help the project team to fulfill its deliverables stated in the contract, minimize lost time due to the initial lack of user participants, and finally, secure that all aspects relating to the positioning will be considered throughout the design process.

4.1 First Iteration: A Theoretical Stance

The first iteration is based on theories on human interaction; that is humans’ cognitive constraints and needs on interaction and not on the end users of the genomics community. By keeping a broad first approach, future iterations can be given a better focus and help trim the design proposals to more and more adequate and user focused propositions. The first iteration’s design proposal will therefore be lacking on relevant features and usability. That is however the intention. The focus is solely on knowledge capitalization, cooperation and community facilitation depicted in descriptive research papers.

4.1.1 Literature analysis

Participants
Frédéric Cadier
Magnus Larsson

To begin with, let us look more closely at the key issues for this project: Cooperative work and knowledge capitalization.

4.1.1.1 Cooperative work

> *"Great discoveries and improvements invariably involve the cooperation of* many minds!*"* (Alexander Graham Bell, Scottish born American inventor)

According to Gerhard Fischer[11], "the complexity of design problems requires communities rather than individuals to address, frame, and solve them" (Fischer 152). However, the most common definition of cooperative work is "work of a group", where the term group is seldom defined and, thus, a basic unit to week for analysis. According to Kari Kuutti[12] there is a need for defining the basic unit for analysis of Computer-Supported Cooperative Work (CSCW) if a more accurate understanding of the process is to be found.

Kuutti defines CSCW, based on the most common definitions on the subject, as "work by multiple active subjects sharing a common object and supported by information technology" (Kuutti, The concept of activity as a basic unit of analysis for CSCW research 252). According to Kuutti, there are some aspects that need to be fulfilled for CSCW and these aspects must be supported by the basic unit. The aspects of CSCW that needs to be fulfilled are:

1. Work is mediated by artifacts and the basic unit should have this aspect too.
2. The unit should allow consideration of socially constructed meaning and cultural aspects of a work situation.
3. Work and the means for it are continuously reconstructed, and thus the unit should be suitable for studying transformation and development.
4. To assist accurate analysis, the unit should have detailed internal structure.
5. It should also be possible to consider topics of control and conflict within the unit. (Kuutti, The concept of activity as a basic unit of analysis for CSCW research 255-256)

A concept like activity fulfills these different needs, and is a concept thoroughly discussed in Activity Theory. An activity has a set of properties, which are:

- An activity has a material object and activities can be distinguished according to their objects.
- An activity is a collective phenomenon.
- An activity has an active subject, who understands the motive of the activity.

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[11] Gerard Fischer is the director of the Center for Lifelong Learning and Design, a professor in the Department of Computer Science, and a fellow of the Institute of Cognitive Science, all at the University of Colorado, Boulder. <http://l3d.cs.colorado.edu/~gerhard/>

[12] Kari Kuutti holds a professor's title at the Laboratory of Human-Computer Interaction and Group Technology, Department of Information Processing Science, University of Oulu, Finland. He is also a member of the Advisory Board of Center of Activity Theory and Development Work Research, University of Helsinki, Finland.

- An activity exits in a material environment and transforms it.
- An activity is a historically developing phenomenon.
- Contradictions are the force behind the development of an activity.
- An activity is realized through conscious and purposeful actions by participants.
- The relationships within an activity are culturally mediated. (Kuutti, The concept of activity as a basic unit of analysis for CSCW research 255-256)

These properties were visualized and given a relation to each other in Yrjö Engeström's systematic model from 1987.

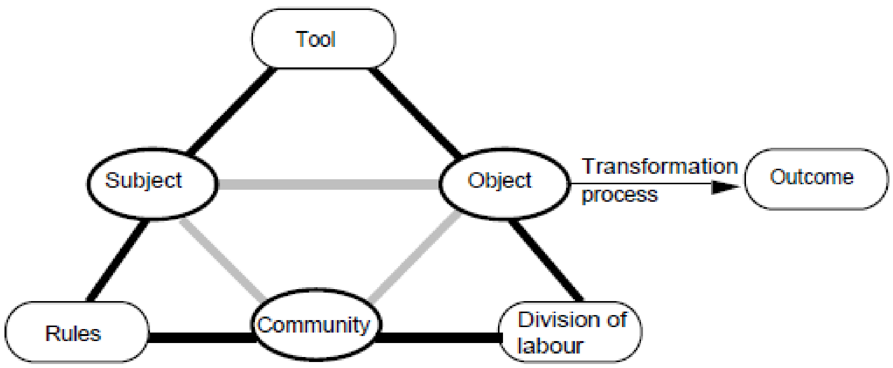

Figure 5: Engeström's activity model (Kuutti, Activity Theory as a potential framework for human-computer interaction research 24)

Due to pedagogical problems with the traditional depiction of Engeström's systematic model a more descriptive model can be found in Figure 6, below. In this picture the "subject" is referred to as "Actor/Role" in accordance with subsequent theories related to Activity Theory. Furthermore, note that "Tools" also have been changed to "Artifact".

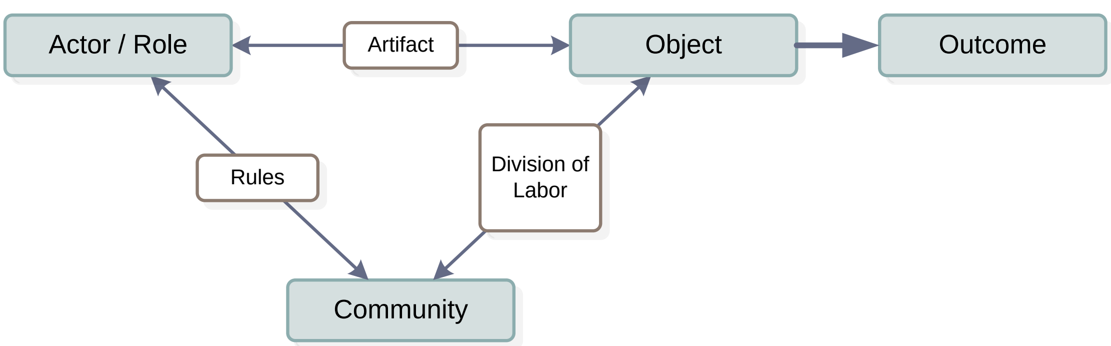

Figure 6: A more pedagogical approach to Engeström's model and theories

It is important to recognize that the development of the activity is not linear and smooth even though the model gives that impression, but rather an uneven and discontinuous process driven by contradictions. (Kuutti, The concept of activity as a basic unit of analysis for CSCW research 257) Engeström stated that contradictions drive the development of an activity and while one contradiction may be solved another is created. Furthermore, Engeström's model gives only the external structure of an activity. The inner structure is based on actions that consist of a series of operations. Kuutti brings forward the intricate interaction between the actor/role and the object, where, as the Actor/Role transforms the Object through a series of actions, the Object also influences the Aactor/Role on a deeper level. The Actor/Role assimilates experiences of the Community, in which the Object is a part. Thus, cognition is looked upon as situated processes and not as a static mental model. (Kuutti, The concept of activity as a basic unit of analysis for CSCW research 258)

Kuutti compares Engeström's classical activity model with previously mentioned five needs of CSCW when analyzing work settings, and derives to the following conclusion:

- Mediation of work by artifacts is a fundamental feature of work activities. The concept of a mediation artifact – tool or instrument – is rich and also covers signs, symbols, models, theories, etc.
- Regarding the existence of socially constructed meanings and cultural aspects, there is an elaborate mechanism for how cultural features are brought into every activity by the corresponding artifacts. Apart from the tool/instrument/sign artifact immediately used in transforming the work object, there are two other groups of socially constructed artifacts, normally rules and division of labor.
- Work reconstruction, transformation and development. From its very beginning, Activity Theory – and thus also the concept of activity – has been developed in order to study developmental processes. The reconstruction of the various artifacts is a basic feature in activities, and there is an elaborate mechanism for modeling the dynamics of this development.
- The concept of work activ*ity has a rich internal structure… [as* mentioned briefly earlier].
- The ability to deal with issues of control and conflict. The concept of activity contains different channels of control: Hierarchical power structures embedded in the division of labor, and control through norms and values embedded rules. (Kuutti, The concept of activity as a basic unit of analysis for CSCW research 259-260)

Given the usability of Activity theory when analyzing CSCW, shown by Kari Kuutti, what classification of basic types of work support can be drawn from the activity model? Kuutti sets up the following generalized classification for information systems, Table 1, below, based on Engeström's classical systematic model. Note that the Actor's/Roles' motivation is expressed as the "Subject 'thinking'" and that Artifact is represented by "Instrument". Depending on the activities to be supported this classification table may change. For a more thorough description of the different support types see Appendix 2: Basic Support Types.

Table 1: A classification of basic types of work support (Kuutti, The concept of activity as a basic unit of analysis for CSCW research 261)

Role of a person in an activity	Areas of support: Instrument	Rules	Division of labor	Subject 'thinking'	Object	Community
Passive	Routine automation	Control	Fixed	Triggering of a predetermined action	Data	Separating, hiding, visibility
Active	Tool	Shared meanings	Coordination	Searching information	Shared material	Visible network
Expansive	Automation or tool construction	Rule construction, negotiation	Organizing work	Learning, comprehending	Object construction	Community construction

By defining and setting up the basic types of work support, ideas and understanding for the work to be supported place can be reached. Kuutti's approach was developed when computers and graphical interfaces still were very primitive and the Internet and online communities not yet developed. However, the general idea and concepts drawn from Activity theory regarding activities and actions are still valid when analyzing cooperative work. Further research within this area has been made alongside the evolvement of graphical interfaces, internet and CSCW.

Recent research has come to the conclusion that the Expansive and the Active roles are necessary to support in CSCW. The Passive role is not applicable in the same way and do not comply with the way cooperative work is conducted. In Figure 7, below, the Active and the Expansive role's basic types of work support are applied to the external structure of an activity.

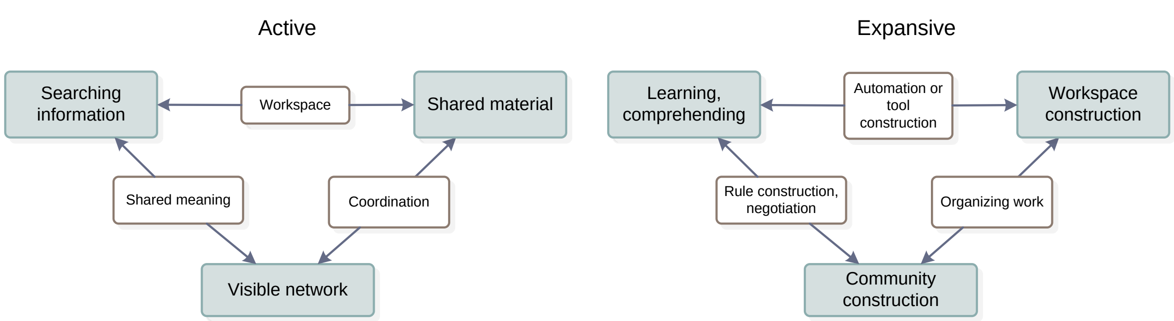

Figure 7: Kuutti's basic support types based on the Active and Expansive roles applied to the activity model

These twelve areas of support, related to CSCW and Activity theory, need to be supported by the CapExBio environment. In Figure 8, below, the relation between the Expansive and the Active roles and their respective general activities' basic types of work support are illustrated.

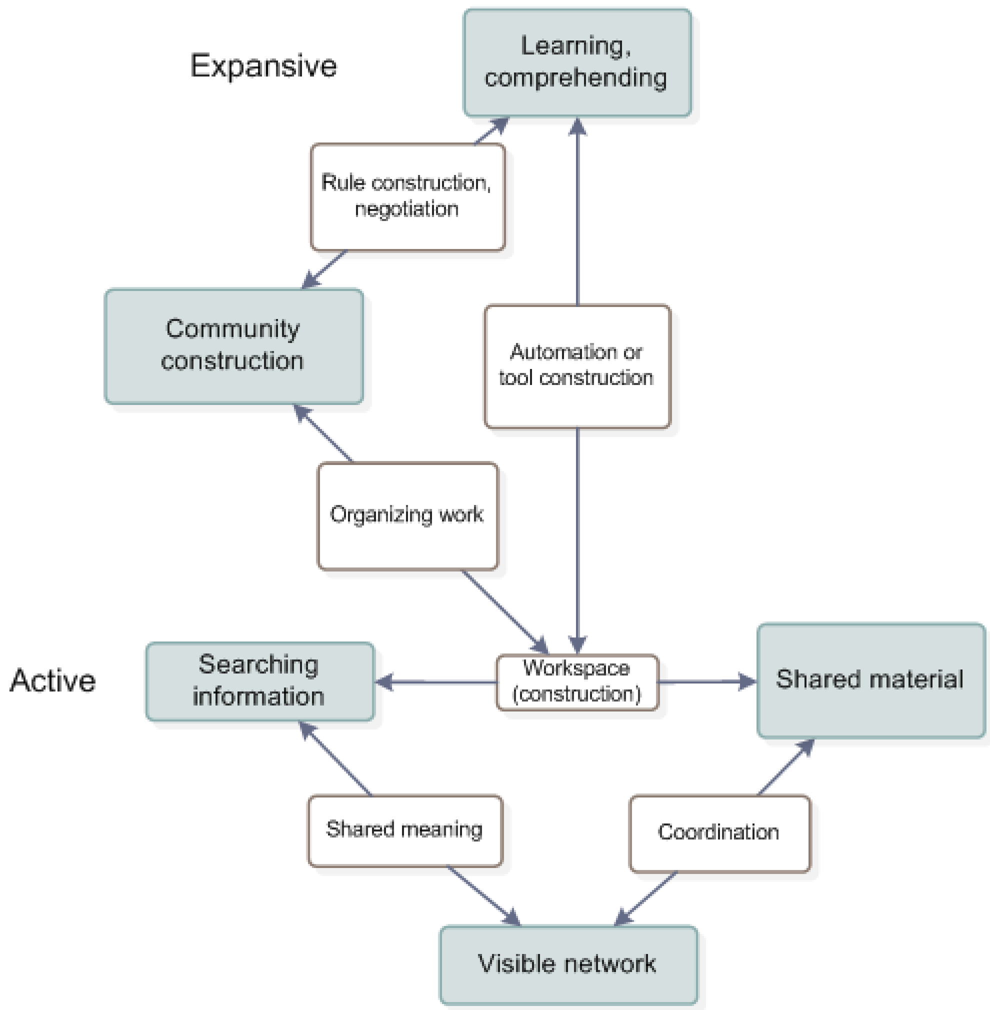

Figure 8: Kuutti's basic support types for work support put in relation to each other based on the Active and Expansive roles

In the article "Les répercussions du travail coopératif assisté par ordinateur sur les systèmes d'information"[13], Frédéric Hoogstoel takes Kuutti's discussion on Active, Passive and Expansive roles further. Hoogstoel highlights the fact that when working with CSCW the most important thing is to support the Expansive role. According to Hoogstoel, the following aspects need to be fulfilled in order for the environment to be expansive and collaborative:

- **Resource sharing** – Guarantee compliance with the rules and the division of work cooperatively defined by the group.
- **Communication** – Structured space for group communication either integrated with or coupled to the environment.

[13] "The impact of computer-supported cooperative work on information systems" (Eng. translation by author)

- **Coordination** – Negotiation with appropriate communication tools and tools for cooperative modification of the group task (rules and division of labor).
- **Implication** – Empowerment of people sharing and negotiating objectives, adaptability of human-computer interaction, flexibility and openness of the system, creation and integration of new tools.
- **Cohesion** – Clarifying rules, status, roles, tasks and objectives, and supporting their negotiation.
- **Organization** – Negotiated and co-developed.(Hoogstoel 142)

These key aspects of a collaborative environment, presented by Kuutti and Hoogstoel, are very general and should only be considered as such. However, they make a good starting point and give a solid foundation on which the system can be designed.

Arnoud Lewandowski and Grégory Bourguin[14] present their research on CSCW in the article “Inter-activities management for supporting cooperative software development”. In this article CSCW, the need for tailorability and the Coevolution[15] principle are presented and put into the context of software development. Lewandowski and Bourguin propose an interface design for a CSCW environment for software development within Eclipse, and even though CapExBio is not an environment for software design, there are strong relations between the two in terms of the interactions that needs to be supported. In Figure 9, below, one can find Lewandowski and Bourguin’s interface design for a software development tool in Eclipse. This design supports both Hoogstoel’s and Kuutti’s research findings.

[14] Grégory Bourguin <http://www-lil.univ-littoral.fr/~bourguin/> is a lecturer and researcher at Laboratoire d'Informatique du Littoral (LIL), Université du Littoral Côte d’Opal, Calais. Bourguin has focused his research on Computer Supported Cooperative Work.

[15] Coevolution is a principle, developed by Lewandowski and Bourguin, which refers to the understanding of that “a system has to support not only the activity it is designed for, but also its own cooperative (re)design activity” (Lewandowski and Bourguin 3). This approach can be derived from Activity Theory where a system is not looked upon as a container of the activity, but rather that the system takes part in the activity. (Lewandowski and Bourguin 3).

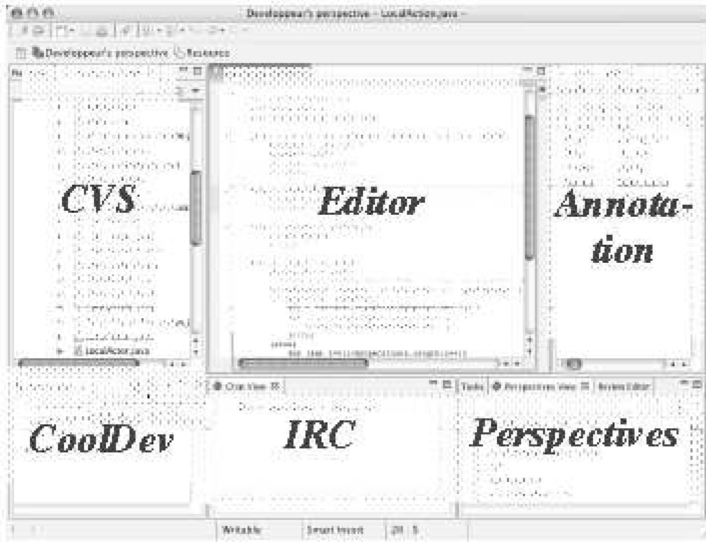

Figure 9: Example of a global cooperative environment (Lewandowski and Bourguin 7)

Frédéric Cadier, team member of the CapExBio project, has, in parallel with this literature study, developed a model on cooperative work in accordance with one of the contracted deliverables. His model is also based on Activity theory, as well as related theories, such as Common Ground by Gary Klein[16], Paul J. Feltovich[17], Jeffrey M. Bradshaw[18] and David D. Woods[19]. According to Cadier the cooperative phase begins with an invitation which can be either accepted or declined. If accepted a so called Basic Compact is created; a goal alignment between the two actors is created upon the same objective/motivation, and both accepts the underlying common ground activity, which is to establish and maintaining pertinent mutual knowledge. (Cadier, Cooperation model) This is illustrated in Figure 10, below.

[16] Gary Klein runs Klein Associates Inc.
[17] Paul J. Feltovich works at the Institute for Human and Machine Cognition
[18] Jeffrey M. Bradshaw works at the Institute for Human and Machine Cognition
[19] David D. Woods works at the Cognitive Systems Engineering Laboratory, The Ohio State University

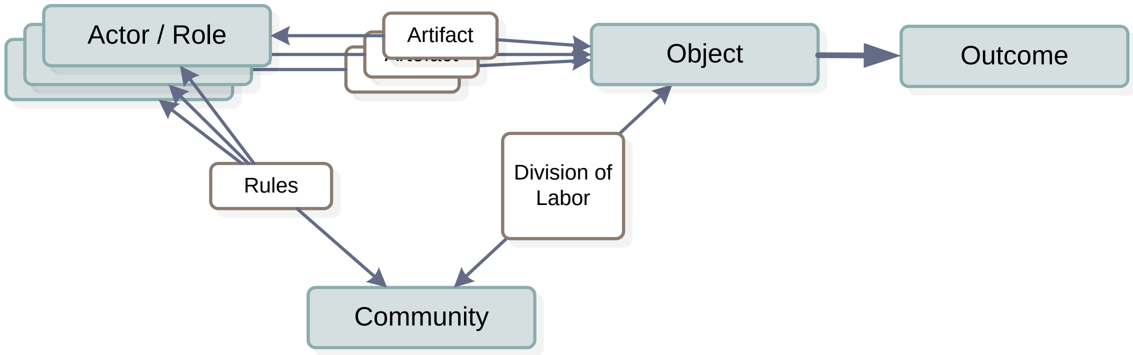

Figure 10: Activity model based on cooperation and the Common Ground theory (Cadier, Cooperation model)

This supplemented activity model shows how a set of actors, in this case different actors from different communities of practice unified under a community of interest, work towards a common goal based on the object to be manipulated. The object is characterized by these goals, a series of procedures for achieving these goals and some structural properties. (Cadier, Cooperation model) We assume that at least one of these goals is known to the actor initiating the activity on the object, and that one goal constitutes the objective of one activity. The actors are throughout their work influenced by their community via division of labor and rules. According to Cadier, the division of labor dictates the roles, i.e. defines the “doing together”, and the rules define the “being together”.

