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Project Discovery

Advancing scientific research by implementing citizen
science in EVE Online

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Abstract

Classification of scientific data can be hard – even for computers. In recent years methods have been developed which allow individuals, with minimal knowledge, to help scientists classify and tag such data while playing video games either consciously or unconsciously.

In this report we introduce a modified version of a video game, within the *EVE Online* client, entitled *Project Discovery*, where the goal is to classify images of cells by observing protein patterns.

This work was part of a B.Sc final project in the School of Computer Science at Reykjavik University, fall 2015.

Partner references

“The previous half year we had Hjalti Leifsson and Jóhann Örn Bjarkason on the team of Project Discovery. The project posed several challenges to the students from the utilisation of diverse technologies to the project team being in different geographical locations (Iceland, Sweden, Switzerland, USA). Hjalti and Jóhann made an excellent job of overcoming obstacles and implementing the in-game citizen science client - taking it from a prototype phase all the way to production quality. Their motivation was unquestionable and they were also very good team players.”

Attila Szantner - MMOS

“Hjalti and Jóhann have both proven to be highly intelligent, self-motivated and dedicated in their work towards making Project Discovery a reality. They have brought this feature to a high standard of quality that even a seasoned developer at CCP could be proud of. As a part of their project, they prepared a demo build that CCP was able to put into the hands of our players at an EVE player gathering in Vegas, and the reception was spectacular. They really made this project their own and it’s been a privilege to be on this mission with them.”

Pétur Örn Þórarinsson - CCP

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1 Introduction

Many scientific projects produce a large amount of data that can be beneficial for other research projects to analyze, tag or classify. Most often, this work can be conducted by a computer program, given that the structure of the data is relatively simple. In other cases, time- and space complex algorithms need to be applied which either do not exist yet or they are not executable on computers as we know them today. Many of these classification problems can be solved by the human eye, but for large data sets that can be a time consuming and expensive task.

The amount of data to analyze can be tremendous and it could take scientists years to work through them. In most cases, the analysis of such data is simple enough for humans with minimal training to perform. If ordinary citizens could be motivated to solve real world scientific problems like analyzing data, we could release the huge bottleneck that is throttling the modern scientific community of the world.

That's where Games with a purpose (GWAPs) come in. In GWAPs people perform basic tasks which cannot be automated, the players might not be personally interested in solving an instance of a computational problem, instead they simply wish to be entertained [1].

The purpose of this project was to design and develop a GWAP based game to help a project named the Human Protein Atlas¹, to improve their publicly available database of images of human tissue and cells, by having ordinary citizens play a game for fun and meanwhile, analyze and identify protein structures in human cells.

Using games to motivate citizens to do science has already been proven useful in the past, with games such as FoldIt [6], where players compete to find the lowest energy state of a protein, thus helping research in the prediction of protein structures, and Galaxy Zoo [7], where players help each other classifying astral bodies in order to find out how galaxies are formed.

These games were successful and people all over the world enjoyed them while competing against each other though scoreboards. However, a problem arose when new players, who were interested in the concept, tried the game out for a short period of time and then never revisited the game. That is, these games had relatively bad retention rate. [15]

One possible, and yet to be proven, solution to increase user retention is to inject such games into an already existing game with a large player base, where people are returning daily to play, have been doing so for years, and will hopefully continue to do so for years to come. This way we hoped to solve the difficult problem from previous citizen science [16] projects by giving players in-game rewards that they can use outside the project, something that was already of value to them in the existing game. This provides further motivation, a source of in-game rewards for solving relatively simple tasks is something no player should miss out on.

¹<http://www.proteinatlas.org/>

The game that we injected our GWAP based game, called *Project Discovery*, into was *EVE Online*, the hugely successful massively multiplayer online role-playing game (MMORPG), made by the Icelandic video game developer CCP Games [2]. *EVE Online* is played by tens of thousands of people around the world at any given time [10], so it provides a great platform for a GWAP to reach a tremendous amount of people.