Additionally, Cadier has shown in his model on cooperative work that an activity, independent of the actor, can be divided into a series of stages. The iterative process always starts with the objective and ends with a solution that relates to that objective. Note however that the solution is referred to as the outcome in Engeström’s classical model (see Figure 5, page 27). The different stages are organized in the following matter, see Figure 11, below.

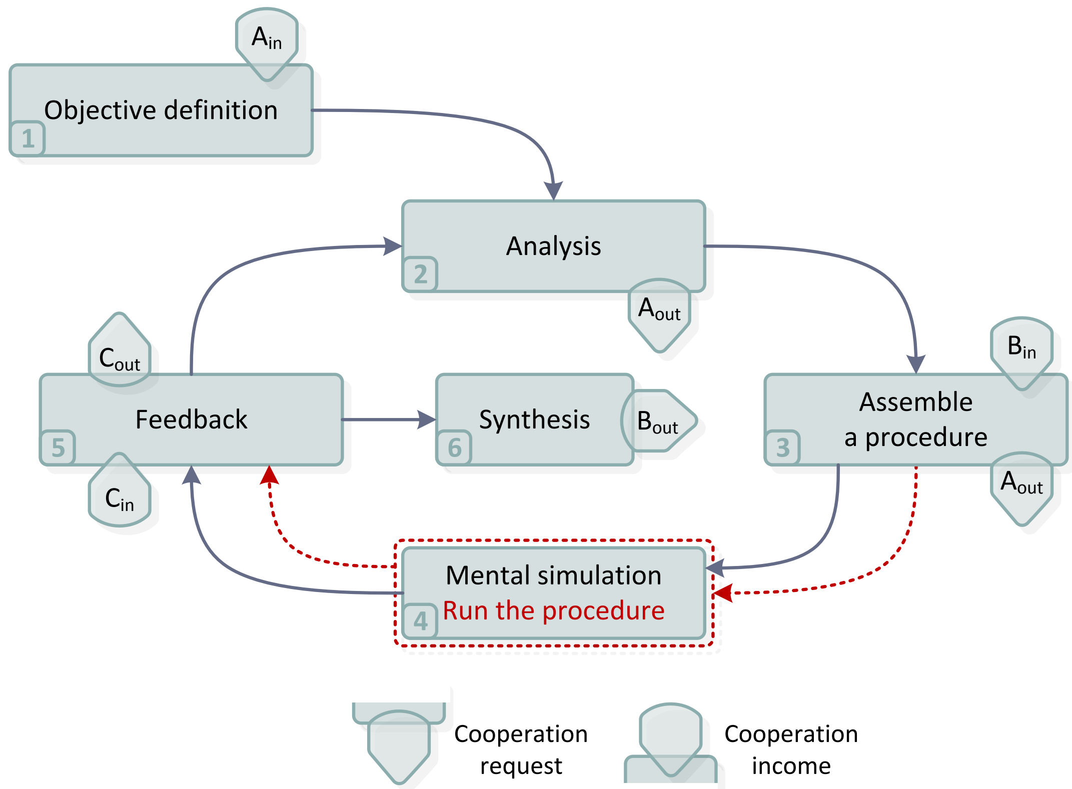

Figure 11: The six steps of an iterative activity process (Cadier, Cooperation model)

This iterative process (Figure 11, above) have the following characteristics:

1. The **objective definition** of the actor is the starting point for the activity acting upon the object. An objective can for instance be to solve a problem or to acquire knowledge within a specific field of genomics. The objective definition can also be initiated by a super-activity or a starting point for a cooperative activity, A_{in}. (Cadier, Cooperation model)
2. To **analyze** the objective is, basically, to choose a procedure to achieve the chosen goal with. A procedure is a sequential organization of sub-objectives with contingent prerequisites and “postrequisites”. At this stage problems might occur if no procedures for achieving the goal are known by the actor. Either the actor needs to require new knowledge by him-/herself, or to find help, A_{out}, to get the objective fulfilled. (Cadier, Cooperation model)
3. By decomposing the procedure into its sub-objectives, and contingent prerequisites and “postrequisites”, one can **assemble a solution** by oneself or in cooperation with other actors. These different actions have their own sub-goals with following procedures, et cetera. Kuutti calls this step orientation and states that: “The better the model, [orientation,] the more successful the action” (Kuutti, Activity Theory as a potential framework for human-computer interaction research 26). The

decomposition of the procedure into sub-procedure complies well with different articles on Activity theory and problem solving. (Cadier, Cooperation model) This step is considered a planning step; the actual execution takes place in the evaluation step. Furthermore, the label A_{out} denotes the connection between a super-process' assembling of a procedure and its sub-process' objective description, A_{in}.

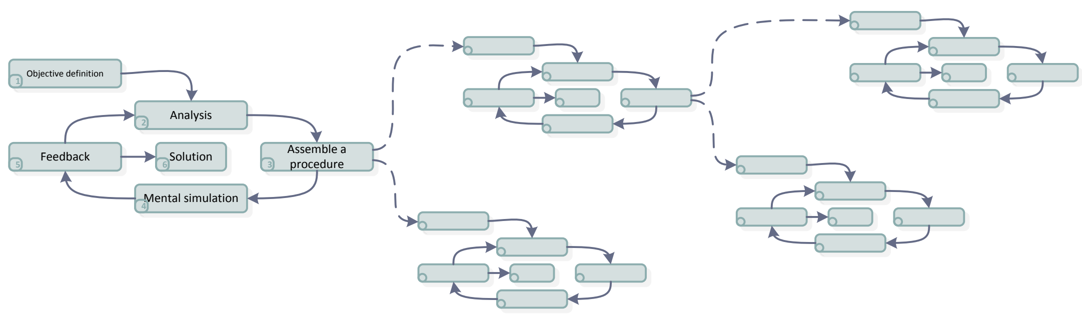

Figure 12: Illustration of the decomposition of a procedure into sub objectives creating a solution

4. When the decomposition reaches the primitive action level, referred to as operations in Activity theory, the execution is fulfilled. The actor, depending on his/her expertise, either performs a **mental simulation** or **run the solution**. An evaluation of the performed action is made instantly due to the instant feedback from the execution of the, for the specific actor, primitive action level. When the actor feels he/she has reached the primitive action level depends on his/her cognitive power.
5. The **feedback** is a quantitative and qualitative process that extracts the elements that lead to problems related to the concerned object. If there was no problem, the process ends in a synthesis, otherwise a new iteration is initiated.
6. A **synthesis** is the final product of an activity. A sub-process synthesis can act as a part of a super-process' procedure. The connections B_{out} and B_{in} in Figure 11, above, show the connection between procedures.

According to Cadier's model, different types of problems can occur during an activity. Either the actor's knowledge for performing a certain task is deficient or the knowledge applied by the actor leads to errors. The actor needs to get the relevant support for handling these two types of errors. It must be able to perform rollbacks if performed actions lead to errors, or preferably, alert the user before errors occur. Frédéric Cadier also shows with his cooperation model, in accordance with both Hoogstoel's, and Lewandawski and Bourguin's theories that, depending on cognitive constraints and knowledge of the tool to be used, the user will need to be able to tailor the interface to match his/her requirements. Cadier has shown that, from a sociological viewpoint, it is possible to make the CapExBio system user friendly for both expert users and novices, like students, by analyzing the different layers and steps of an activity process. For instance, what actions might be grouped by an expert user and which will not, et cetera? Illustration of the life cycle of an activity starting with an objective and ending with a synthesis is useful when analyzing work tasks and information usage (see Figure 13, below).

The analyses proposed in the UCSD process aims at retrieving the same data as the Activity theory tries to organize and depict (see Figure 13, below). This means that the UCSD process is not only necessary for securing project success as mentioned in the project description, where a strict focus needs to be on the usability and usefulness of the design, but also for future iterations when trying to operationalize the Activity theory. One could say that without real user input, Activity theory is just a theory and useless for the system design process.

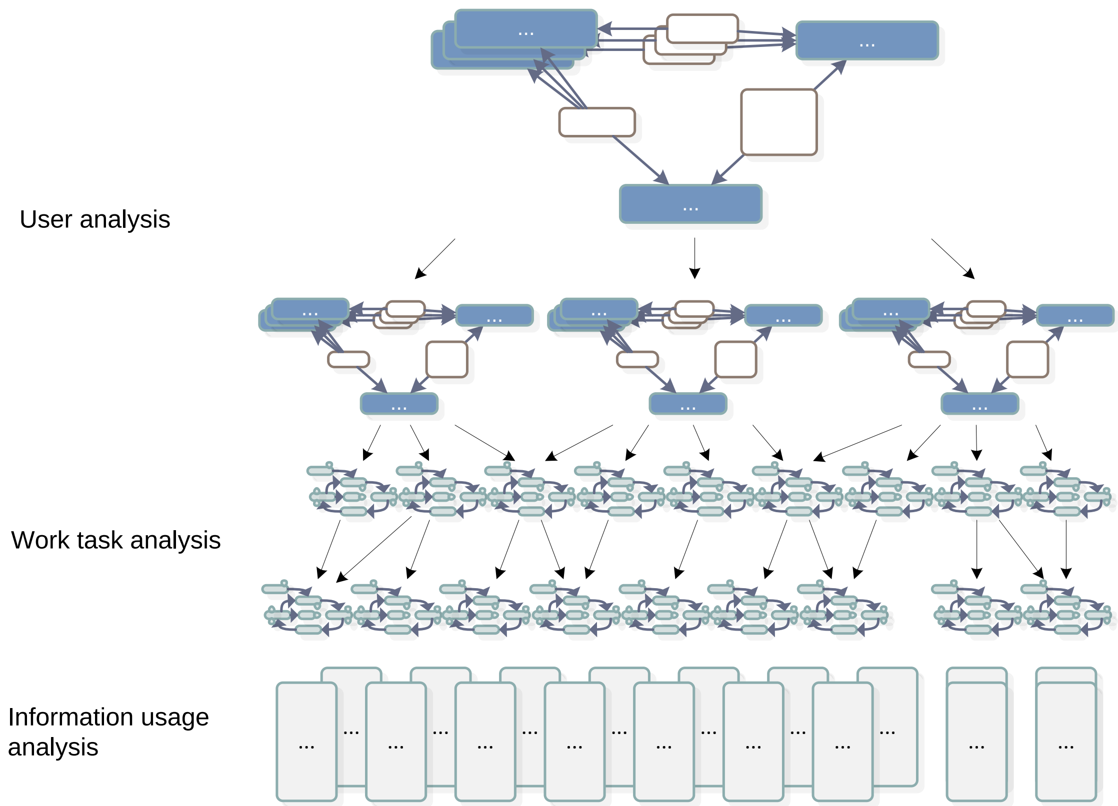

Figure 13: The different levels of Activity theory in relation to the analysis step within the UCSD process

Some further aspects to take into account on top of activity theory presented in this section are the time and space issues surrounding cooperative work. When trying to support cooperative work via computers, one popular strategy has been to minimize the complexity of coordinating the cooperative activities by regulating the cooperative interactions. This approach aims at regulating routine coordinative activities by providing normative models of cooperation. The idea is that the users, thus, should perform their work more reliably and efficiently. This approach is often used within high risk settings. (Schmidt and Simone 1) At the same time, another strategy has been to support cooperative work by supporting the users to cope with the complexity of coordinating their activities by themselves. One way of doing this has been to give the users a "shared workspace" where the users can interact directly (Schmidt and Simone 1), e.g. Skype or Google Docs. To what extent each of these two strategies will be adopted will be decided based on the analysis of the users. However, the second strategy is more in line with the recommendations retrieved from Activity theory.

4.1.1.1.1 A Closer Look at Communities and Roles

As mentioned earlier, according to Activity theory, the context, in which the cooperative activity is conducted, plays a big role for the actual activity. The Community affects the Actor/Role and the Object via Rules and Division of Labor. Due to these understanding, it is interesting to look more closely at the characteristics of communities and the Actors/Roles participating in that same community.

Within the field of sociology difference is made between societies, e.g. organizations, enterprises and groups, and communities, e.g. the genomics research community. A society is based on functional differentiation, whereas a community is an informal social integration of people based on interest (CoI), e.g. genomics, or practice (CoP), e.g. biology or bioinformatics. Membership, roles and networks develop dynamically and participants are not formally bound within communities.

From a sociological viewpoint, communities are based on communication processes and role-expectations, thus building boundaries against their environment by processes of selection. (Herrmann, Jahnke and Loser 165-166) However, according to Giorgio De Michelis[20], these borders also invite newcomers; "Boundaries can be crossed and memory shared"(De Michelis 238). These boundaries have their strengths and weaknesses. CoP:s have a strong ontology, but might experience group-think, whereas CoI has the possibility to make profit from social creativity, diversity and making all voices heard, but also suffer from lack of shared understanding. (Fischer 157) De Michelis mean that all communities also act within a "four-dimensional taxonomic space" (De Michelis 237) which is an aggregation of "interacting people sharing a place [such as a virtual community place], a language [such as the terminology of biologists], an experience [in capacity of a community of practice] and memory [which is the cognitive counterpart to the place of the community]" (De Michelis 237-238). The memory is what links the community's place,

[20] Dr. Giorgio De Michelis holds the position of Director of the Department of Information Technology, Systems and Communication. De Michelis is also member of the Advisory Board of CSCW Journal. He is active within the fields: Interaction design, knowledge management, information systems and e-government. <http://www.unimib.it/go/Home/Pagine-Speciali/Elenco-Docenti/DE-MICHELIS-GIORGIO>

language and experience together. Furthermore, “communities build themselves by mutual engagement, commitment *and activities”* (Herrmann, Jahnke and Loser 166), and thereby facilitates an ongoing exchange of ideas, knowledge and beliefs. It should be an environment for and by the users. Through the community’s memory, in the capacity of a knowledge creating process, its members can “share knowledge of past experience, transform the space where they live in their place, and co-create the language through which they can interact and give sense to their actions” (De Michelis 239). Within CoP, newcomers move towards the center as they adopt the knowledge system of their specific community. Learning within CoI is more than just participating in the overlapping spaces of CoP:s; it is about interconnectedness and shared understanding. (Fischer 156)

According to Thomas Hermann[21], Isa Jahnke[22] and Kai-Uwe Loser[23] et al. do “[c]ommunities exchange knowledge about a domain to develop individual capabilities”(Herrmann, Jahnke and Loser 167). This is further supported by Cristen Torrey[24], David W. McDonald[25], Bill N. Schilit[26] and Sara Bly[27], who, in their article, show that within these communities the interactions between different actors are fully decentralized expertise-location systems where the actors share knowledge in order to, among other things, gain personal knowledge and expertise. (Torrey, McDonald och Schilit) Additionally, the major benefit with the knowledge communities is that they shorten the “time to intelligence”, due to this interaction. Future studies need to clarify what would trigger the users within the genomics community to share workflows, how-to:s, experiences, expertise, et cetera. Without an interest in sharing and using this virtual

[21] Professor Thomas Hermann works for Ruhr-University of Bochum, Germany. Some of his research areas are: Design of socio-technical processes and creativity, Computer supported Collaborative Learning, Knowledge Management and organizational memories - software components, methods of introduction, evaluation, Social and Psychological Theories of Communication, Cooperation and Coordination, and Human centered design of interactive systems and groupware. <http://www.imtm-iaw.rub.de/personenund/personen/th/index.html>

[22] Prof. Dr. Isa Jahnke is Assistant Professor for Institutional Research and Sociotechnical Communities at Dortmund University of Technology, Germany. <http://www.hdz.uni-dortmund.de/index.php?id=276>

[23] Dr. Kai-Uwe Loser works at Ruhr-Universität Bochum, Germany. His fields of study are: Privacy, Modelling socio-technical systems, Knowledge Management and Learning organizations, and Use of groupware for KM and LO. <http://www.imtm-iaw.rub.de/personenund/personen/kul/index.html>

[24] Cristen Torrey is a PhD Student at the Human Computer Interaction Institute, School of Computer Science, Carnegie Mellon University. <http://www.cs.cmu.edu/~ctorrey/>

[25] Dr. David W. McDonald researches on Computer-supported cooperative work (CSCW), human-computer interaction (HCI), social computing and computing in the home. McDonald is employed by The Information School, University of Washington. <http://projects.ischool.washington.edu/mcdonald/index.html >

[26] Dr. Bill N. Shilit is employed by Google Research and works at the intersection of HCI, information retrieval, and ubiquitous computing. He has several publications and patents in his portfolio. He has worked for FX Palo Alto Laboratory and AT&T Bell Labs. <http://schilit.googlepages.com/home >

[27] Dr. Sara Bly runs her own consulting firm, Sara Bly Consulting. She has 20 years of experience from user studies with focus on understanding the context of the activity as well as the specific user task. <http://www.ekistics.com/sarably/index.html>

community space the CapExBio project might lose its strong positioning towards other software on the market and a big part of its strength.

One key role within communities, such as the genomics community, is that of knowledge broker. Knowledge brokers establish knowledge relationships between the people with knowledge and those who need it. These knowledge brokers can be compared to the ‘blog editors’ (Torrey, McDonald och Schilit), who in a similar way are gatekeepers to information. An interesting aspect of the blog editors is their validation of the actors’ contributions via their comments and opinions. (Torrey, McDonald och Schilit 407) This is especially interesting for the CapExBio project where one of the ideas is to facilitate a virtual community where validation of knowledge is going to be very important. More and more communities do validate themselves with the use of comments and rankings of the participants’ contributions, specialties and other, for respective community, relevant qualities. Furthermore, according to Fischer, knowledge brokers with an interest in the technologies used within the community might develop into power-users who are able to make modifications and customizations to the systems at hand. (Fischer 158)

The knowledge communities must serve two key strategic objectives: Facilitate knowledge development (identification, creation, harvesting and organization of knowledge) and be a mechanism for knowledge application (sharing, adaptation and execution of knowledge). (Rivard, Aubert and Patry 273-274) De Michelis gives further support to this approach and lists five important requirements that need to be considered when designing an environment that is to support the memory process of a community:

- The environment can not only be a knowledge management system; it must also support knowledge enrichment, storage, presentation, and diffusion; thus supporting the whole knowledge creation cycle and not only its final stage.(De Michelis 240)
- Community memory is present in any situation of social life. The environment must therefore deliver its service to members whoever, wherever and whenever they are. (De Michelis 241)
- “Supporting communities requires presenting records of past experiences so that the actions of members become more effective.”(De Michelis 241) Contextualized representation of information regarding explicit, tacit, internal and external knowledge. (De Michelis 241, 243)
- “Supporting community memory should avoid creating distinction between content creators and consumers.”(De Michelis 243)
- It is important to supply an environment that supports the community’s ontology. (De Michelis 243)

With this general understanding of the different social groupings and the needs of each and every one of them, what can be the needs of support by the actors and roles acting within these communities? To begin with, one need to define the characteristics of a role. The definition of roles within computer science is fairly clear. A role is "usually characterized by a set of access rights" (Herrmann, Jahnke and Loser 164), where these access rights most often define who can view and handle information in databases, and who cannot. However, this simplified definition of Actor/Roles is not applicable on actors within more informal, dynamical, knowledge based, cooperative systems, such as communities and the sought for CapExBio environment. Actors within this type of environments need to be able to take on different roles depending on the situation and might even sometimes have several roles at the same time. Hence, solely supporting roles as administrator, moderator, tutor, et cetera, does not support the creation and flexible redefinition of roles that is needed. This is also supported by De Michelis, as mentioned previously. According to Thomas Hermann, it is important to support role development more actively in order to gain more effective social interaction, communication and role transfer. (Herrmann, Jahnke and Loser 164) One of the aims with the CapExBio project is to provide an environment where cooperative work and knowledge capitalization between different actors within the genomics community can be facilitated. Thus, in order to create a knowledge capitalizing, cooperative, workflow system a more sociological viewpoint on roles and their interaction within communities is of interest.