In this report, we seek to illustrate and outline the nature of the project, and the work done by us in the available time frame. In section 2, we discuss the problems the project faced and the solutions we offered, as well as listing and discussing the numerous partners to the project, and what benefits they brought. Finally, we explain the previous work already committed to the project before our arrival.

In section 3, we explain the gameplay of *Project Discovery*, as well as outlining the network communications necessary for the project, the architecture of the code, and finally we discuss the *Project Discovery* website that we created alongside the game.

In section 4, we discuss a user test that we performed with an early version of *Project Discovery*. Its purpose was to expose any game breaking bugs and test the user experience of the newly created tutorial interface, alongside the overall gameplay. The results of the user test were positive, we learned that the tool-tips we used contained too much text, and that the tutorial needed to be more difficult. We also noticed that players got less interested in getting the correct solution when they did not receive immediate feedback in some cases. As a result, we changed the tutorial to be harder and shortened the text on every tool-tip, so that new players will be more inclined to actually read them. We also give players immediate feedback for every submission, to keep the player interested for longer.

In section 5, we discuss the methodology we used which was Scrum, why we chose it and how it worked for us during the project. We also go over the initial plan for the project, in terms of the team's capacity and the stories we intended to implement. Finally we discuss the actual progress of the project for its duration.

In section 6, we discuss the future work for this project, and how the *Project Discovery* client has been designed with the express goal in mind to be able to incorporate other science projects into *EVE Online*.

Finally, in section 7, we conclude this report, and discuss what we learned from this experience, what we would do better if we could do it again, and how the overall progress went. We also thank the various collaborators that helped us along the way, and showcase the attention that *Project Discovery* has garnered in Iceland and abroad.

2 Background

In this section we discuss the concept of GWAP and how this project is related to that. We name the partners, and their participation in the project. Finally, we outline previous work already committed to this project by previous students.

2.1 Game with a purpose

In the modern world a lot of people play video games, either competitively or casually, in fact “the average American has played 10,000 hours of video games by the age of 21” [14]. We could do amazing things if we could channel some of that time and energy into solving large scale, real world scientific problems.

Many scientific research projects require analysis and/or classification of large datasets that for various reasons can’t be performed by computers, these include image analysis and transcribing ancient texts. Computers don’t possess many skills and capabilities that humans take for granted, such as perceiving an image and discerning its patterns.

Because humans possess complex conceptual intelligence, perceptual capabilities and pattern recognition that modern algorithms and machine learning can not yet mimic, computers can not be used to solve these problems for us; human interaction is needed. If we could use a large number of people as biological processors in a distributed computer-like system, we could solve real world large scale problems that would otherwise be considered impossible or too time consuming.

As stated above, video games are an incredibly popular medium at the moment, what if we designed a game whose purpose is outsourcing computationally difficult functions to humans in an entertaining way? These GWAPs are an implementation of citizen science and ways for regular people outside the scientific community to contribute to scientific research in various fields, and entertain themselves in the meantime.

Project Discovery revolves around just that, delivering scientific data to ordinary citizens in an entertaining way, with the express purpose of having them analyze data in a short amount of time that would otherwise take years to solve. That is why *Project Discovery* is a Game with a purpose.

2.2 Human Protein Atlas

This project’s purpose is to finish analyzing and classifying the images in one subpart of the The Human Protein Atlas (HPA), the subcellular atlas [17].

The subcellular atlas contains around five hundred thousand, high resolution, multicolor images of immunofluorescently stained cells that reveal spatial expression patterns at the subcellular level. Around half of those images have already been classified by scientists at the HPA the past few years, and by way of citizen science, we can classify the rest of these images much faster, freeing up the time of these scientists.

The HPA is a scientific program based in Sweden, and is funded by the Knut and Alice Wallenberg foundation in order to allow for a systematic exploration of the human proteome using antibody-based proteomics. The HPA contains information for a large majority of all human protein-coding genes regarding the expression and localization of the corresponding proteins based on both RNA and protein data.