Hermann et al. argue that roles have four main characteristics: Position, Function/Tasks, Behavior-Expectations and Social Interaction. The two first can evidently be found in the traditional approach of computer science, whereas the last two are derived from sociological theories. To begin with, a role has always a position relative to other positions within the sociological network. This position is connected to functions and tasks, and indicates the social status. The position matrix within a society or community reflects the structure of the social system. Often are the functions or tasks connected to a position addressed by the social system and comes in the form of explicit and documented expectations, rights and obligations. Within virtual communities these roles most often bear the name of the position and function/tasks, for instance administrator, contributor, or moderator. The third characteristic, which is not supported in traditional software development, is Behavior-Expectations. Roles develop within a social context, hence, it is important to understand what non-explicit expectations, as well as what possibilities to negative and positive sanctions, there are. For instance, if an actor does not comply with the non-explicit expectations set up by the social system, like informal notions and agreements, there is a risk of exclusion. This is an example of a so called negative sanction. The last characteristic is called Social Interaction which sheds light on the fact that actors in a social system can reshape and change a role he or she has taken. However, this forming depends on the interaction with other actors of the social system, either face-to-face or virtually. (Herrmann, Jahnke and Loser 168-169)

In order for CapExBio to be an environment that supports knowledge capitalization and cooperation between different actors within the genomics community satisfactorily, it is necessary to take into account the social and cultural aspects imposed on the different roles, and their development represented in the targeted social system. All in accordance with previous discussions on cooperation and Activity theory. Furthermore, it is important to keep in mind the dynamics of roles, and their interactions within the genomics community, given by a sociological viewpoint rather than the traditional access-based definition within traditional computer science. Finally, one must also see to that the environment actually facilitate knowledge capitalization and does not set limitations for knowledge development and application. How can the ideas, knowledge and beliefs processes be facilitated and capitalized?

4.1.1.2 Knowledge Capitalization

> "*An organization's ability to learn, and translate that learning into actio*n rapidly, is the ultimate competitive business advantage" (Jack Welch, former CEO of GE)

The second key positioning part is knowledge capitalization, which has proven to be a key factor for both the success of cooperation among different actors as well as a essential part of community construction and development. However, there are different approaches to knowledge capitalization. One approach that has become more and more important the last couple of years within enterprises and corporations is the use of knowledge management systems which can keep track on basically everything. Customer Relationship Management (CRM) and Enterprise Resource Planning (ERP) systems are examples of such knowledge management systems that are very complex and that can turn data in to usable knowledge for the users of the system. The stored information can be used to show on future trends or areas of improvement, as well as propose best practices and connect people who are working on the same kind of problems but are separated by time and space. One of the aims with the CapExBio project is to create an environment that facilitate and store knowledge. Thus, it is important to study the difference between knowledge and information.

4.1.1.2.1 What is the Difference between Knowledge and Information?

When referring to knowledge many bring up Plato and his alleged claim that knowledge being a statement which must be justified, true, and believed. (Wikimedia Foundation, Inc.) However, according to Ikujiro Nonaka and Hirotaka Takeuchi, two leading Japanese business experts, too much focus within Western epistemology has been on truthfulness rather than justified belief. (Nonaka and Takeuchi 58) Nonaka and Takeuchi mean that three observations can be made. To begin with, knowledge is about beliefs and commitment, unlike information that is not a function of a particular stance, perspective, or intention. Secondly, knowledge, unlike information, is always about action; social interaction based on a unified language, with intention and commitment. Thirdly, and finally, knowledge, like information, is about meaning: Contextualized and relational.

(Nonaka and Takeuchi 58) This means that "[w]hile traditional epistemology emphasize the absolute, static, and nonhuman nature of knowledge, … [Nonaka and Takeuchi] consider knowledge as *a dynamic human process of justifying personal belief toward the 'truth'*" (Nonaka and Takeuchi 58). Thus, information is a flow of contextualized messages, while knowledge is created by that very flow of information, anchored in the beliefs and commitment of its holder. (Nonaka and Takeuchi 58) Therefore, it is important to facilitate the interaction between actors, which is a part of the knowledge process, and put more focus on the semantic aspects of information than on the syntactic. This approach to knowledge fits nicely with previous discussions on communities where knowledge is looked upon as a process rather than a static entity.

This makes their approach very interesting for the CapExBio project which in excess of capitalizing knowledge tries to facilitate a virtual genomics community. For the project, this means that more focus needs to be on the semantic aspects of information and that the interaction between the actors need to be facilitated and stored. Key factors are thus contextualization, beliefs and commitment bound to the genomics community. It is an issue of cultural rootedness; to take into account the specific community's behaviors, incentives and culture when designing the technology for the knowledge capitalization to be effective.

4.1.1.2.2 Aspects of Knowledge Management Systems

In the age of information technology, globalization is made possible and the majority of organizations act on the global market. Experts all over the world can build teams and run highly complex projects disregarding time and space due to computers, internet and knowledge management systems. This applies for multinational companies as well as for research institutions. Organizations reorganize in order to minimize time and space limitations and so called networked organizations gain more ground, where staff quality and not their location is the key. (Rivard, Aubert and Patry 14-15, 17)

Within the field of genomics the knowledge capitalization through CapExBio could be such a mean for individual actors and organizations to gain and share knowledge, best practices, build connections between people within the organization or outside it, et cetera. Internet provides the infrastructure for information distribution and enables individual actors or organizations to reduce costs and increase the value of information. The easy access to information enabled by this global infrastructure will also lead to a more heterogeneous group of users. Thus, it is very important to construct a robust collaborative environment that can handle the participants varying technological sophistication and provide functionality and support usability (Rivard, Aubert and Patry 102).

In the book Information Technology and Organizational Transformation: Solving the Management Puzzle Suzanne Rivard et al. advert IT's potential to transform innovation processes. IT can facilitate experimentation and identify subtle trends such as potential problem areas or show on opportunities. By using effective interfaces users can access data for their particular purposes, systems can work together, and the environment “does not impose its own limitation on what can be done” (Rivard, Aubert and Patry 104). One very important aspect to take into account here is that IT by itself cannot transform how organizations work, or people interact, to the better. Thus, it is also essential to understand the behaviors, incentives and culture that are the value framework when designing technology for it to be effective. (Rivard, Aubert and Patry 103-104, 270) For instance, what are the value frameworks of the actors within the genomics community? On what points do they differ and on which do they comply? Is the genomics community really ready to act within a virtual community setting, et cetera? These understandings further supports the importance of not introducing the traditional term roles and use it as purely access rights to databases without considering what effects it might have on the interaction between, and knowledge capitalization among, the different actors.

Furthermore, even though there is a mountain full of information available it is easy to suffer from “info-glut” due to the lack of contextualization of the same information. (Rivard, Aubert and Patry 270) This can be strongly linked to Ikujiro Nonaka and Hirotaka Takeuchi’s third observation: knowledge is about meaning, which is contextualized and relational. (Nonaka and Takeuchi 58). Consequently, it is important when designing CapExBio to provide the data in a contextualized manner with sufficient and spot on metadata for each and every user. This type of data could be annotations, logs, descriptions of the project members and how they know each other, where they can find information or people that are related to their project or type of study, et cetera. In the case of CapExBio it could also be relevant to look into the possibilities of applying a recommendation-system structure (Sarini, Blanzieri and Giorgini 137-144). A positive effect of contextualizing information, beyond supporting knowledge creation and application, is that it opens up for a broader communication between the different actors and work domains; it creates mutual respect and can create links between people who otherwise would not meet and share knowledge.

4.1.1.3 Human factors

In preceding sections, functionality and usability constraints related to computer-supported cooperative work, communities and knowledge capitalization have been discussed, but system design is also much about expectations, look-and-feel and accessibility. Thus, in this section, important human factors such as emotions and deficiencies will be discussed; factors which can both make and break the success of an environment.

4.1.1.3.1 Emotions

According to Donald A. Norman there are two perspectives on products: the designer’s and the users’ perspective. The system design affects the users’ affective reactions to, and interaction with, the environment. The goal of the designer is to create positive emotions relating to the product, which has proven to be a difficult task due to the difference in perspectives between the user and the designer.

The designer has to take a series of considerations into account depending on context. It can be everything from “functionality, physical limitations, appearance, cost, time-to-market, characteristics of market segments, and legacy and brand-identity issues” (Norman and Ortony, Designers and Users: Two Perspectives on Emotion and Design 91). Of these are functionality and appearance the two most relevant for emotional design. According to Norman, the users’ emotional reactions to the design take place on three different levels: on a visceral (perceptually based), a behavioral (expectation based) and a reflective (intellectually based) level. However, a big challenge for the designer is that “emotions reside … in the user of the product rather than in the product itself” (Norman and Ortony, Designers and Users: Two Perspectives on Emotion and Design 92). These different levels are presented in Table 2, below, together with illustrative examples.

Table 2: The levels of human disposition map to different dimensions of product design as illustrated in this table with both profession and example(Müller-Prove)

Human Disposition		Profession	Example
Reflective	Intellectually driven	Brand/Image	Perrier table water
Behavioral	Expectation driven	Usability	Water in plastic bottle
Visceral	Perceptually driven	Graphic design	A beautiful blue bottle that is used as a vase

A visceral response is an automatic evaluation of perceptual properties in an object. It is a quick classification of the object as good or bad, cold or warm, safe or dangerous, et cetera. This primitive evaluation of the object, the CapExBio environment in our case, is important to design for and enable the user to have a positive experience. According to Norman, this level is all about look-and-feel and surface appearance; it is pure style, like colors, shapes, contrasts, et cetera. Visceral responses has nothing to do with the past or the future, it is all about the present state. It is primitive reactions and is therefore fairly appreciated to work with. User evaluations help guiding the process and seeing to that the right triggers are being pushed. By establishing what colors and shapes indicate within the genomics community the CapExBio environment can become compelling to the users. According to Norman, it is the visceral level that is the origin for the more complex emotions anxiety and concern, and satisfaction and pleasure. (Norman and Ortony, Designers and Users: Two Perspectives on Emotion and Design 94) For instance, the colors blue, black, and gray are perceived on a visceral level as conventional colors and indicate stability and strength. Perceptions that affects and give rise to emotions on the reflective level. For example, dark blue is often chosen as a corporate color in the financial sector to indicate security. (South) Furthermore, it should be noted that users’ interpretation of colors relates to their culture, age, class, gender and trends. (Kyrnin)

In contrast to the visceral reactions to design, which is innate and biological, is the behavioral level responses learned. This means that “they also involve past experience and expectations on future states and events” (Norman and Ortony, Designers and Users: Two

Perspectives on Emotion and Design 94). It is here the usability of an object is evaluated and reflected upon, but also the physical feel of the object and the subjective “feeling of control”. The behavioral level is automated and subconscious, but has a level of awareness, and because it is learned it varies from person to person, from culture to culture. (Norman and Ortony, Designers and Users: Two Perspectives on Emotion and Design 94-95) It is therefore important to not fail in fulfilling the users’ expectations. Only proper user studies can give the necessary information for designing such an emotional design.

The highest level of processing is reflection, where emotions such as pride, shame, admiration and gratitude resides. This level is the one of the three mentioned that is conscious and self-aware. At this level the emotions has its origin in the visceral and behavioral levels, together with a conscious interpretation of those feelings. (Norman and Ortony, Designers and Users: Two Perspectives on Emotion and Design 95) Important to consider at this level is the users’ pride of ownership, view on quality and brand. Based on the outcome word of mouth can make or break the success of the project quickly. Ones experiences, cultural background, social group, age, sex, and fashion determine how a design will be interpreted. Some viscerally appealing, accidental design features can transform into reflective level emotions. Norman mentions as an example the iconic sound of a Harley-Davidson motorcycle.

Norman’s discussions on emotional design can be boiled down to an understanding of the importance of addressing all three levels of emotional responses. Even though the designer only has functionality and appearance to work with, a good design should affect the user positively on all three levels: the visceral, behavioral and reflective level.

4.1.1.3.2 Deficiencies

About 8 % of the male population and 0.4 % of the female population have some sort of color deficiency. (Wikimedia Foundation, Inc.) Therefore, it is important when designing the CapExBio interface to take this into account. Making the right decisions regarding color does not only alleviate the work of the users with color deficiency, it alleviates the work for all users. Furthermore, choosing the right colors also contributes to the attractiveness of the environment as mentioned earlier. In the book Exploring Interface Design the author Marc Silver explains that the most common problem for people with color deficiency is to distinguish one or more colors from each other. According to Marc Silver, the best way of dealing with this problem is to minimize color differentiation by “increasing the contrast between foreground and background as much as possible” (Silver 247). If the CapExBio project would result in a web environment there are a set of tools that could be of interest when trying out accessibility for deficiencies like color blindness. For instance, IBM aDesigner is such a tool that tests the web interface for several types of visual deficiencies and proposes changes to the design. (Keates 70)

4.1.2 Design

Participants
Frédéric Cadier
Magnus Larsson

I will start by giving a brief description of the overall structure of the first design proposal. After that I will discuss more thoroughly the two focus areas of the first theoretically based iteration respectively; cooperation and knowledge capitalization. However, these two focus areas are strongly intertwined and cross references will occur. As seen in Figure 15, below, the CSCW and Activity theory study have had the biggest impact on the general disposition of the interface. The study of communities and knowledge capitalization can be interpreted as more of added features and functionalities supporting the activities of the users. It is important the environment remain a powerful scientific tool, hence the focus on the actual work, the main activity.

The design discussions will be based on a set of drafts that shows how the knowledge drawn from the analysis has been applied. Other sources of inspiration, than presented in the literature study, have been current software such as the Microsoft Office 2007 Suite, Microsoft Visual Studio 2008, Google Docs, Gmail and LinkedIn. All of which have been given good remarks on usability. The method used for the first iteration have been almost exclusively Framing and Design described in section 3.3.2.2 on page 21. References to design illustrations will be made continuously in the design section.

In the following paragraphs, references will be made to Figure 15, below. In this illustration one can find each part's connection to mentioned theories. To begin with, in this design proposal the interface has two main spaces; one area dedicated to work related tasks (**Figure 15:Work task area**) and another area dedicated to the communication tasks (**Figure 15:Communication area**), all in accordance with recommendations made by Hogstoel, and Lewandowski and Bourguin. Note that, these two spaces can be altered by the users independently of their initial computer sophistication due to the implementation of the Eclipse RCP[28] framework (see Figure 14, below).

[28] By implementing the Eclipse RCP the users can tailor their work environment as it pleases them by the drag-and-drop functionality, and co-evolve the software. More information on the Eclipse RCP can be found on Eclipse's own wiki page: <http://wiki.eclipse.org/index.php/Rich_Client_Platform>

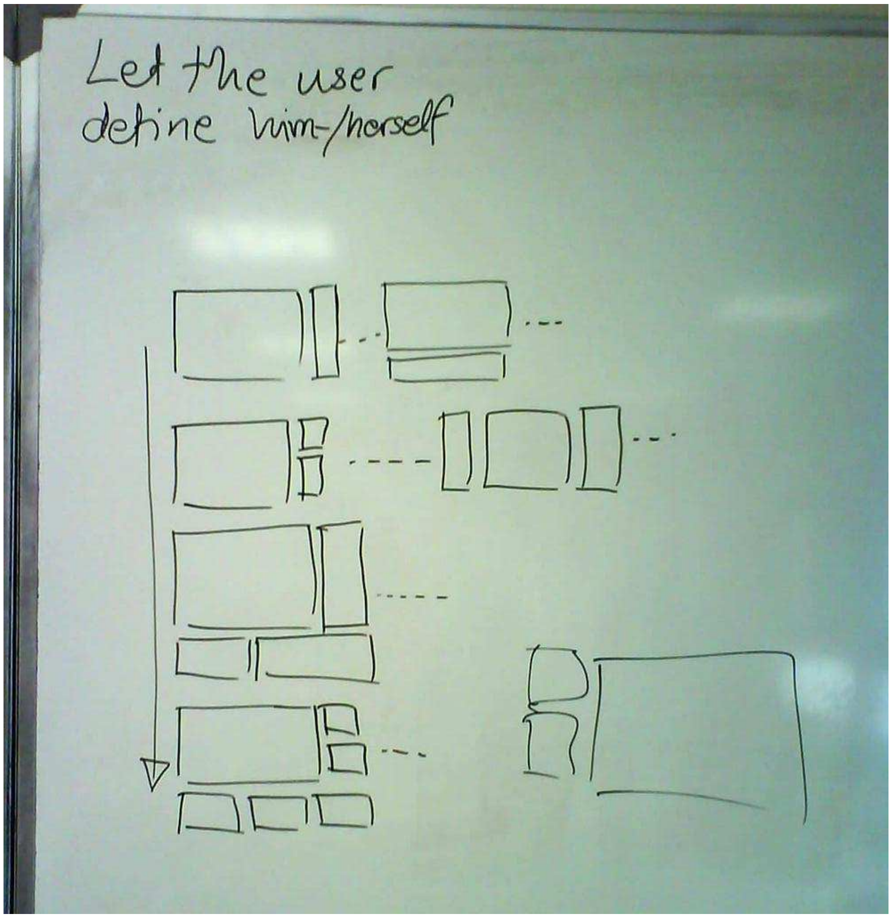

Figure 14: Drag-and-drop functionalities via Eclipse RCP will enable the users to adapt the interface to their needs. Draft from brainstorming session.

The work task area has two sub-spaces; the Workspace (**Figure 15:A**) is dedicated to the actual work, which is to create workflows/programs, to search data, to share workflows/programs/perspectives, to publish workflows, et cetera, and the Community space (**Figure 15:B**) is dedicated for community actions, which could be to manage ones profile, ones privacy settings, ones contacts and groups, or to search for expertise or friends, or to participate in Questions & Answer sessions. These actions are all accessible via a system of tabs (**Figure 15:C**) related to each project. The user can keep track of work history and annotations (**Figure 15:D**) relating to a specific project. Possibilities to enclose files, notes and links (**Figure 15:E**) to the project are also possible.

The communication area gives the user real time information on friends and colleagues doings (**Figure 15:F**); it gives information on online status, group belonging and current work. One can take advantage of live chat functionality (**Figure 15:G**) or share work perspectives (**Figure 15:H**) with other users, et cetera.

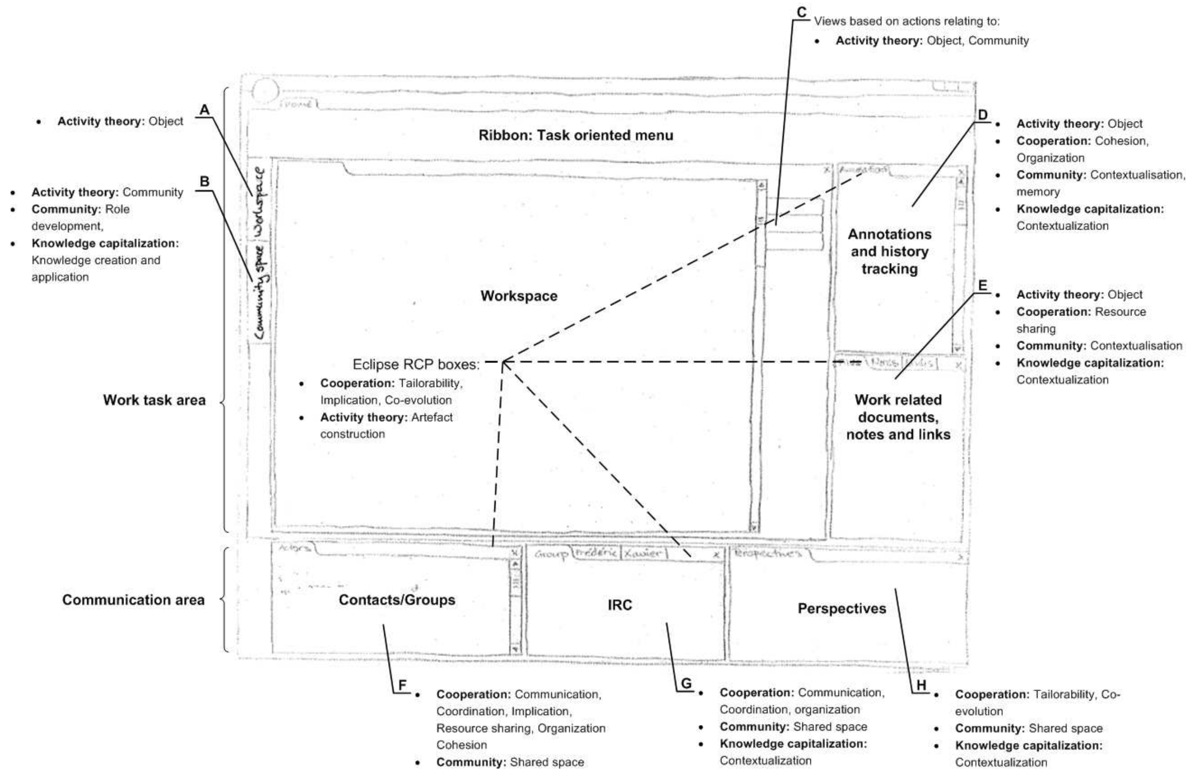

Figure 15: First general design proposition

With this general layout as foundation more specific design proposals, based on cooperation, community characteristics and knowledge capitalization, can be applied. Furthermore, the general layout is based on Lewandowski and Bourguin's design proposal for a cooperative software development environment in Eclipse. Their layout has the general features that are needed for a set of users to interact with each other while developing. However, important to recognize is that Lewandowski and Bourguin's design proposal is not the one best way to fulfill the demands set upon a cooperative environment, but it is a good starting point when lacking user input.