The HPA consists of four subparts: normal tissue, cancer, subcellular and cell lines with each subpart containing images and data based on antibody-based proteomics and transcriptomics.

If this project succeeds, the HPA can provide a better database of images to scientists around the world, since the database is open to researchers anywhere to use. This can have drastic improvements in the fields of biological research, and really help in understanding how diseases such as cancer operate, which in turn could help finding a cure.

Moreover, if this project succeeds with an acceptable accuracy, the same method can be used on other parts of the HPA, in fact, this whole project has been designed with that in mind, to ease the transition into classifying different kinds of data.

2.3 MMOS

Massively Multiplayer Online Science (MMOS) [11], the name of the concept, and the name of the Swiss company behind it, challenges the way that citizen science is carried out today.

While current citizen science projects either create entire new games or “gamify” menial tasks for each research project, the MMOS method is to inject research projects into existing, popular games as seamless parts of their gaming experience (including mechanics, narrative, and visuals). The MMOS method benefits from the time that players already spend on existing games. Even if only a small fraction of that time can be directed to scientific projects, that can provide a huge network of human volunteers to scientific research.

For this project, MMOS provided an API, which served as a thin interface between the scientific research data from the HPA and the MMORPG *EVE Online*. It took care of everything related to the citizen science problems, such as task allocation to players, tracking and scoring player performance, giving feedback to the *Project Discovery* reward system and aggregating results for scientific research. This interface made it easier for us to integrate *Project Discovery* into *EVE Online*, since we could focus on coding the client itself within *EVE Online*. This also substantially lowered the entry barrier for CCP to implement this feature.

The MMOS method addresses the core challenges of citizen science games for the following reasons:

- **Engagement:** There is a large user base already engaged, motivated to solve complex tasks.

- **Motivation and retention:** The motivation of helping science is vital to citizen science projects. However, to keep up the long-term engagement, integrating it with in-game reward systems and other game mechanics is vital and adds an additional layer of motivation.
- **Separation of concerns:** Researchers can do their research work (defining tasks, analyzing results, communicating in research related issues) and professional game designers handle creating the in-game experiences.
- **Reliability:** Popular, massively multi-player games tend to last for many years, with some running for more than a decade with hundreds of thousands of devoted players.

This approach can offer a win-win situation that benefits all parties: scientists, gamers and the gaming industry at large.

2.4 CCP Games and EVE Online

CCP Games is one of the biggest video game developers and publishers in Iceland. CCP is best known for producing virtual worlds such as the multiple award winning game *EVE Online*, a player-driven science fiction massively multiplayer online role-playing Game (MMORPG), set in space. *EVE Online* is home to over 7,000 star systems and is frequently played by hundreds of thousands of players, with tens of thousands playing every day. CCP showed much enthusiasm for this project and was willing to see if the *EVE Online* community would show positive reactions to helping real world science while playing their favorite game. If a prototype would be well received, CCP was willing to integrate the game into *EVE Online* where the whole EVE universe would be able to participate in the project, thereby possibly activating thousands of human brains to solve the scientific problem at the HPA.

With this project, *EVE Online* would be the first MMORPG to incorporate a real world scientific project, pioneering a change that could shape the foundation of modern game development, setting an example to other large games around the world to dedicate some of their energy to help the scientific community.

EVE Online was an excellent fit for this project, since EVE is a science fiction game set in space, a scientific project like this would not feel out of context to players. Especially since the subcellular atlas from the HPA was chosen especially because its images complement the theme of *EVE Online* and look truly stunning within the client, as shown in figure 1. Furthermore, *EVE Online* players are already used to getting quite technical and difficult in-game tasks, such as the hacking mini-game. *EVE Online* gameplay is also well suited to mini-games of this sort since there are periods in the game which players spend waiting, such as camping stargates, and players could utilize those waiting periods to analyze a few images.

In order to entice EVE players to play our GWAP, we offer *EVE Online* currency for each task solved. That way the game offers the players something that is already of value to them, something that other citizen science games

were unable to do, since the rewards are usually only based within the game itself.

2.5 Previous work

This project was a continuation of work done by Reykjavík University graduates Gunnar Þór Stefánsson and Þór Adam Rúnarsson. They worked on it as their final project for the spring semester of 2015 in collaboration with the same companies as we did for this project.

They created a web prototype very quickly which allowed for basic functionality with a connection to the MMOS API. This prototype was showcased at EVE Fanfest 2015 [4] and was very well received by *EVE Online* players and CCP alike, which is why they decided to start integrating the prototype into the *EVE Online* client immediately. They used their remaining time for the semester to focus on integrating the client into *EVE Online*, and managed to create a crude version of the game before the semester's end.

They continued their work on the client during the summer of 2015 with a research grant from Rannís, The Icelandic Center for Research. In the beginning of July, Gunnar Þór Stefánsson left the project, and Hjalti Leifsson replaced him. The work continued until Þór Adam Rúnarsson left the project and Jóhann Örn Bjarkason joined at the end of August, when Reykjavík University offered to continue the project as a final project.

When we started the project, the game itself was at a prototype stage within the *EVE Online* client. The user interface had a hexagonal category selection feature as well as header and footer elements according to the current design. The game was able to connect to the MMOS API using HMAC-SHA256 authentication [9], receive new tasks and submit classifications. A simple rewarding system was already in place, rewarding players with in-game currency (ISK), experience points (XP) and loyalty points (LP) when players submitted a solution. When the client received a response from the API, it calculated the appropriate rewards, and displayed a rewarding screen. Finally, a rudimentary tool-tip based tutorial phase was implemented, which explained the interface to the user. Nothing else was implemented at that point in time, and that is where we started work on the project, implementing the remaining features according to design with help from CCP Games and MMOS.

3 Project Discovery

In this section we discuss the *Project Discovery* game in detail and explain how its played. We describe the communications between the game and the MMOS API. We outline the architecture of the game client and how it relates to the *EVE Online* client. Finally, we go over the website we built to go along with the game launch. The purpose of the website is to describe *Project Discovery* and the science behind it.

3.1 Gameplay

The objective of the game is to classify images of cells correctly by observing the protein patterns of the images (which are stained green) and matching them to the correct categories. The typical gameplay flow is as follows: The player opens up *Project Discovery*, an image is loaded and the player studies the image. To help the player do so we implemented a magnification function which allows the player to zoom in on the image by hovering over it with his cursor, this gives the player the full resolution of the image and enables him to examine its details very effectively. There is also a mini-map in the bottom right corner of the zoomed in version which shows the player the position of the zoom. This magnification effect can be seen in figure 1.

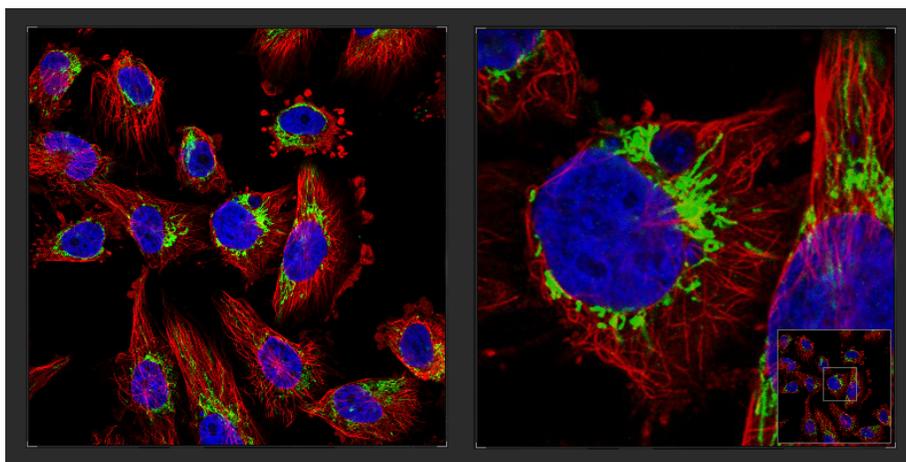


Figure 1: Subcellular image with its original resolution and a zoomed in version.