As shown, the design proposal has one set of tools dedicated for the actual work to be performed and a second set of tools relating to communication, joint tailorability and co-evolution. These tools will then be possible to use and combine, with the help of the functionalities of an Eclipse RCP environment, in a way that fits the specific user's needs. The users will therefore be able to not only choose perspectives from a set of predefined layouts, based on, for instance, private or cooperative work, beginner or expert user, et cetera, but also define their own layouts with the set of tools they need when doing their work.

Furthermore, the use of a Ribbon menu instead of a traditional function based menu will increase the usability and functionality of the environment. In the following three sections the design proposal, with the most common features and tools for working in a knowledge capitalizing, cooperative environment, based on literature studies will be presented.

4.1.2.1 Computer-supported cooperative work

All aspects of the first design proposal relating to cooperation and its support have been based solely on Activity theory and the Active and Expansive roles. This approach is an attempt to secure the general demands on a cooperative environment. As shown in Figure 15, above, the general layout complies with the activity model and Kuutti's basic types of work support. The interface follows the general recommendations of Hoogstoel, as well as the CSCW interface proposition by Lewandowski and Bourguin. Kuutti's basic types of work support are put in a CapExBio context in Figure 16, below. This model has been used as a mean to secure all aspects of cooperative work when prototyping, and it can favorably be modified as more input are retrieved from the end users of the genomics community. The actual workflow creation has not been mentioned yet, and will not be discussed to any extent in this paper. Philippe Picouet is responsible for analyzing the workflow creation of the users and his results will be applied to the design proposal when his research is finalized.

As mentioned in the analysis the similarities and linkages between Activity theory and the UCSD process are striking. In Figure 16, below, one can see Kuutti's basic types of work support put in a CapExBio context. By using these recommendations one can draw a first design proposition. Future user studies can help alter and trim the basic types of work support, and the model can help the researchers from missing out on important aspects of CSCW, as well as fulfilling deliverables stated in the contract. As seen in the figure, it is important to not only support the actual workflow creation, but also the development of the tool and the programs to be used for creating the workflows. The environment shall therefore make it possible for the users to create workflows, tailor their work environment and create programs that they can use during their workflow creation. They shall be able to share their work with each other inside the community, create work groups and their own sub-community spaces.

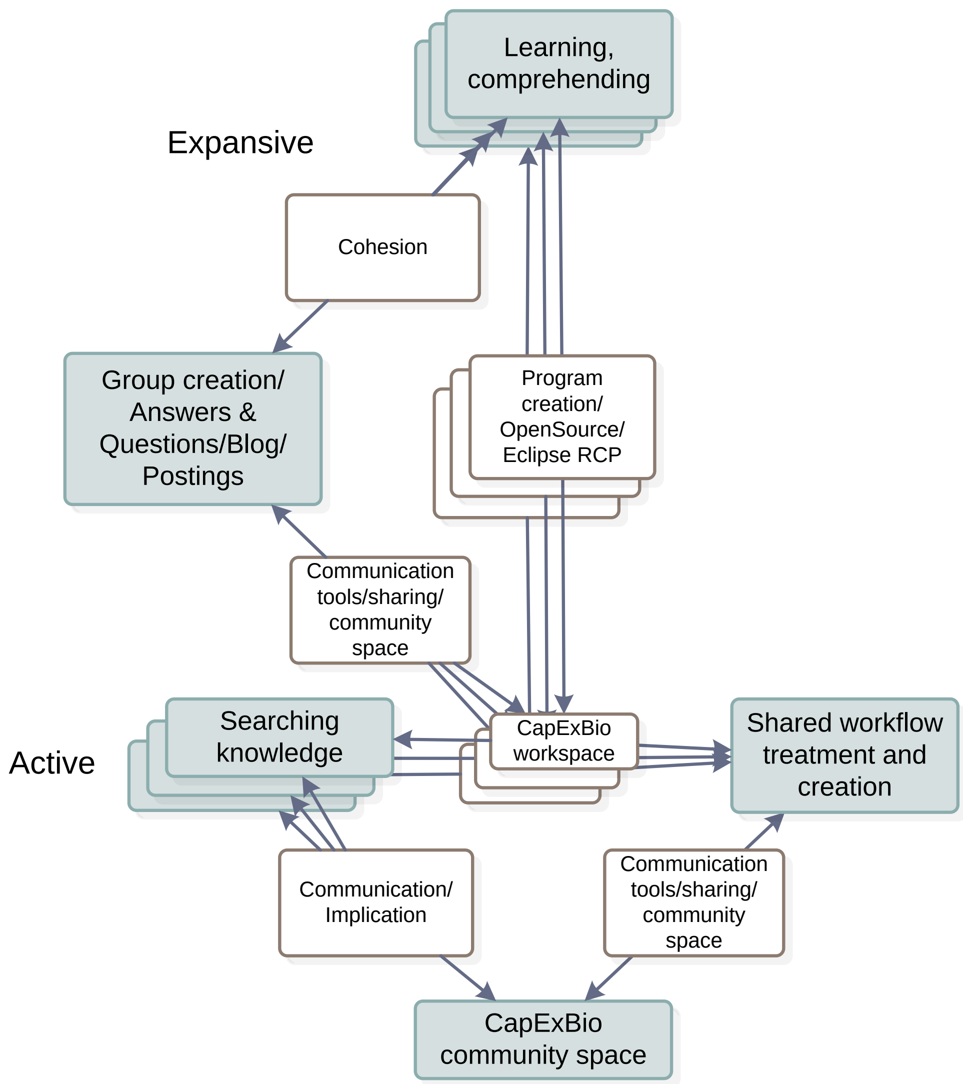

Figure 16: Kuutti's basic types of work support put in a CapExBio context and in relation to each other based on the Active and Expansive roles

In the preceding BioSide project the research team brought forth two separate environments, BioSide and BioDescription, with the purpose of trying out the technology of both workflow creation and program development. These two applications' separate functionalities can favorably be incorporated in the new software where both these types of technologies need to be supported; all in accordance with the Active and Expansive roles' needs of work support (see Figure 16, above). It is however, due to the diversity of users and levels of computer literacy among them, important that they feel they can rely on the programs they use and that the results are valid. Thus, one proposition is that programs provided by the CapExBio environment can be divided into two main categories; the "Featured Programs", which are programs certified to be reliant and valid, and "Programs", that can be everything from alterations of featured programs or brand new programs. If the community finds any program belonging to the "Programs" group of such quality that it might fit among the “Featured Programs” the community members can recommend the program and a group of skilled researchers assigned the tasks of certifying programs can take a closer look at the program. The “Featured Programs” should be available for all users, and the “Programs” group should only be available to the people who have in their profile settings granted the environment to present all programs available within the community. There might be a case where a program belonging to the “Programs” group is far better than the equivalent in the “Featured Programs” group but it has not been certified. Furthermore, a corporation might have their own R&D unit where they try to find an alternative way of calculating a big dataset where they want to alter a featured program in order to save time. They should, thus, be able to use their own alteration, and maybe, if they feel the program keep a high standard, search for certification. The certification and “Featured Programs” group are, hence, a way of ensuring the general user of the reliability and validity of the results produced by that very program and workflow. It is thus important that the users get the possibility to make, as they work on their workflow, necessary alterations to the programs they use, if they feel they have the competences of doing such. It is a way of supporting the Expansive role and boosting the knowledge enrichment of the community. Furthermore, indirectly it is also a way of supporting the Active role, which gets access to an enriched environment, with new modifications to the software via OpenSource, perspectives and new programs. The first design proposition is, thus, a general proposition, however somewhat anchored in the work performed within the genomics community.

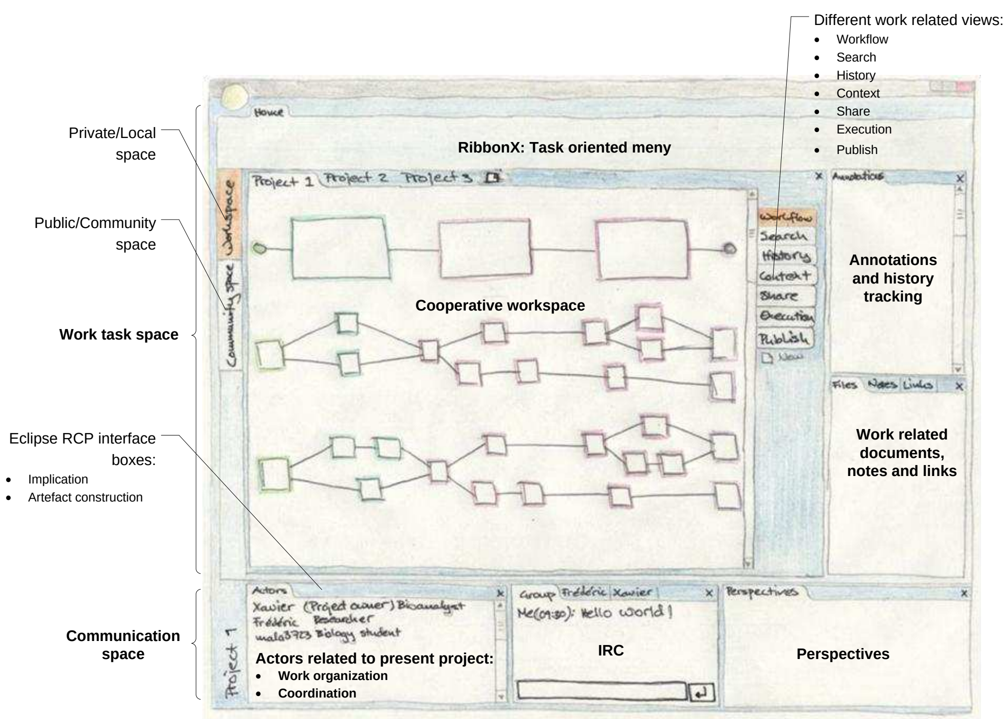

Figure 17: Design proposal Workspace|Workflow

In Figure 17, above, one can see how the different view tabs have been given content. These views are supposed to enrich the users work via extra information about their current project. They are supposed to be able to search information, to view the projects history, to see the context of their work in relation to the rest of the community, to share the project with other users of the CapExBio environment, to execute the workflow and view recent executions, as well as publish their work to community site. Some of these views provide a static view in time, such as history, while others also provide the possibility to perform actions, such as search. However, they all provide some information about the project being processed. It makes it possible for users to, if lacking knowledge about procedures, to either search for knowledge or to view the context and thereby get in contact with people with expertise on the subject. It also makes it possible to share the work with people one might know in order to fulfill the objective of the group or oneself. The researcher can also publish the project, and all relating data, to the community to get input on the work and help other. These views are mostly related to the Active role. However, in the Perspectives tool box the users can save their own layouts and share layouts with, and import layouts from, the community. The users can alter each part of the workflow. Even make alterations to the programs if they have the right settings, and they can make alterations to the CapExBio environment itself thanks to OpenSource. Hence, the Expansive role is also supported.

In order for the cooperation to work properly there need to be a strong connection to the genomics community. Otherwise the true potential of cooperation and its benefits will not be explored and utilized. In the following section some of the environment's community supporting features will be presented.

4.1.2.1.1 Communities

A virtual community is a place where members can interact and share experiences. There are several examples of successful virtual communities on the internet. Recognized communities are Facebook.com[29], MySpace.com[30], YouTube.com[31], LinkedIn.com[32] and Sourceforge.net[33]. A new community, developed by The University of Manchester and University of Southampton, is myExperiment.com[34, 35]. myExperiment is a community

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[29] Facebook is a social utility that connects people with friends and others who work, study and live around them.
[30] MySpace is an international site that offers email, a forum, communities, videos and weblog space.
[31] YouTube hosts user-generated videos and includes network and professional content.
[32] LinkedIn is a networking tool that supports business networking.
[33] SourceForge is a source code repository and acts as a centralized location for software developers to control and manage open source software development.
[34] myExperiment is a tool where one can find, use and share scientific workflows and other research objects, and build groups and communities.

which aims at helping people share and discuss scientific workflows. A lot of the features proposed in the CapExBio design drafts are very similar to the ones present on the myExperiment website. However, myExperiment focus solely on bioinformaticians and their scientific objects and not on the genomics community as a whole, and in some aspects focus more on information exchange than the full potential of communities as knowledge creators and capitalizers as mentioned in the literature analysis.

One of the aims with the first community design proposal is to introduce a more dynamical role creation and redefinition within the CapExBio community based on the ontology of the users. A move away from the traditional role definitions related to access rights is hoped to have a positive effect on the users cooperation and knowledge development. My proposal is to let the definition and recreation of roles be let on to the actual members of the community; to the people who actually know who they are and what they are doing. There will of course be a separation between the group of end users and admin/developers, but the community members should be able to manage the creation and redefinition of roles relating to themselves, as well as the evolution of the community space. For instance, instead of defining a user based on their educational background, professional title, or as contributor, reader or knowledge broker, the users could describe their forts and competencies in their personal profile based on activities and actions. Thus, the focus can be moved from functions, which are more static entities, to activities, which are dynamic. Furthermore, one could also let other members contribute with their impressions of each other by introducing, for instance, cloud tags with a set of characteristics relevant to their work. In Figure 18, below, one can see the first design proposal for the community site. The idea is to push community related information to the CapExBio environment, as depicted in Figure 18, as well as to web browsers. This way the users can gain access to the system whoever, wherever and whenever they want.

Another aim is to keep the system, and therein the community, as autonomous as possible. The need for training can be kept down as well as increase the user participation in the content creation and enrichment by introducing a familiar environment. At Jakob Nielsen's website, useit.com, one can read:

> In most online communities, 90% of users are lurkers who never contribute, 9% of users contribute a little, and 1% of users account for almost all the action. (Nielsen, Participation Inequality: Encouraging More Users to Contribute)

There are no implications showing that the CapExBio community would house more active users than the general community site, rather less due to the confidentiality of information surrounding research projects and the diversified set of community members. Without any concrete user studies one might assume that the community space will be mainly used by

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[35] One can find myExperiment related articles published by the founders of myExperiment and Taverna at http://www.semanticgrid.org/myexperiment/

younger members of the genomics community used to use sites like Facebook, Sourceforge, LinkedIn and Amazone. Thus, to lower the use threshold sources of inspiration have been Facebook and LinkedIn; environments used by millions of people on daily basis. These two environments are not aiming at the work of researchers. However, their community development and creation features are universal and can be adopted for the use in the CapExBio environment. Instead on focusing on social networking, the focus should be on connecting people with similar ideas and problems; the community can be a . Some of the features that will be adopted are for instance the use of rating, rejecting and commenting tools. One could also introduce the use of cloud tags when defining the different users' contributions to the community pool of knowledge. By doing so, the knowledge enrichment, storage, presentation and diffusion can be supported. Even more so by giving the users the tools to define their work and publish their workflows, programs, additional tools and tool boxes, and perspectives together with relevant comments, notes, metadata, audio, video and external links and files. These tools are to be found in both the Workspace, Figure 17, above, as well as in the Community space, Figure 18, below.

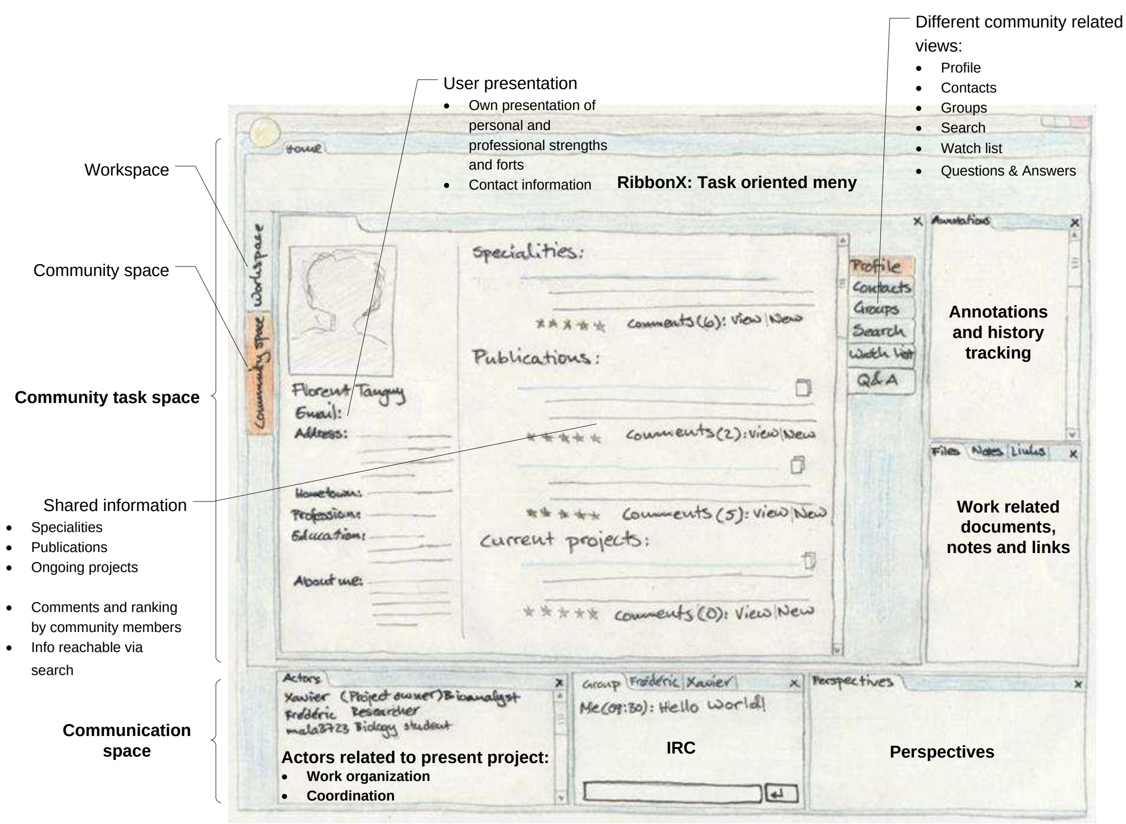

Figure 18: Design proposal Community space|Profile

Security issues are very important when discussing public areas like communities. The importance of keeping the research material secure and private is of outmost importance for the end users. Encryption of data sent through the system is therefore not an option, but a must. The users need to have full control over access rights and the creation and management of user groups related to their work. I therefore recommend the security levels: Private, Limited and Public. Furthermore, it is important for the users to be able to manage the privacy settings and to observe the state of the project at any time. The tool must not only be secure, but also feel secure. The latter relates to Normans discussions of visceral, behavioral and reflective levels of emotions (see section 4.1.1.3.1). Hence the color scheme; colors like blue are easy for the eye and are interpret as professional and secure, and orange-yellowish is one of the nuances that the eye easy recognize independently of color deficiencies. The same goes for black on white background. For other famous applications that use these four colors as their basic color scheme see Microsoft Vista, Microsoft Office 2007, LinkedIn, Facebook and Google.

4.1.2.2 Knowledge capitalization

According to Nonaka and Takeuchi, contextualization is the key to success for knowledge creation and application. One way of supporting the knowledge creation and capitalization within the community is by facilitating an enhanced search engine which presents its results in a contextualized form. The search engine can show how a specific set of information was created and how it relates to other types of data in the system, how it relates to the user's field of work and his/her projects, and where the user can find similar information. Another way of contextualizing the information and flow of information is by using a rating and commenting system. This way the users are able to rate and comment on the different postings to the shared community space and together create mutual knowledge.

In Figure 19, below, one can find the first proposal for a search interface. A search interface is one of many ways of retrieving knowledge or, as in the most cases, information. In the first design proposal, the search space layout has been inspired by the search engine of Microsoft Visual Studio 2008. Visual Studio has been recognized among system developers to be useful and usable. This graphical layout will most certainly change but the features presented are very much related to the analysis of the theoretical background posted in this paper.