Below the image is a color channel filter which we implemented. It has four buttons which each gives a different version of the same image, with a different combination of red, green and blue although green is always present. Using the color channel filter can aid players in classifying images correctly as some patterns are more easily identified with certain filters.

The player then compares the image with the 27 categories that are available. The categories are divided into four super categories, three of which cover

different parts of the cell and one is for unidentifiable patterns. That way players can quickly see which super category they should be comparing with the image. The categories are laid out in a hexagonal pattern and each of them can be viewed more closely by hovering over it. Once the player identifies a category he feels matches the image he can select it by clicking it. An image can match up to six different categories although most images match one to three categories. When the player is satisfied that he has selected all the relevant categories he submits his classification by clicking the submit button. What follows then depends upon which phase of the game the player is currently at, we will discuss those phases later.

Players always get rewarded for submitting solutions to images based on their historical accuracy which we call an accuracy rating. This way we can reward players instantly based on how good we have calculated their accuracy to be. Players start with a 50% accuracy rating, and they can raise that rating by classifying images correctly. The accuracy rating is affected instantly if we already knew the solution to the task a player submitted. However if a task is unknown then all the players, who submitted that particular task, get an updated accuracy rating once the task has reached a consensus.

3.1.1 Game tutorial

When a player opens up *Project Discovery* for the first time he must start by going through a tutorial phase. We created the tutorial from scratch with the exception of some tool-tip functionality which was already in place, although we refined it. The purpose of the tutorial phase is to allow the player to familiarize himself with the controls and the user interface of the game, as well as teaching him the basics of analyzing subcellular images. To achieve this we first introduce the player to the controls by using tool-tips which explain the functionality of each control element, one at a time, while also allowing the player to interact with the controls. A typical tool-tip of this kind can be seen in figure 2.



Figure 2: Tool-tip explaining the cytoplasm category.

Once the player has gone through the tool-tips he gets his first image to analyze, this image is the first stage of seven in the tutorial. Each stage contains one image hand picked by scientists at the Human Protein Atlas and it presents a gradual increase in difficulty from the previous stage. To ease the player into the game and not overwhelm him with all 27 categories, we limit the number of categories available to choose from, to the correct ones plus a few similar but incorrect categories. An example of this can be seen in figure 3.



Figure 3: Example of a tutorial stage where the categories are limited to only three nucleus categories.

When the player submits his classification a results screen is displayed. It shows the correct result by overlaying the categories the player picked with either a green correct or red incorrect texture and giving any categories that are correct but the player missed, a green outline texture indicating a missed category. The reward screen can be seen in figure 4. By giving the player instant feedback on their submission we allow the player to learn from any possible mistakes they make. Players do not have to get the correct results for the seven stages of the tutorial to advance, we believed that could be a source of frustration since it would make the tutorial longer.