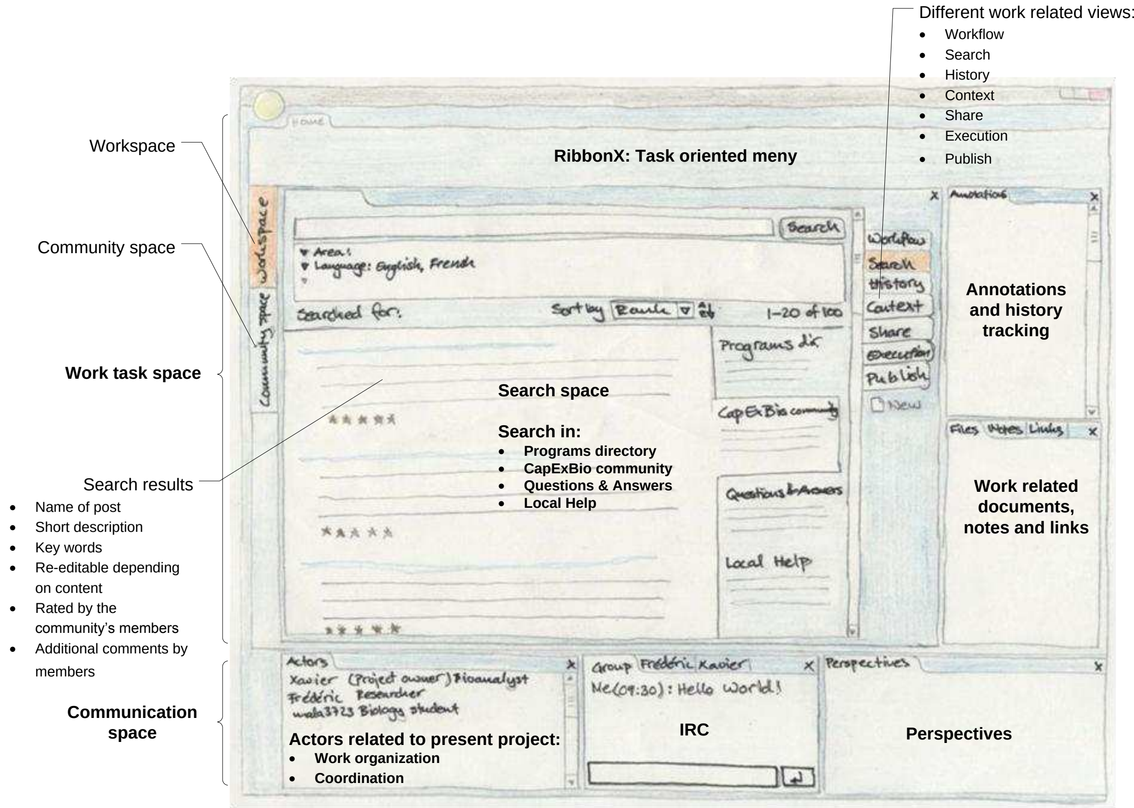

Figure 19: Design proposal Workspace|Search

The search shall be reachable both from the workspace and the community space. One will be able to search external data (e.g. www), internal data (e.g. programs directories and local help), explicit knowledge (e.g. Questions & Answers) and tacit knowledge (e.g. CapExBio community entries). It is important that comprehensive results are presented independently of previous computer skills, or even skills within the field of genomics. The users should be able to sort their results by rank, source, rating, author, et cetera, depending on their preferences. Furthermore, by introducing the opportunity for community members to rate the content and comment upon how well the search result answered the user's specific question and solved his/her problem, future searches can be optimized and the knowledge creation and application can be supported. In addition, high quality posts can also be promoted and given more focus. Posts that otherwise might drown in the stream of hyperactive members material. This approach is supported by Jacob Nielsen, who states that: "The lower the overhead, the more people will jump through the hoop" (Nielsen, Participation Inequality: Encouraging More Users to Contribute). Thus, by giving the users the option to either rate a post by clicking a star rating or by writing a comment, or do both, the users can choose, depending on their participation threshold, how much they want to contribute and promote material within the knowledge community.

It is also possible to reward users who contribute with quality posts with the help of a rate and comment system. By crediting hard workers who normally would not contribute, and not hyperactive users that do not have much to say, one can level out the participation inequality. An example of such an attempt can be found on the Microsoft Silverlight community who has initiated a points system[36] for awarding the contributors based on the actual contribution to the knowledge pool of the community. Similar points systems are used by several technology forums. The business-oriented social networking site LinkedIn have chosen to award good posts with acknowledgements and a wider access to the content pool rather than diversifying the users after a more user-contributor separation. The grading is done solely by the community members and is not moderated by the "system", as is the case with the Microsoft Silverlight community. The latter approach is also supported by De Michelis who states that when "[s]upporting community memory [one] should avoid creating distinction between content creators and consumers" (De Michelis 243). When creating the community space, which is to facilitate the knowledge creation and capitalization, a more soft approach will therefore be used to rating posts. One needs to increase the signal-to-noise ratio without discouraging and creating unnecessary distinction between the community members. Thus, an adaptation, based on user studies, of the LinkedIn rating and commenting system will be used in the final product of the CapExBio environment.

Knowledge brokers have an important job in knowledge communities and one way for them to communicate ideas and share expertise is by actively participating in Questions & Answers sessions and by validating other users work via ratings and comments (see also Figure 18: Design proposal Community space|Profile, above). They could also be participating passively by being referred to/recommended in Questions & Answers sessions or by showing up in what I would call a contextualization map (see Figure 20: Design proposal Workspace|Context, below).

[36] For more information on Microsoft Silverlight's rating system see their community page. <http://silverlight.net/community/recognition/>

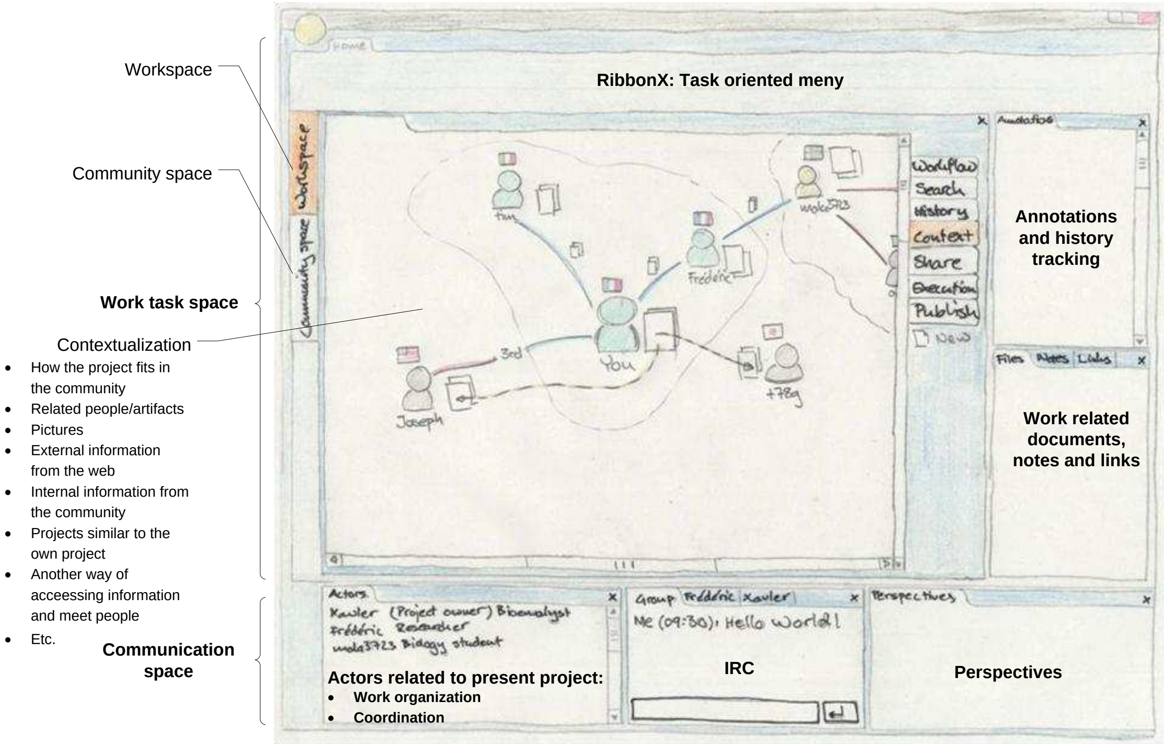

Figure 20: Design proposal Workspace|Context

In the contextualization map, Figure 20 above, the user is put in relation to other users and information sources based on project type, project content, supposed lack of knowledge, interests, contact network, et cetera. The user can acquire an understanding for how his/her work fits in the community. One might also include external links to the internet if it is relevant for the user's project. The contextualization map is another way of retrieving and accessing data. Future studies of the end users will show what type of information might be useful when trying to contextualize their work and community experience in order to create a steep learning curve for the members of the CapExBio community.

4.1.3 Evaluation

The evaluation of the design proposals was made throughout a series of meetings with the domain experts one-by-one but also together in groups with both representatives from TELECOM Bretagne and Station Biologique de Roscoff. During these sessions a series of aspects of the first design proposal was brought up.

Participants
- Xavier Bailly
- Sébastien Bigaret
- Frédéric Cadier
- Erwan Corre
- Magnus Larsson
- Gildas Le Corguillé
- Philippe Picouet
- Philippe Tanguy

To begin with, the complexity of the interface is an issue that needs to be taken into consideration. Several of the participants, both domain experts and developers, thought there might be problems with introducing to many features at a too early stage. For instance, features such as cooperation and communication functionalities are important, but a researcher, who needs to be fundamentally selfish in order to be successful, might feel these actions are of a secondary nature; the actual work space is the main item of concern. An alternative approach, proposed by one of the domain experts, could be to have an initial over-simplified interface, to which you can add the tools you need, when you need them. This means that there would only be one Work task space and that, if the user would like to make use of the communication and cooperation features, he/she should be able to access these tools from the Ribbon and add them to the Workspace. Another issue regarding the complexity of the interface is the use of different work related views. For instance, the separation of the conception view and the execution view of a workflow is not optimal. The proposition from the domain experts is to try to show both these levels of a workflow in the same view. Philippe Picouet, responsible for the resource models will specify the specific needs of the users regarding workflow creation and management.

One of the strong parts of the design is the Ribbon menu which focuses on activities. However, one of the evaluation participants expressed his concern using an activity based menu, rather than a function based, due to the extensive problems getting user participants to the project. However, all participating in the evaluation step agreed on that further development of the Ribbon would empower the application.

Security issues are also of outmost importance. Some were worried that it would be cognitively exhausting to have access to both a workspace and a community space in the same application. Due to the importance of keeping information private and only sharing it on need to know basis, a dedicated community space could cause anxiety among the users. Some were also concerned with the possible risk of creating yet another social networking tool, like Facebook, and drift away from the main purpose of creating a powerful scientific tool. Due to these notes on the design proposition, all actions relating to the community will be moved to the Ribbon and handled in new popup frames. The users will be able to alter their profiles and manage the content on their community site, however in the look-and-feel of a dialog window. Thus, a natural threshold is created and the users do not need to worry whether or not they are acting in a public or private space during their day-to-day work, or sharing their research by accident. Furthermore, it is important that the users know the state of the project and its separate parts. Some sort of sign and control handling the privacy settings of the experiment are needed, and the users should be able to have access to that information passively.

Regarding the community interaction, the same set of tasks are available for the user to use and the information can be pushed to the community server and back to the application if changes are being made either in the application or on the community website. The importance of having one’s own space where the profile is based on scientific achievements, as well as strengths and forts within the area of genomics was appreciated. However, in order to minimize redundancy and extra community upholding activities the possibility of making referrals and connections to other sites is of interest. Using this approach makes it possible to bridge the environment with other CoP:s and CoI:s instead of creating yet another complete community. Sites mentioned during the discussions with the domain experts were, for example, Faculty of 1000 Biology[37], PubMed[38] and LinkedIn.

Other features that got a lot of positive feedback were the search, perspectives and contextualization of the work. These features should be further developed and learning from their success should be applied to the parts of the system that were not as successful. Regarding the search functionalities, some notes were made. The search needs to be able to not only search by keywords, but also by navigation, context and program. As this paper is being written the development team does not have sufficient knowledge in search engine development, which is a big problem for the development of the project. During the evaluation sessions the importance of relevant search results were brought up. The proposed search engine's strong linkage with De Michelis' discussions on knowledge capitalization, and the importance of facilitating knowledge enrichment, storage, presentation, and diffusion, makes the search engine essential. The right type of data needs to be stored and the reliability of the search results can make or break the success of the application.

4.1.4 Feedback

The evaluation turned out to be successful, with a lot of good constructive feedback. All alterations proposed by the evaluation group will be taken in consideration during the next analysis and design step. More focus will be put on the Ribbon and a more scaled down workspace will be considered. Features such as an advanced search, the possibility to save and share perspectives and contextualization of one's own work, proposed by Kutti, Lewandowski and Bourguin, was well received.

4.2 Second Iteration Based on the Genomics Community

The second iteration takes its starting point in the feedback of the domain experts and the TELECOM Bretagne development team. The feedback, together with an analysis of possible work domains, will be the foundation for the second design step where, together with domain users, new mockups will be drawn. It needs to be stated that this approach is, in no way, the best one. However, due to the prominent lack of user participants, it is the only possible way to fulfill contracted deliverables and at the same time to not lose too much time. The main intention with the mapping of community members is to open up for a new discussion regarding how to approach the members of the genomics community, and

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[37] Faculty of 1000 Biology is a revolutionary online research service that comprehensively and systematically highlights and reviews the most interesting papers published in the biological sciences, based on the recommendations of a faculty of well over 2300 selected leading researchers. <http://www.f1000biology.com>

[38] PubMed is a service of the U.S. National Library of Medicine that includes over 18 million citations from MEDLINE and other life science journals for biomedical articles back to the 1950s. PubMed includes links to full text articles and other related resources. <http://www.ncbi.nlm.nih.gov/pubmed/>

maybe question the current division of user groups. Furthermore, due to the lack of team members and user participants made it impossible to conduct the evaluation and feedback steps. Thus, this will be on the responsibility of the team members to perform.

4.2.1 Analysis

As mentioned earlier, a very important part of the design process is to understand the users' work tasks and different needs. In the first iteration, the analysis took its starting point in the positioning of the project and analysis of relevant literature on the subject was conducted. The second iteration will try to move away from the theories and towards the users. However, when faced with the task of making a user analysis it became evident that it would be impossible to perform one at this point in time. To begin with, preceding attempts by the project team to acquire user participants for the system design process had failed. It is not determined if it was due to how the project, its goals and the proposed degree of involvement was introduced to the future users, if the wrong people were approached or if not enough time and effort was put into the work of finding user participants. Either way, as the diploma work was conducted no end users were available for user studies. However, one could look more into what the project team knew about the user domains, brought forth in the contract.

Participants
Xavier Bailly
Magnus Larsson

The user domains listed in the contract are: Biologists, bio-analysts, bioinformaticians and administrators. However, no one within the project team could give a really good explanation to why the future users were initially divided into these separate work domains, and why the focus was strictly on these user domains alone. This uncertainty demanded more extensive discussions on the in silico bio era with Xavier Bailly, domain expert at Station Biologique de Roscoff. During these discussions a better understanding of the historical perspective of the in silico bio era could be acquired (see Figure 21, below). The discussions also lead to a deeper understanding for the relation between the different competencies within the genomics community. According to Bailly, the once big difference between the different work domains at the beginning of the in silico bio era in 1995-'97 had been smudged out. Bailly believes that the work domains are closing in on each other more and more, and that, for instance, all biologists are more or less skilled within bio-analysis today. (Bailly) However, any clear definition of the different domains could not be given during these discussions. In order to get a better understanding of the work domains, a mapping of the community's competences is therefore of interest. Furthermore, with a general understanding of the work domains based on their competences the future search for user participants might be more successful than in the past.

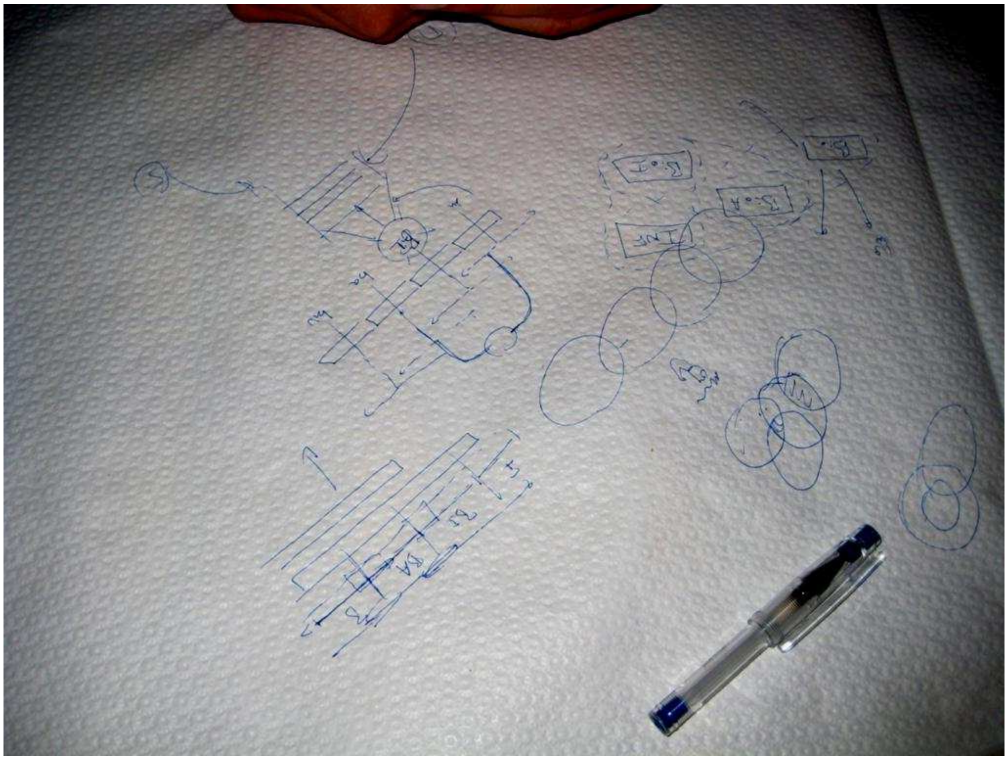

Figure 21: Some sketches on the realtion between different user groups drawn on a table cloth during a lunch brake

Hence, the second iteration analysis will have two objectives. To begin with, a mapping of the community based on the members' educational backgrounds can help the project team target and approach the members of the CoI known as the genomics community. One might assume that within the genomics community, there are a series of CoP. It is, hence, important to gain knowledge of the CoP present within the genomics community in order to approach them correctly. Otherwise, it will be impossible to keep the user participant diversity at a maximum. Secondly, the mapping can be used as input when conducting the second iteration design step together with the domain experts.

4.2.1.1 Mapping of work domains

The environment is supposed to support expert researchers, but also act as an education tool for future ones. Therefore, one approach that might be successful in the long run is to begin by mapping the basic set of competences of graduates within the genomics community; the starting point of every researchers career. One might assume that the researcher, after finalizing his/her graduate level studies, move towards a specific area of interest within his/her field; that is, moving towards the center of his/her CoP. However, due to the importance of being able to cooperate in order to fulfill his/her objectives one might also assume that the researchers acquire knowledge, however brief, from members of other CoP within the same CoI in order to create a common ground. The more time a researcher spends on his/her own project the more successful he/she will be (Corre). This implies that an expert researcher within one CoP do not have the time or ability to acquire the same set of competences of members of other CoP:s. Hence, there is an evident need of cooperation in order to succeed.

At universities the graduate level is supposed to be research preparing, and, thus, offer the minimal level of competences required for being successful within research. Therefore, an analysis of the different Master of Science programs relating to genomics research provided at, for instance, Uppsala University[39], is of interest. Furthermore, by studying the disposition of courses applicable at a well renowned university, in one of the biggest genomics centers in the world, an understanding for the sought for desired level and disposition of competences in future genomics researchers can be acquired.

At Uppsala University, there are four main Master of Science programs within the field of biology:

- Master of Science in Biology
- Master of Science in Applied Biotechnology
- Master of Science in Molecular Biotechnology Engineering
- Master of Science in Bioinformatics[40] Engineering

Due to the Bologna process[41], some of the higher courses have not yet been classified in accordance with the new system. Therefore, the work domain study will be based on information retrieved from the education programs before July 1st, 2007, when the system came in force.

The first two programs, Biology and Applied Biotechnology, are built on the same biology undergraduate foundation, whereas the two latter have their respective engineering foundation. In Figure 22, below, one can see the difference between the programs in distribution of available courses over a set of competence areas.