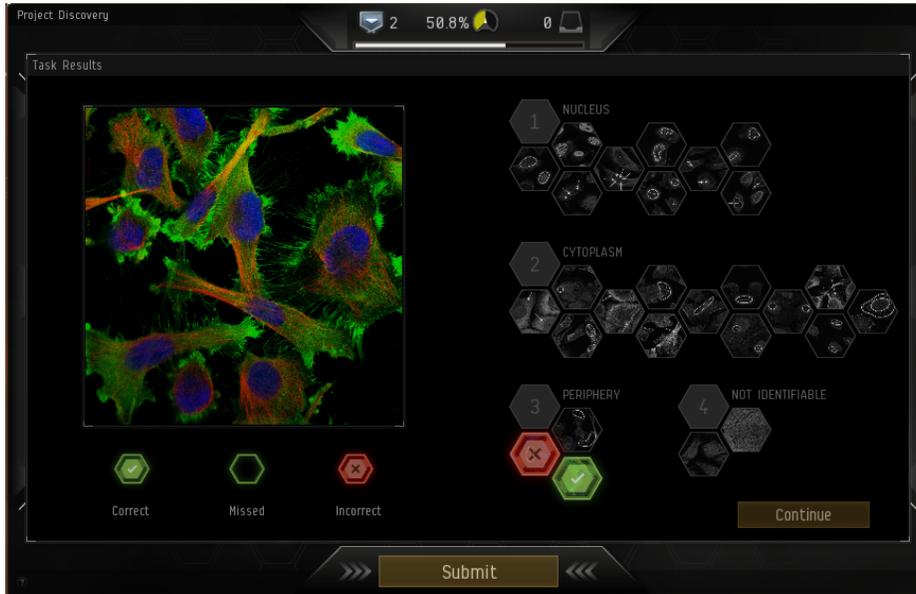


Figure 4: A result screen, which shows the player getting one category right and one wrong.

3.1.2 Training tasks

After finishing the tutorial the player receives rewards for doing so and is then moved on to the next phase of the game which we refer to as the training phase. This phase, like the tutorial, consists of seven stages containing images that have already been classified by scientists. However, unlike the tutorial, players must get the correct result in each stage to advance to the next phase of the game. The stages also increase in difficulty and are in general more difficult than the tutorial images. Players get the same result screen as in the tutorial so they can continue to learn and better understand how to correctly classify images.

The purpose of this phase is to continue to teach players how to classify images and to make sure that only players that have the skills and/or will to solve images correctly can make it to the next phase and thereby contribute to classifying images that haven't already been classified by scientists. Since players get rewards for submitting solutions based on their accuracy rating, they can extract some amount of rewards even if they get everything wrong. We had to make arrangements for players who are only interested in getting rewards with as little effort as possible. With the training phase requiring players to get correct results to be able to move on to classify unknown images, those players would never get to that stage and therefore won't contaminate the results of those images.

3.1.3 Unknown tasks

Solving unknown tasks, that is classifying images that haven't already been classified by scientists, is the main component of the game. It is through these tasks that data is generated for scientists to use. The major difference between training tasks and unknown tasks is the result screen, classifying the image itself is done in the same way as with training tasks. Since we don't know the correct classification for unknown tasks we can't give the player a result screen which reveals the correct answer. What we do instead is we show the player a screen we call a community consensus screen, as can be seen in figure 5. This screen gives the player feedback on his answer by gathering up answers from other players and displaying which categories have been chosen, how popular each category was, showing popular categories in green and less popular ones in red. This way the player can't be certain of the correct result but it gives him a sense of what it could be. Giving the player feedback to his solution, even though it is not complete, is integral to keeping players interested and engaged with the game.

When a certain number of players have agreed on a solution of a task, the task is considered solved and is no longer in the rotation of tasks served to players. The tasks that are considered solved are gathered by the API and made available to research scientists.

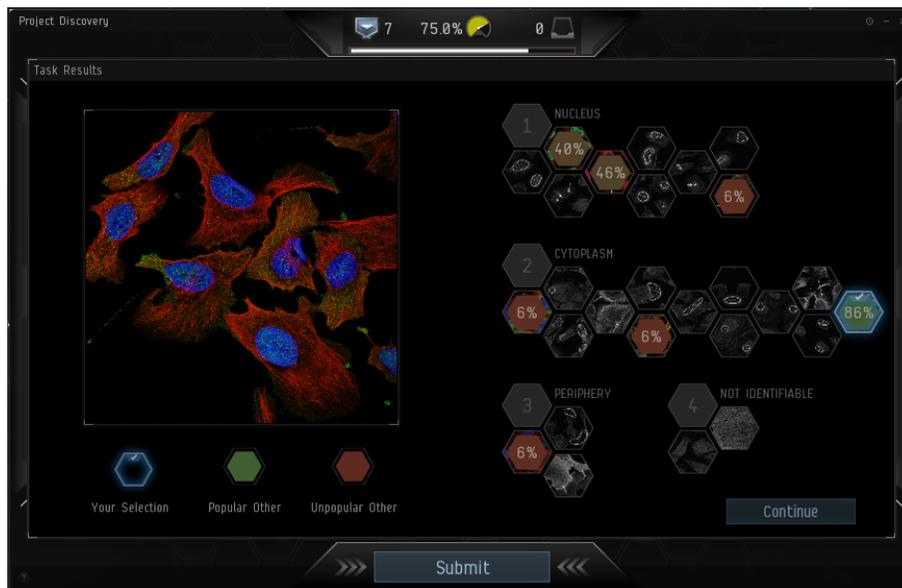


Figure 5: Typical result screen for unknown tasks.

3.2 Network Communications

The *Project Discovery* client utilizes a connection with two different parts, the EVE server, and the MMOS RESTful API, which uses the Amazon CloudFront content delivery network and an Elastic Beanstalk container.

When a player opens up the client, it automatically contacts the EVE server through a proxy, which was provided by CCP to bolster security. The server issues a POST request to the MMOS API through the proxy to ask for a new task for the player. The MMOS API then allocates a task for the specified player and fetches it from the Elastic Beanstalk container, which returns the appropriate task object to the EVE server, which finally sends it to the EVE client.

The task object includes a security pass that the client needs to access the URLs for each image that he needs for the task. Each time the client needs an image for that task, it contacts the EVE server, which contacts the MMOS API with the security pass. If that pass is still active, the Amazon CloudFront CDN returns a signed URL that leads to that image. As a security feature, the image itself is only accessible for a few seconds, so the client needs to cache the image in case the player needs to access it again. When a player has submitted his classification for the task, the EVE server issues a POST request to the MMOS API like before, and returns a solution or a community consensus that it uses to grade the player and which we can use to reward them in-game.

The MMOS API authentication uses a HMAC-SHA256 method [9], based on Amazon authentication methods. The server has an API key and secret, which are changed at regular intervals. The API key and secret are used to generate a signing key, this adds an additional layer of security, since every message is hashed with different values.

3.3 Architecture

The *Project Discovery* architecture follows *EVE Online* client architecture by example. The language used is Stackless Python, the code is located in a package within the *EVE Online* client, and contains a server side and a client side. The server side is split into two parts, the MMOS server and the *Project Discovery* server.

The *Project Discovery* server is used to contact the EVE database, to insert new players into tables and keeping track of their experience within *Project Discovery*. It also connects to the MMOS server, requesting tasks and their information, submitting classifications, and receiving player statistics. The MMOS server is the server that connects to the MMOS API through a CCP proxy. This server keeps the API keys and secrets, as well as allocating new authentication signatures each time a GET or POST request is made. This separation of the server side is necessary because of security reasons suggested by CCP employees.

The *Project Discovery* client side mostly contains code for the user interface, which utilizes libraries already existing within the *EVE Online* code base. The client side also contains all the logic for the tutorial, UI help, category tool-tips,

rewarding algorithm, animations, category exclusion, audio, scene switching, and the general handling of messages and information coming from the server side.

3.4 Project Discovery Website

We developed a *Project Discovery* website to go along with the release of the game. The website serves as an information hub for the project. Interested parties can get information about the game, the science behind the game and our partners, MMOS and the Human Protein Atlas. The website also displays videos related to the game and screenshots of the game in action. To build the website we used HTML5, Less and JavaScript. We were provided with a template from web developers within CCP which helped us make the website look professional and consistent with other *EVE Online* websites. The website boasts a vertical layout and is fully responsive, so it can be viewed on all devices. The top part of the website can be seen in figure 6.