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[39] Uppsala University is an internationally well reputed university in Sweden. "Uppsala University is among the world leaders in biological research with centres of excellence and strong research groups… Uppsala is also one of the top ten biotech regions in the world with a great number of small and large biotech companies, influenced by, and employing, new researchers from Uppsala University." (Uppsala University) Furthermore, Biology in Uppsala was awarded an Excellence Ranking by the German Centre for Higher Education Development (CHE). For more information on the ranking, see: <http://www.excellenceranking.org/eusid/EUSID?module=Fachbereich&do=show&id=11010003>.

[40] Bioinformatics treats computer-based methods for analysis of DNA sequences, and for studies of the structure of proteins. Both theory and practical applications of bioinformatics discussed. The area integrates knowledge of computer technology, mathematics and molecular biology.

[41] "The purpose of the Bologna process (or Bologna accords) is to create the European higher education area by making academic degree standards and quality assurance standards more comparable and compatible throughout Europe. It is named after the place it was proposed, the University of Bologna, with the signing in 1999" (Wikimedia Foundation, Inc.).

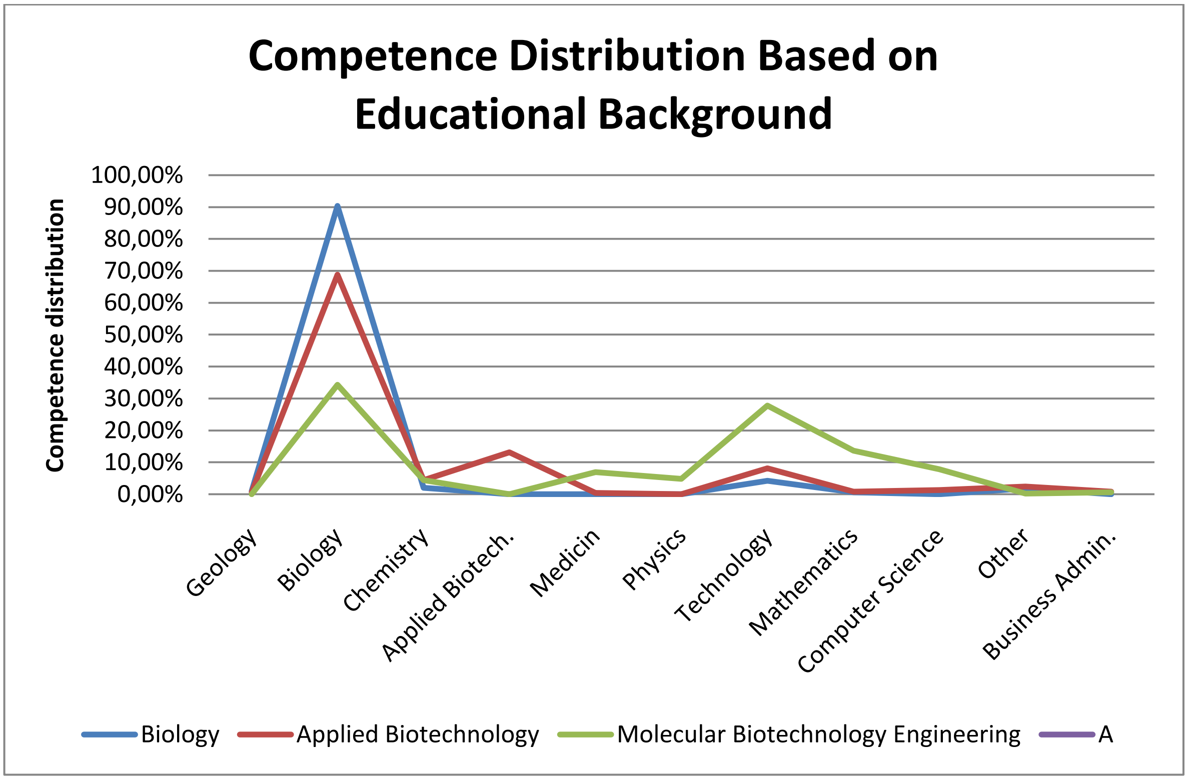


Figure 22: Each Masters programme's distribution of available courses given their competence areas

The two biology based programs have a solid foundation within biology and some minor knowledge within technology relating to the biology studies. The courses first and foremost target the area of bio-analysis. The engineering based programs have some biology, but also several courses within technology, mathematics and computer science. One could, thus, assume that there are two main work domains; one based on biology with some brief influences of technology, and one based on engineering with some aspects of biology. Hence, there are some indicators showing that a common ground between these two main work domains is instituted during the higher education via technology and biology studies; mainly via bioinformatics related biology courses. One could thus define a bio-analysist as a person with the knowledge of bioinformatics tools and programs as well as the needs of biologists. When looking at the genomics community they make an invaluable resource in the work of biologists. However, in the academic world no education targets the area of bio-analysis head on. Either the student chooses bioinformatics or biology. Bioinformaticians can when choosing focus area either turn to analysis, and then preferably bio-analysis, or turn to computer science, and then develop new software. The first choice could be interpreted as applied bioinformatics and the other as bioinformatics research. This means that the bio-analyst can have two completely different backgrounds; either from pure biology studies or from biology oriented engineering studies. As Bailly stated, biologists do move closer to the bioinformaticians through their education today. It has been more and more important for biologist to have an understanding for the computational part of their field of study. However, it is the bioinformaticians who have the real knowledge about the programs. One might say that, the Active roles are, thus, owned in majority by biologists, biologists with some knowledge of applied bioinformatics and bioinformaticians. The Expansive roles are mainly represented by bioinformaticians interested in program development and the so called power-users. One should not forget the administrators, but they should not be considered primary actors, but rather secondary actors, and their "use" of the CapExBio environment should be investigated. However, one should not put too much effort into this. The focus needs to be on the primary users, biologists and bioinformaticians, both, who in order to even consider working in this kind of environment with this kind of subjects, need to have at least brief interests in each other's work.

4.2.2 Design

The initial design proposition was changed based on the feedback from the first iteration, as well as on the discussions and analysis of user domains. The features not discussed in this design section will remain the same as in the latter version of the design proposition. Cross-references to prior discussions on cooperation, communities and knowledge capitalization might occur.

Participants

Xavier Bailly
Sébastien Bigaret
Frédéric Cadier
Erwan Corre
Magnus Larsson
Philippe Picouet
Philippe Tanguy

4.2.2.1 Branding

As mentioned in section 2.7.1.3 Legacy and brand-identity issues, on page 9, the team cannot use the preceding project's name, BioSide, due to trademark issues. On the positive side, the new proposed name, BioDesktop, relates better to the work that is to be done; a researcher has a desktop on which he/she keeps all his data and references connected to that specific topic, et cetera. Furthermore, one can use the name when referring to actions within the application, for instance: "Do you want to clear your desktop from projects and start over?", "Save all projects on the desktop?", et cetera. Figure 27, below, illustrates a proposed splash screen for the BioDesktop environment.

Figure 23: Proposed Splash Screen for BioDesktop

The naming of the CapExBio projects product is very important for the progress of the project. Prior to the naming of the application the project team kept referring to the preceding projects name, BioSide. Several of the BioSide projects functions will be used in the new application, but in order to keep focus on this project and keep an opened minded approach, it is important to stay away from the risks of inheriting unwanted limitations posed by previous projects.

4.2.2.2 Modifications made based on feedback

There was an expressed need of simplification of the interface. Due to this need, the interface has been reduced to only containing one area; the work task space (see Figure 24, below).

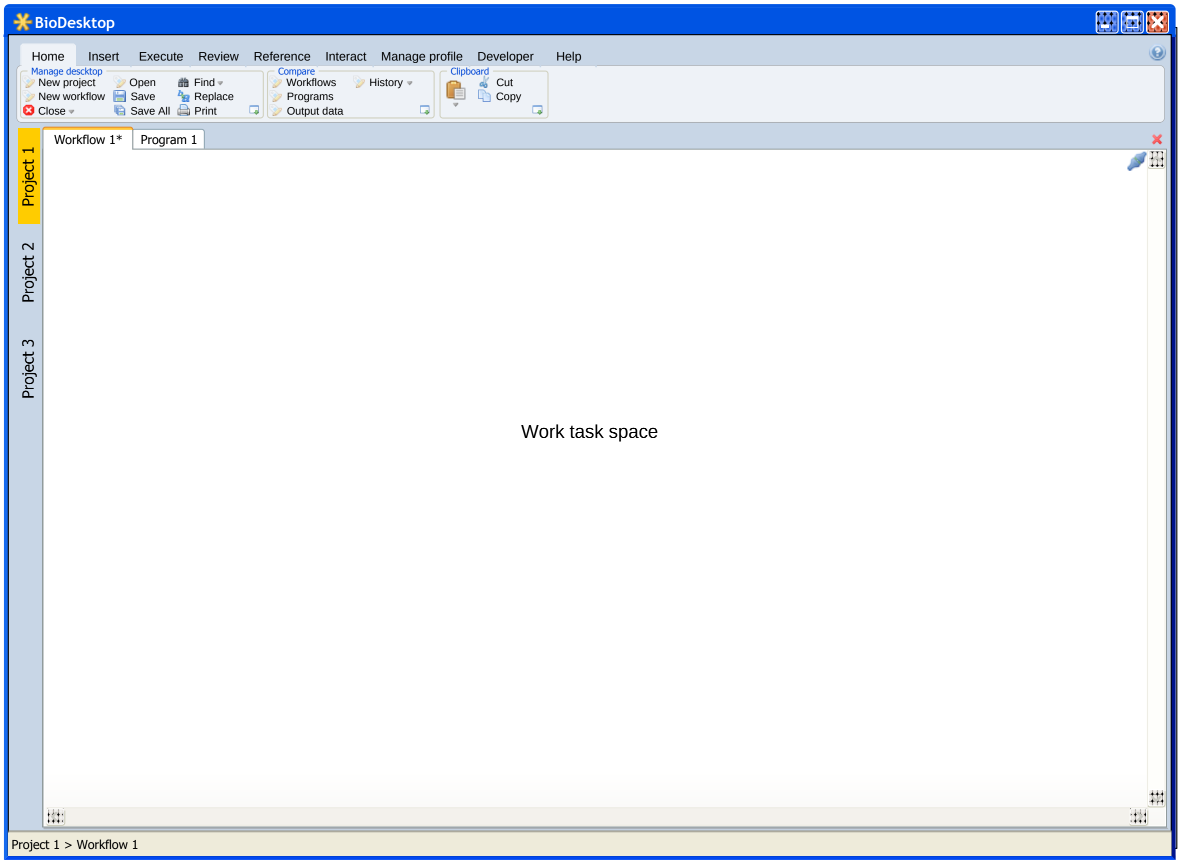


Figure 24: Design proposal Work task space

All actions related to the former Communication area and Community space (see Figure 15, page 48) have been moved to the activity oriented Ribbon menu and grouped with appropriate actions. From there sought for actions can be accessed and the user can, thanks to the Eclipse RCP, tailor the interface. For instance, under the menu tab Interact one will be able to manage contacts and groups; share projects and perspectives or publish projects, programs and perspectives to the community page; and communicate, with tools such as IM and email. Management of data shared with the community, such as personal profile or workflows, perspectives and programs can be managed from either the community website, or the Interact or Manage profile menu tab.

The Ribbon menu was interpreted as a good tool for dealing with actions and for supporting both individual and cooperative work. However, in the first iteration design step no actions were discussed and assigned to the Ribbon. It was only after discussions with the domain experts and the mapping of the user domains that this could be done. The Ribbon, with all assigned actions, can be found in Appendix 4: The Ribbon menu. Note that actions not yet defined are marked with three dots, and that the icons used in the prototypes are only to some extent representative for the tasks at hand. There are several providers of free icons available on the internet. One such provider is FamFamFam.com, <http://www.famfamfam.com/lab/icons/silk/>. Furthermore, the actions marked with dots might belong to a group where the activity is known, but not its actions. Team member Philippe Picouet will for instance assign the actions relating to insertion of programs when his resource model is finalized, and Frédéric Cadier will refine the actions already assigned so they comply with the ontology of the genomics community based on his future user studies. Cadier will also assign new actions to the menu when the need for such occur. Additionally, note that some actions will open dialog windows, such as Share, Open or IM, whereas others will be instant actions, such as Cut or New Screen Clipping. User studies will determine what type of approach is preferred.

If the user wants to, he/she can add the actions/tool boxes from the Ribbon menu to the workspace by drag-and-drop (see Figure 25, below); the drag-and-drop functionalities are provided by the Eclipse RCP interface as mentioned in the first iteration. This feature was intended in the previous proposal as well, however, in this proposal all actions shall be reachable and drag-and-drop-able from the menu and no tools will be initially assigned to any other space than the work task space. Instead of proposing a certain perspective to the user based on his/her preferences, the user can, with the help of the Rules, which is a short tutorial of each part of the system, tailor his/her own workspace. The Rules will be presented at first startup, and reachable from the Ribbon.

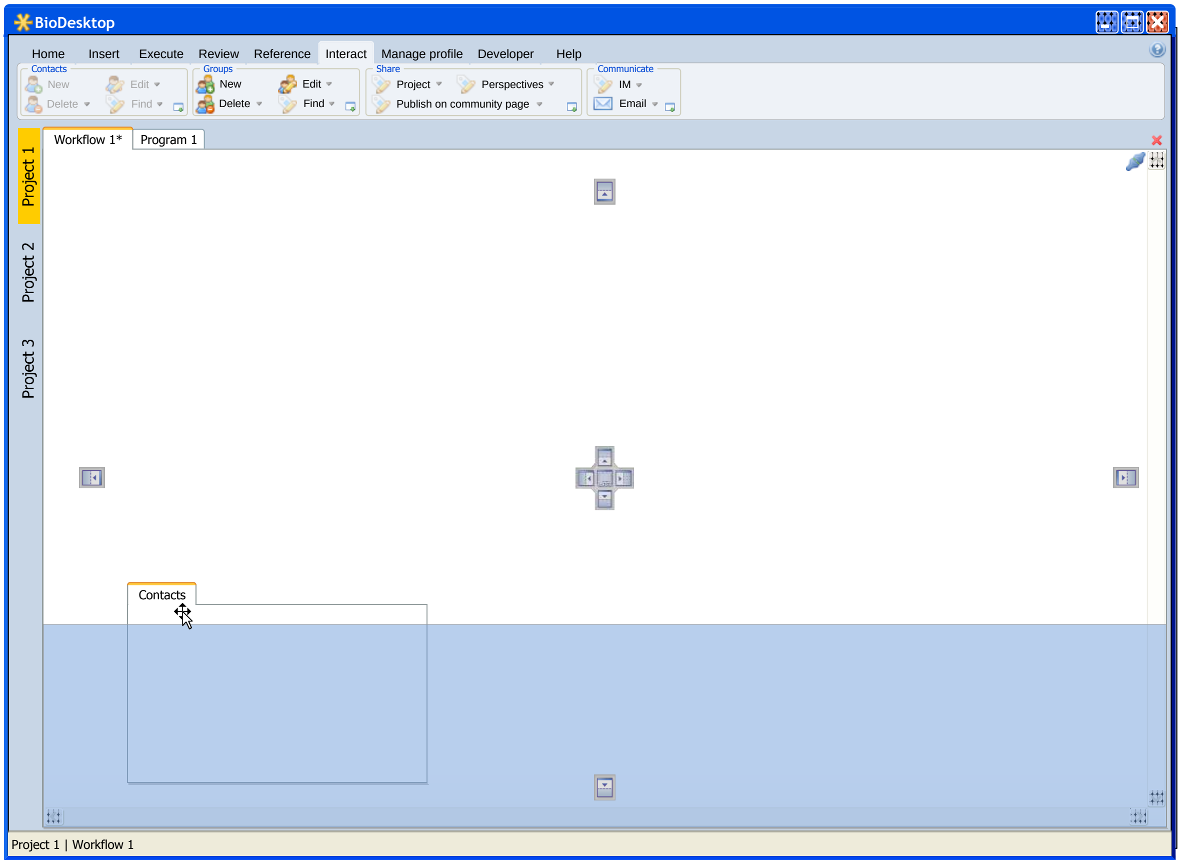


Figure 25: The Ribbon menu drag-and-drop functionality provided by Eclipse RCP.

By grouping all tasks relating to actions it will be easier for the users to manage their work, but also to understand what impact an action on their behalf will have on their work and the community with which they are interacting. This setup will also affect the sense of security mentioned in the feedback of the first iteration as well; less layers, less confusion. The increased focus on actions and activities provided by the Ribbon menu, as well as the possibilities to evolve the tool either by oneself or together with other users via perspectives, available programs, and OpenSource, supports both Activity theory and theories on cooperation. In Figure 26, below, the bottom panel of the work task space has been extended with different tools available from the Ribbon menu. Note, however, that it is only a prototype and that continuous user input is needed in order to tune the application.

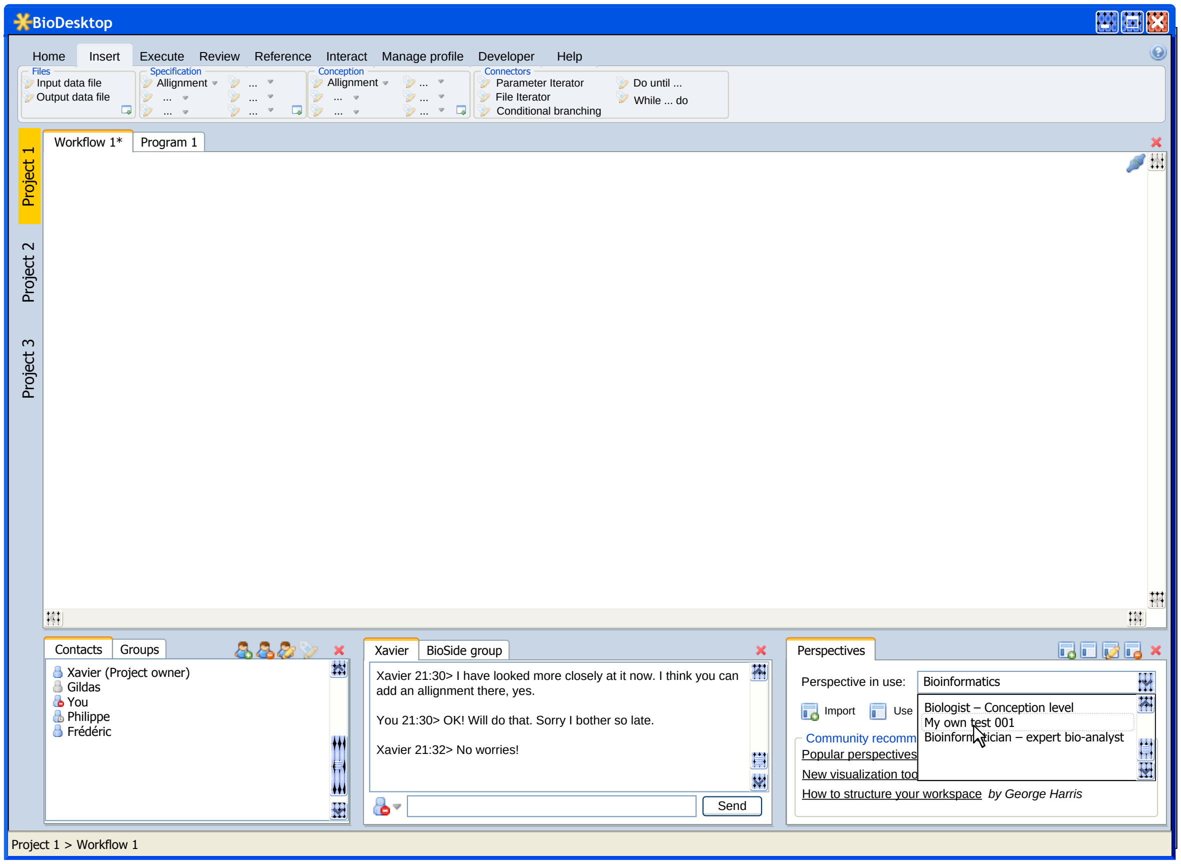


Figure 26: Design proposal with tools from the Ribbon menu added to the bottom panel of the work task space.

Furthermore, as seen in Figure 26, above, one user can have several projects open in one session. The user does also have the possibility to have several workflows connected to each project. This increases the user's possibilities to compare workflows, programs and executions in a completely new way; an activity that will lead to the creation of new, and adaptation of present, knowledge. Additionally, one can also open and edit programs if one has enabled the Developer menu tab. During the discussions it became evident that the active roles were to design workflows, whereas the expansive roles were to develop the interface and programs used for creating workflows. Due to security issues, and credibility and validity of the workflow outputs, it is important that the users cannot adapt featured programs, unless they really want to. This is managed by keeping the Developer menu tab hidden unless the user has chosen he/she wants to have accessibility to program development and tool management.

The "view tabs" previously attached to each workflow project in the initial design proposal have also been moved to the Ribbon. The tabs contained different views of the same workflow project; one could view a projects workflow, search, history, context, sharing of data, execution and publication of workflow. The activities relating to the "views" are accessible from the Ribbon and grouped with other actions related to the same activity. One exception though, the Publish feature has been completely removed. According to the domain experts the share functionality is enough and a publication could rather be a link to a published article relating to that same workflow.

4.2.2.3 CapExBio on a technical level

But how do all these new features discussed in this paper fit together on a technical level. During discussions with Philippe Tanguy and Sebastien Bigaret regarding the technical architecture an interesting approach emerged. In Figure 27, below, one can find the proposed technical architecture of BioDesktop. The BioDesktop environment is going to be a server-client system, which communicates with a BioDesktop Content Management Server situated at TELECOM Bretagne. It is the BioDesktop Content Management Server who connects the BioDesktop application and community site. The BioDesktop application has two parts; the $\text{BioDesktop}_{\text{HCI}}$ and the $\text{BioDesktop}_{\text{CORE}}$. When installing the software one can choose to install the whole package on a local platform or to install $\text{BioDesktop}_{\text{CORE}}$ on a separate machine and execute all programs on that platform while $\text{BioDesktop}_{\text{HCI}}$ is run on a local platform. Furthermore, several web services providing programs to the BioDesktop environment are connected to the $\text{BioDesktop}_{\text{CORE}}$. This means that if the BioDesktop environment is not connected to the internet it will not be able to access the web services and it will not be able to talk to the community site. It is the communication with the internet that will make it possible for the environment to give the users added value.

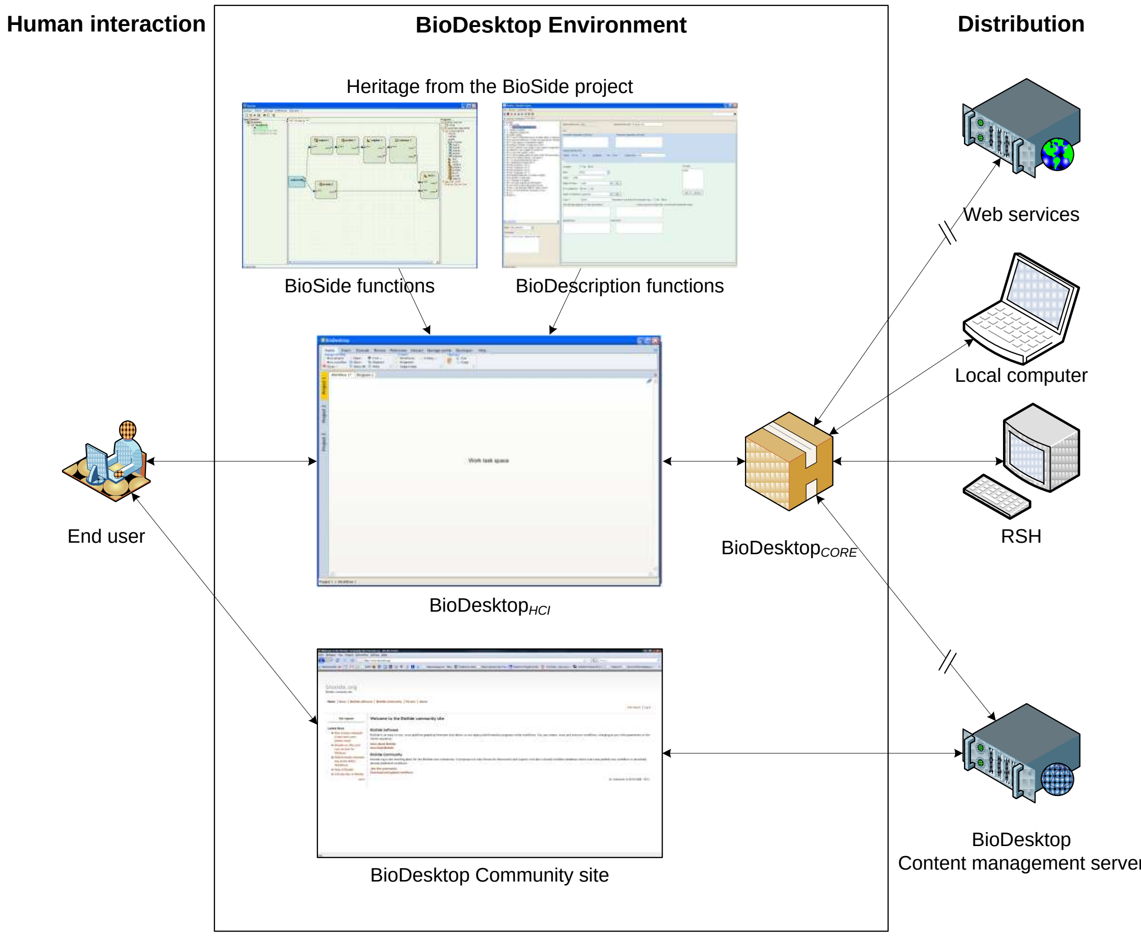


Figure 27: Proposed technical architecture of BioDesktop

4.2.3 Evaluation and Feedback

Due to vacation and, thereby, a lack of team members, no evaluation and feedback of the second iteration could be performed before the due date of this diploma work. It will therefore be on the responsibility of the project team to finalize the second iteration and initiate the third iteration based on these findings. The input from this iteration will be necessary when the team shall approach the users and their work during the third iteration.

5 Conclusion

This diploma work has had three main objectives:

1. Look more closely at the constraints of the project plan and, if necessary, make alterations
2. Evaluate system design approaches and set up a set of methods with which the design process can be approached
3. Initiate the design process

In this chapter the results from each of the three objectives will be discussed.

5.1 First Objective

Look more closely at the constraints of the project plan and, if necessary, make alterations.

The execution of the first objective exposed several problem areas relating to the execution and management of the project; issues that, if not dealt with, could most likely have a negative effect on the outcome of the project, and therein the system design.

The two main problems within the CapExBio project are the project management and the user involvement. These are issues that also are ranked by the Standish Group as the two main reasons for projects being either challenged or failed. Extensive discussions regarding these risks have been conducted, but it is of outmost importance that the project team continues to perform risk assessments. The evaluation of the project plan and the risk assessment showed the importance of user involvement. These learnings were also useful when looking more closely at the choice of system design approach for the second objective. Furthermore, it is of outmost importance that the team members' competences and time are spent wisely.

Another risk area is the legacy and brand-identity issues of the project. The preceding BioSide project had problems with both issues and there was a concern that these issues would be inherited if no precautions were taken at an early stage of the project. One major problem with the BioSide heritage was the pride among the team members for their achievements and their own work. This posed problems on the current project because the BioSide project was conducted without any extensive user input nor feedback. Due to the preceding project's success one could sense an indifference towards extended user participation, and it was hard to make the project team understand the importance of real user participation, both when it comes to user satisfaction and ROI[42]. In order to break this

[42] ROI is an abreviation for Return on Investment. ROI is a "performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments. To calculate ROI, the benefit (return) of an investment is divided by the cost of the investment; the result is expressed as a percentage or a ratio." (Investopedia: A Forbes Digital Company)

pattern one approach was to try to move away from the preceding project and its heritage. For instance, the new product will, most likely, take on the name BioDesktop which reflects the products services, focus on the users' work at the desktop and it is a name that works well with researchers from the genomics community.

It was hard to make the team members move away from their safe zone, and the BioSide project. The biggest challenges for the project team are to reach out to the users and begin conducting proper user studies in accordance with the proposed system design methods, and to use the resources wisely and in accordance with project management best practices. Thus, move away from the academic approach towards a more business oriented one.

5.2 Second Objective

Evaluate system design approaches and set up a set of methods with which the design process can be approached

The design approach chosen for this project was the UCSD process by Jan Gulliksen and Bengt Göransson. This choice was based on the results from the first objective, as well as the results from the studies of the two main fields of system design; Usability Engineering and Interaction Design. There are a series of different approaches available that tries to combine the two doctrines, but as far as this project is concerned the flexibility and iterative approach of the UCSD process makes it ideal for the project's purposes. In chapter 3 System Design, on page 13, a series of methods useful for the project team when conducting their development work was presented. The UCSD process will, thanks to its iterative design, cover the whole lifecycle of the CapExBio environment. In order for the system design process to merge with the project plan, alterations were made to the project plan. These alterations made it possible to approach the system design process iteratively rather than incrementally as was initially proposed.

However, due to difficulties getting hold of user participants, the question whether the system design approach should be considered user-centered, or not, is of interest. As mentioned earlier, the project team did not prioritize the user involvement. Why it was so, has however not been clarified as of now. Either way, it is alarming considering the negative consequences it might have on the project outcome. What would be needed is some sort of formalized milestones that needs to be fulfilled in order for the project team to continue on to the next step of the UCSD process. If these milestones are not fulfilled, the process should not be considered as user-centered and the team should not proceed before set milestone is fulfilled. In the ISO 13407 (Human-centered design processes for interactive systems) standard, the definition of user-centered design is based on four characteristics. These are:

- *Active involvement by user and a clear understanding of the user's and the tasks needs;*
- A sound allocation of functions between user and technology;
- Iteration of the design proposals;
- Cross-disciplinary design.(Gulliksen and Göransson, Användarcentrerad systemdesign 105)

In this case, the first criterion is not fulfilled, which means that the second bullet cannot be evaluated. However, the third and the fourth criteria could be considered fulfilled. Thus, in order for the project team to say they perform a user-centered system design process, and thereby minimize project failure (or increase project success) and increase the sponsors ROI, they need to find a way to get active user involvement and a real understanding for the users' work, as well as, keep a sound balance between usability and functionality. What these milestones should be defined by the project team based on the ISO 13407 standard. It needs to be milestones relating to previous mentioned ISO standard and all members of the project team should agree on set milestones, which they then can work together to uphold and follow through.

5.3 Third Objective

Initiate the design process

The UCSD process was received with much enthusiasm by the team, but the CapExBio project is suffering from immense problems with user focus and there are probably more reasons than one to why this is the case. If the project is to be successful, the team members need to step away from all the familiar, general, fancy-structured models of the academic world and get their hands dirty meeting the users face to face and really study their work and needs. As mentioned in previous section the intent was to use a user-centered system design approach. However, as of now, except for the overall process structure with analysis, design and evaluation, with following feedback, the process was never user-centered. The first iteration was solely literature studies of general aspects of cooperative work and knowledge capitalization within communities. These findings, however, are crucial for the progress of the project. Especially for the project team when they are to face the users during their user studies, design sessions and evaluations when moving towards a more user-centered design process. There they will have to know and understand the underlying factors that influence the users on a technical, individual and organizational level. Furthermore, with the first very general design proposition based on Activity theory, the threshold for the user studies should have been lowered and it should be easier to approach the users with the help of the domain experts, which were a big part of the second iteration.

5.4 Learnings for Future Iterations

This project lost a lot of time in its initial stages due to lack of project management and user participation. Thus, it is especially important that the project team perform continues scope creep management and risk assessments throughout the rest of the project; it is imperative that the project team sees to that the project plan and all its subcomponents are in line with the vision, goals and objectives. The usability and usefulness of the end product can be secured and supported to the fullest, and the success of the project maximized if the project team puts more focus on project management and user participation. Good usability and usefulness will give the best impact on the market and among its future users, and the software will act as a strong marketing factor in itself via word of mouth.

Appendix 1: Initial Project Schedule

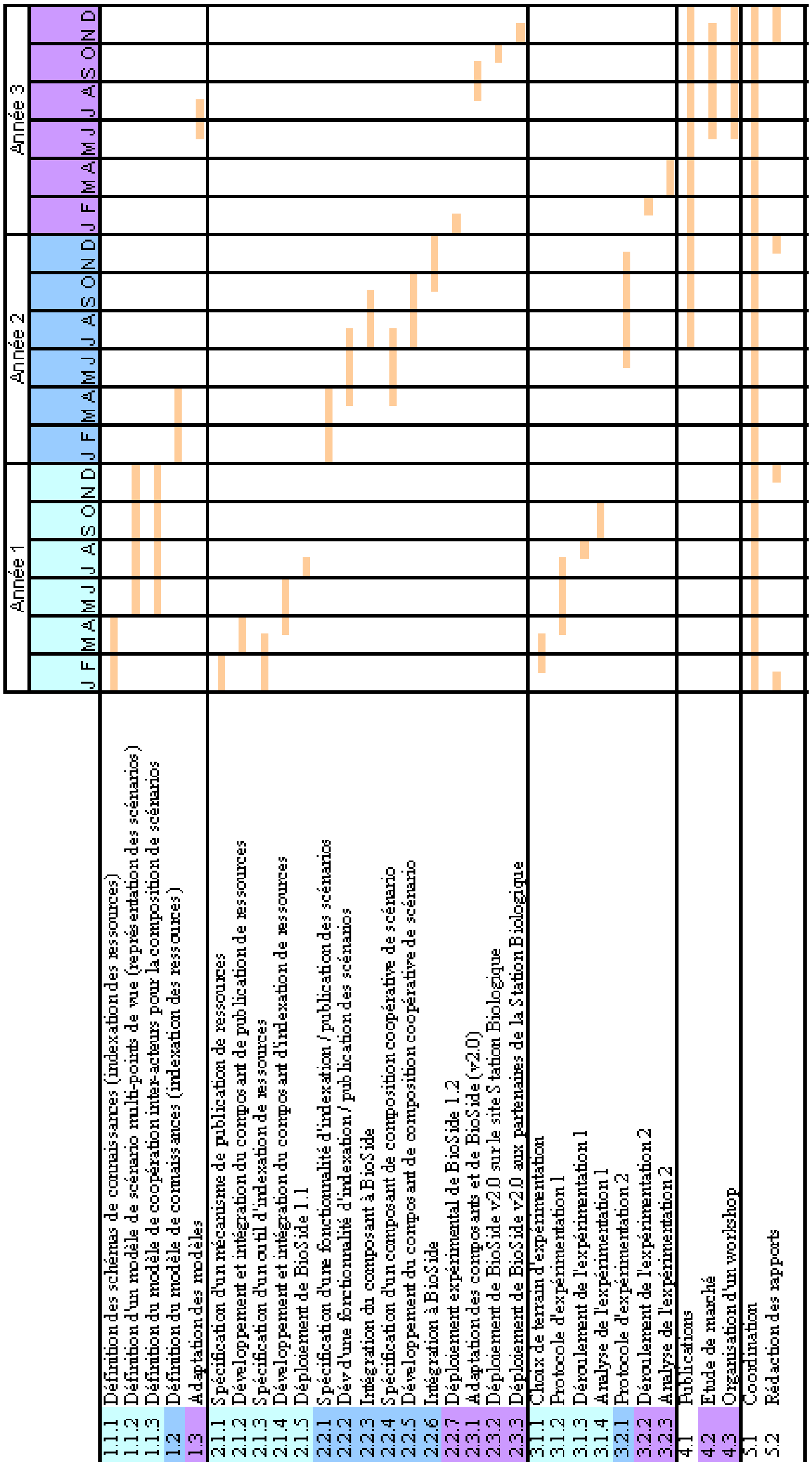


Figure 28: Initial CapExBio project plan (Picouet 15)

Appendix 2: Basic Support Types

The basic support types are considered in more detail below and relates to the tables presented in the paper. The descriptions below are quoted from the book section “The concept of an activity as the basic unit of analysis for CSCW research” by Kuutti.

Passive role

Routine automation: has been the old cornerstone of all computer applications replacing the work of a person by automating some accurately defined routines. Control of somebody using information technology. Counting of the customer throughput of a cashier etc.

Fixed division of labour. A computer system place the people automatically in a defined relation with others. The different work positions are strictly defined by a system -e. g. between a clerk (data input) and a supervisor (data use) etc.

Triggering. A computer system produces a triggering impulse for preplanned actions - various alarms etc.

Data. The object of the work can reside in the computer, but for passive participants it is merely 'data'.

Separation. A computer system may separate the members of a work community from each other and make them invisible.

Active role

Tool. A computer system is used to produce and transform an object. Examples: Text processing, diagram drawing etc. When used by a group, this needs a corresponding object (shared material).

Shared meanings. A computer system makes a set of existing rules and shared meanings more easily accessible.

Active coordination. A computer system helps a community of active subjects to coordinate their efforts.

Search of relevant information. A computer system enables the finding of additional information. Examples: database queries, running a ready-made spreadsheet model.

Shared material. A computer system helps several people to transform an object together by giving them access to the shared material.

Visible network. A computer system forms a network which promotes the existence and visibility of a community. Example: e-mail within an established work group.

Expansive role

Tool or routine construction. A computer system enables the automation of a new - not predefined - routine or the creation of a new tool for handling objects. Examples: Devising of a letter form, building a spreadsheet model, programming.

Rule construction. A computer system helps in negotiating a new set of rules for a community.

Work organization. A computer system helps in generating a new work organization.

Learning, comprehension, innovation. A computer system enables the construction of a new mental model of an object. Example: what-if analysis with spreadsheet models, visualization.

Object construction. A computer system enables a phenomenon to become a common object of work.

Community construction. A computer system helps in creating new communities or establishing new contacts. Examples: Creation of a new e-mail posting list for a new project team, using UNIX News or some other bulletin board in asking help.

Appendix 3: Hand-out to Domain Experts at SBR

To get an understanding of the users and their work tasks, one need to do user and work task analyses. There are different ways this can be done. The method used in the CapExBio project is a part of the Contextual Design Process, by Karen Holtzblatt and Hugh Beyer. Their method is called Contextual Inquiry and calls for "one-on-one observations of work practice in its naturally occurring context"(Wikimedia Foundation, Inc.). By participating and watching how the user does his/her work the researcher can get an understanding for the work to be done. This method is very well suited as it provides an insight into the users work conditions, user categories, informal organization structures, "tacit knowledge", use frequency, et cetera.

In the following three chapters, one can read more thorough descriptions of the three main activities during the analysis stage of the design process. Some best practices are also included as well as some example questions for each analysis stage. One begins with the User Analysis to get an understanding of the objects of study. When the user domains are described and characterized one continue with the Work Task Analysis which aims to establish what activities and sub-activities are performed. Finally, one tries to establish what type of information and information carriers are needed to perform these activities.

User Analysis

When doing the user analysis one needs to answer the questions: "What are the user categories, for whom is the system developed and what characteristics do these categories have?" (Gulliksen and Göransson, Användarcentrerad systemdesign 220) Gulliksen and Göransson propose some relevant questions, such as:

- *What is the users' level of experience of the task to be performed*?
- *What is the users' educational background?*
- *What is the users' experience level with computers?*
- How much effort will be spent on training?
- Use frequency?
- In what environment will the system be used?
- Will there be users with physical disabilities? (Gulliksen and Göransson, Användarcentrerad systemdesign 221)

The result of a user analysis could be presented as user profiles or design recommendations, or act as a foundation for a requirement specification.

Work Task Analysis

If the user analysis answers the question of which user categories there are, then the work task analysis should answer what tasks the users perform, and how these are performed. Gulliksen and Göransson propose the following questions to exemplify:

- Why is the user performing a certain task?

- How often is this task performed?
- How long does it take?
- What steps or maneuvers are needed to perform the task?
- Does the user collaborate with another user?
- What tools or artifacts does the user need to perform the task?
- *Are there a lot of critical tasks or "bottle necks", which makes the task more difficult to perform?*
- How can the situation and the information support be improved? (Gulliksen and Göransson, Användarcentrerad systemdesign 222)

By making a thorough user and work task analysis, the amount of functions in the system can be held as low as possible which makes the system more easy to use. In order to have a successful user centered project the work task analysis is of outmost importance and it keeps the size and complexity of the system to a minimal. (Gulliksen and Göransson, Användarcentrerad systemdesign 222-223) Interesting here is the strong connections between the user and work task analysis and Activity theory.

The following best practice will be used when summarizing the data collected from the work task analysis:

- *Formulate the users' goals and milestones.*
- Always formulate a global goal with the whole interaction.
- Formulate the approaches to achieve the goals.
- *Make a breakdown into "width first"* – identify common work tasks.
- Stop the breakdown when the leaves in form of specific work tasks have been reached.
- Using pen and paper can make the work a lot easier, e.g. Post-It Notes. (Gulliksen and Göransson, Användarcentrerad systemdesign 224)

Usability goals, which can be followed up during the evaluation phase, should be formulated.

Information Usage Analysis

Today, a lot of the work performed is in some way connected to knowledge management or data treatment. In the CapExBio project is identification, creation, harvesting and organization of knowledge as well as sharing, adaptation and execution of knowledge critical for the success of the project. This applies not only to the knowledge capitalization within the project but also to the cooperative part of the project, as well as for the success of the activities to be performed by the different users. The information usage analysis is therefore very important to conduct. It is therefore not only necessary to analyze what information is to be used, but also how it will be used. It is important to create a system that presents information in a relevant way so the user's cognitive capacity is free for the actual work. The analysis can also help showing on functional adaptations that might be of use for the users. "It is an analysis which purpose is to describe which decision and assessment tasks are present in the work and how data is used to solve these tasks."(Gulliksen and

Göransson, Användarcentrerad systemdesign 226) Together with one or several users from each user category the following activities have to be performed:

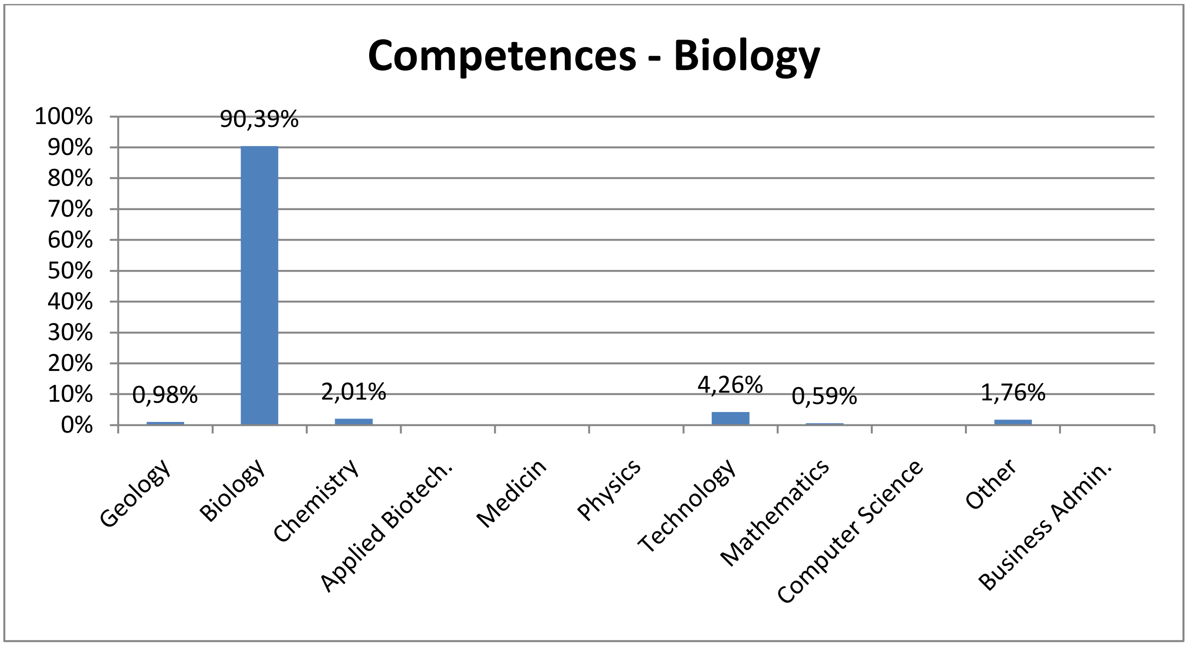
1. Make a general description of the work content.
2. Gather copies of, and describe all sorts of, information carriers that are being used.
3. Describe all management routines used with each information carrier.
4. Describe what decisions and evaluation tasks that are part of the work.
5. Describe what information amounts (variables) that are being used in each of the different decision and evaluation situations mentioned above.
6. Analyze the material for each decision and evaluation situation.
7. Describe concurrency demands on the data.
8. Information amount and variable properties.
9. What must be done, e.g. how the decision/evaluation is being documented.
10. Analyze the material in terms of what decisions and evaluation situations that needs to be done at the same time. This defines work situations. (Gulliksen and Göransson, Användarcentrerad systemdesign 226-227)

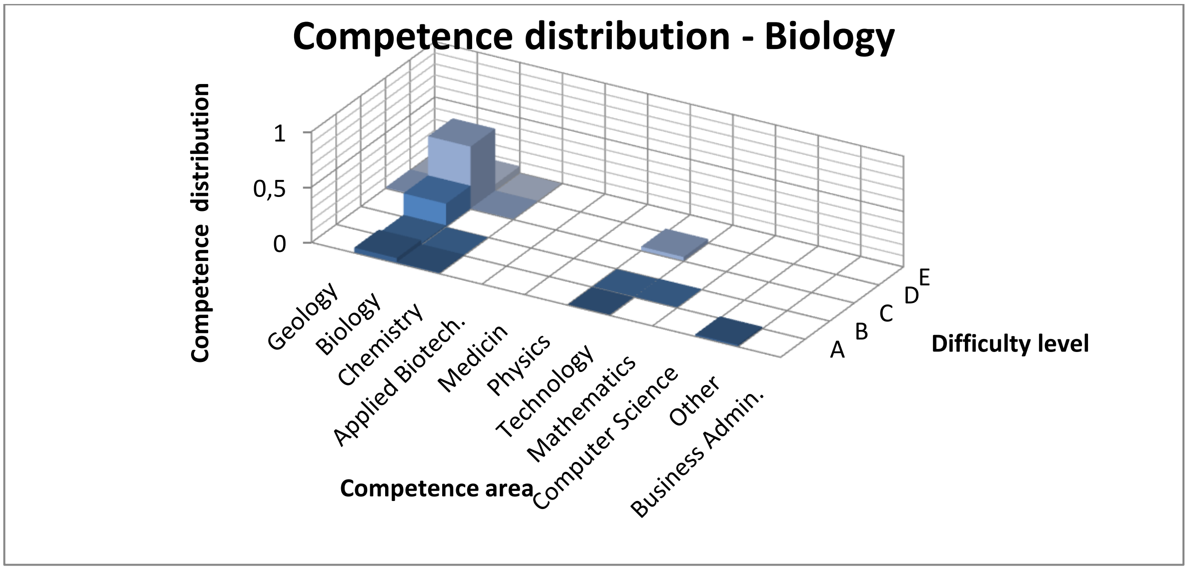
One question that arises is how to document the information retrieved from mentioned activities. In a document the following paragraphs should be listed:

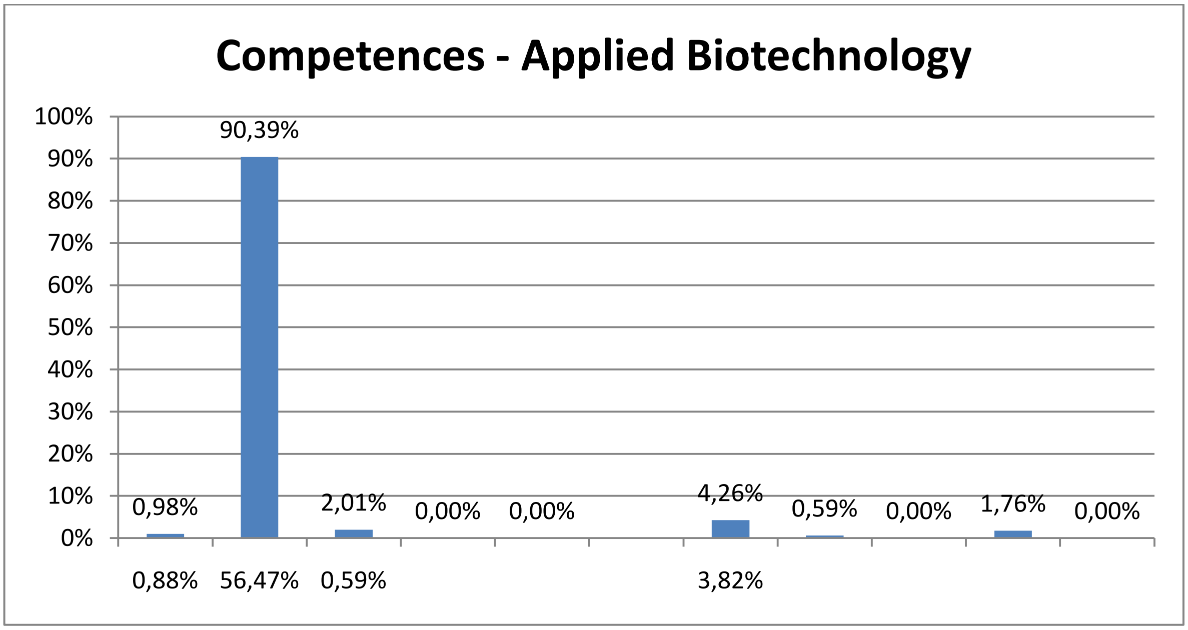
- A description *of the work process of a "typical" day, week, or another appropriate time unit.*
- A list over work tasks
- A list over work situations[/contextualized work tasks]
- A list of variables with properties for each variable
- For each decision and evaluation: A list of used variables
- For each work task: What needs to be performed. (Gulliksen and Göransson, Användarcentrerad systemdesign 232-233)

By doing an information usage analysis important information about the users' work can be discovered. The information usage analysis can complement prior data models and can act as a good foundation for future design decisions.

Appendix 4: 2nd Iteration User Competences Analysis



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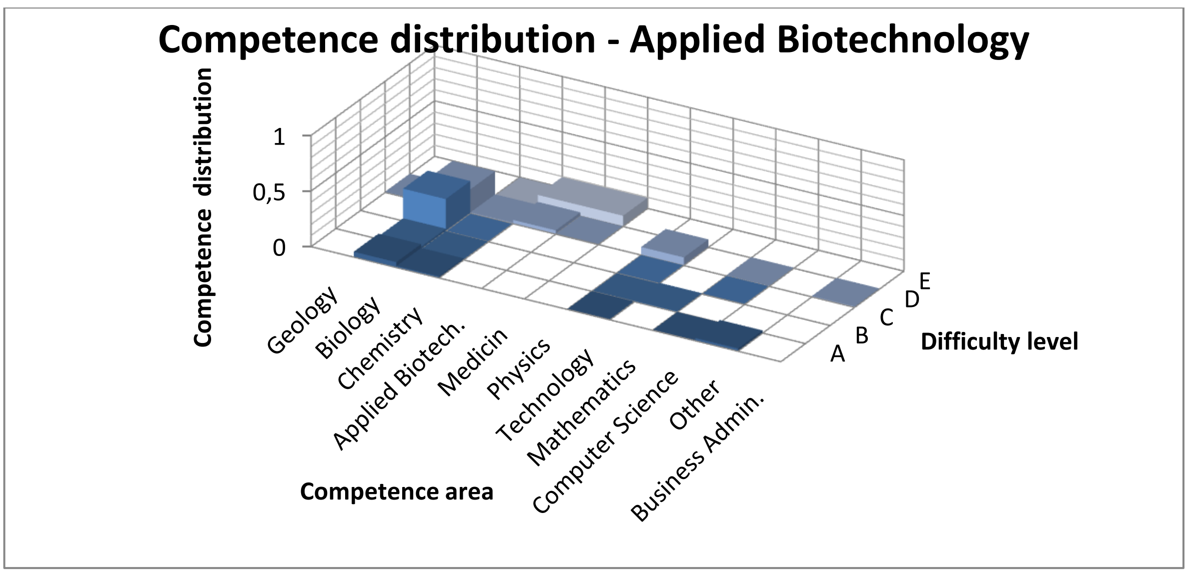
Competence distribution - Applied Biotechnology
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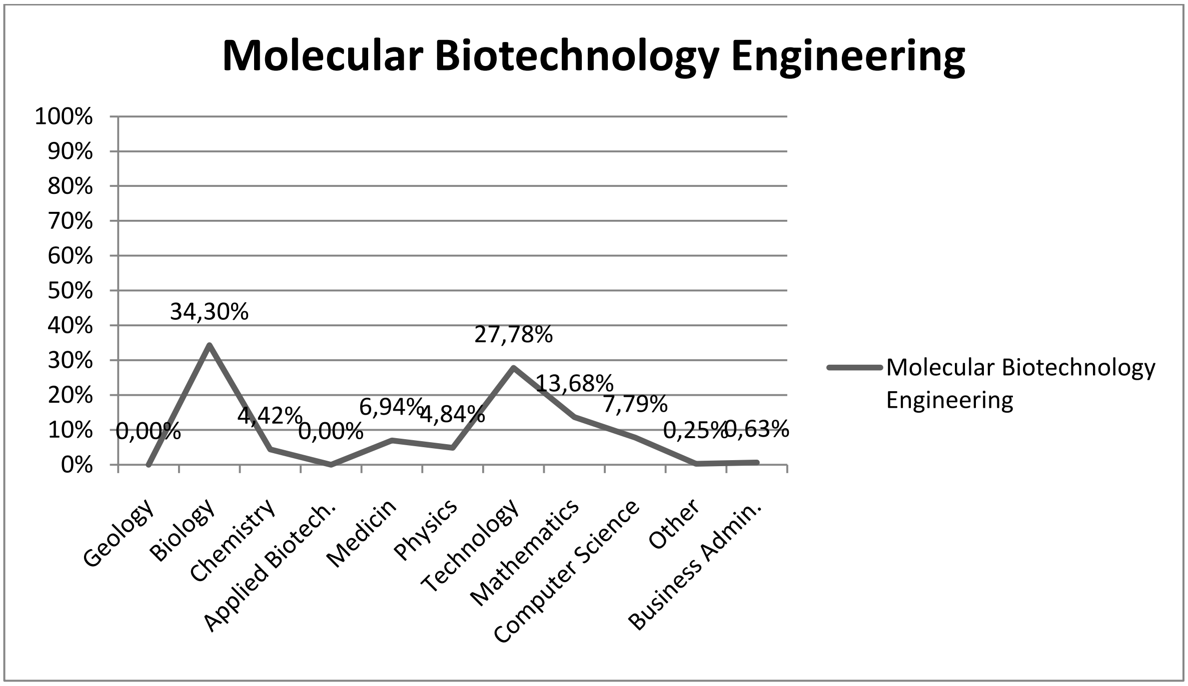
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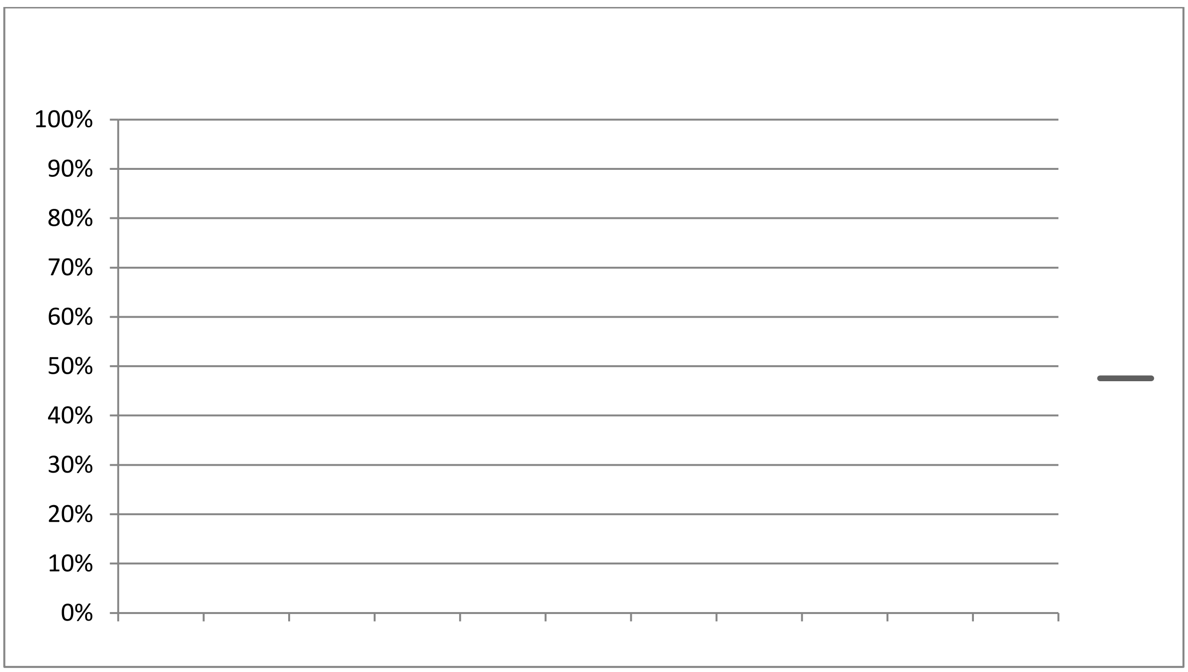
Molecular Biotechnology Engineering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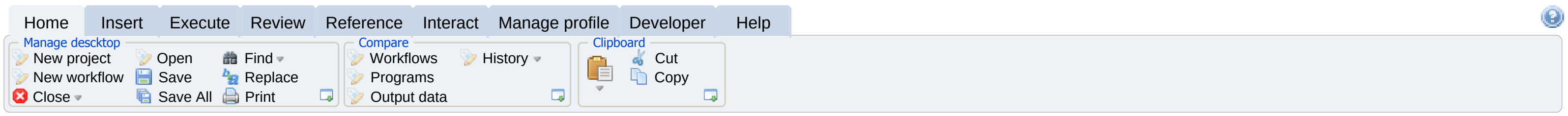

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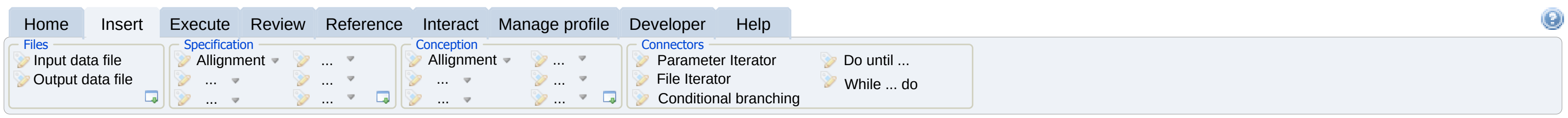
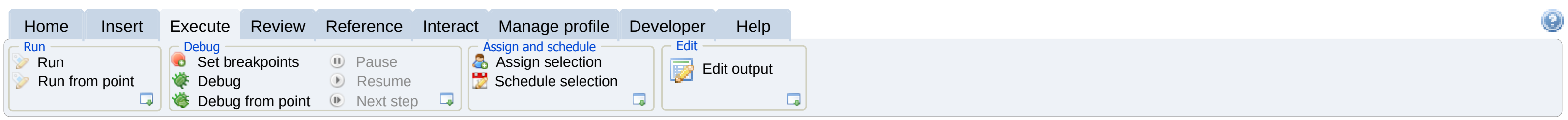
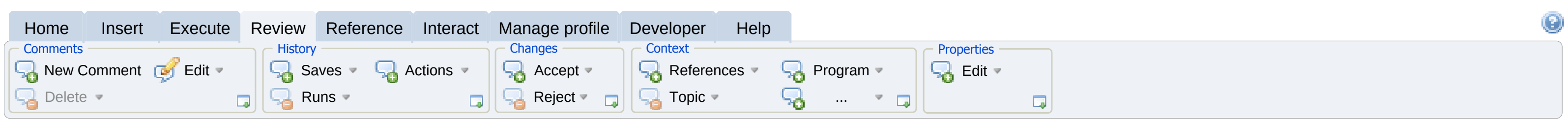


Execute



Review



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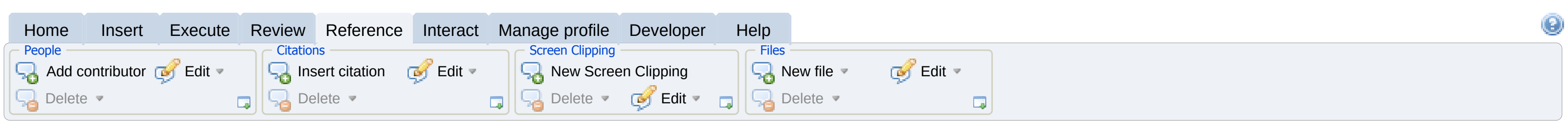
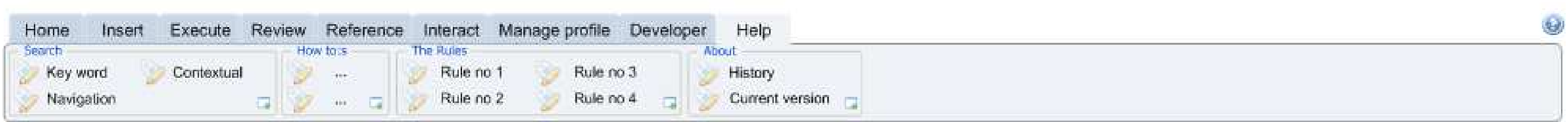


Interact

Manage profile

Developer

Help



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