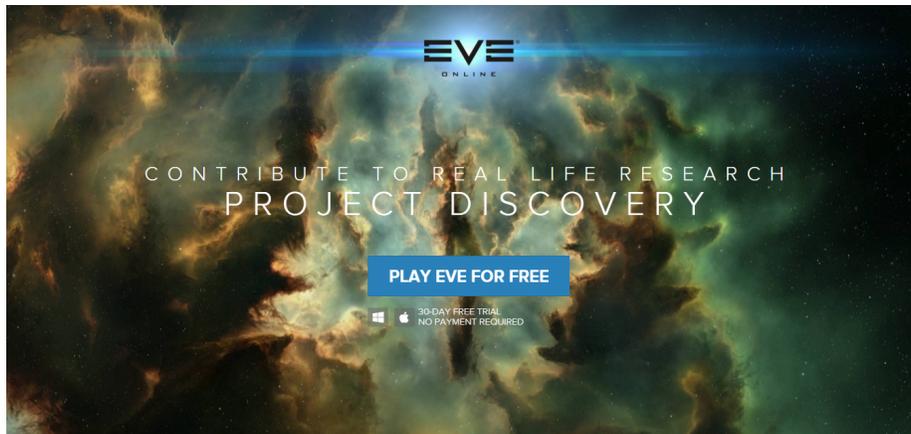


Figure 6: Page that greets visitors to the website.

4 User evaluation

We performed a preliminary, in-house user evaluation in early October. This was not a part of the original project description but we were advised by Pétur Örn Þórarinnsson, our project manager, to do this before the *Project Discovery* game would be showcased at EVE Vegas [5], a conference for *EVE Online* players and fans. The purpose of this test was to shed light on any obvious errors with the game, especially the tutorial phase which was at an early stage at the time.

4.1 Implementation

The tests took place on the 9th of October 2015. We got five participants from CCP, four males and one female between the ages of 25 to 40. The people were a mix of game designers, quality assurance people and community developers. The reason we only got people from within CCP to partake in the tests was that the game was not ready to be revealed to the public so we could not get people outside of CCP to take part.

The test was performed on a computer that remotely connected to our personal work desktop. The evaluation was performed as follows, a participant arrived, we greeted them, thanked them for coming, and explained the procedure. The procedure was that the participant would sit down and we would observe them while they played *Project Discovery*. The participant would open *Project Discovery*, finish the tutorial and a handful of other tasks. While playing, we asked the participant to think aloud. Participants could play for as long as they wanted within a reasonable amount of time, given that they continued to think aloud.

After the participant had finished playing we asked them questions about their experience playing the game and then thanked them for their contribution to the project. The questions we asked participants and their answers can be found in appendix A.

4.2 Results

In this section we analyze the data we derived from the tests and how we used that data to improve the game.

4.2.1 Tool-tips

We gathered that proper use of tool-tips was paramount to the players understanding of the game. Some players seemed to be confused about the objectives of the game. We saw that the tool-tips needed to be clear and helpful to the players understanding the interface. So we decided that tool-tips should be utilized when the players first see the interface, and also throughout the whole tutorial and training session, gradually teaching players about the game as they face the actual problems. The tool-tips also needed to be shorter and focused on one specific message. Participants did not immediately grasp that they could

change the color filter on the main image, so we added a tool-tip that describes this functionality.

4.2.2 Tutorial

Participants felt that the tutorial was too easy and did not teach them very much about the real game. To rectify this we implemented a more extensive tutorial, where each task teaches the player a specific aspect of the game, such as explaining the interface, or how to classify certain patterns in images.

Participants expressed the need for an explanation after each tutorial task, so we reached out to the researchers at the HPA to get explanations for each training task, and to explain why the correct solution was correct. We also enlisted their help in making the tutorial more focused and better at teaching players the skills needed to classify images.

4.2.3 Interface

Participants did not have much to say about the interface with the exception of everyone being in agreement that a magnification function was necessary on the main image. We responded to that by implementing a magnification function that allows players to zoom in to the full resolution of the main image within the image container and it gives players the option to fix the position of the zoomed in image so they can easily compare the image to the categories available.

We observed that participants, who had completed the training phase, and were contributing to unknown tasks, did not get a result screen. That is normal behavior since the solution is unknown, we can not reliably give a result. We saw that when users weren't getting instant feedback they were not as interested and seemed less motivated to find the right solution to the tasks. Our solution to this problem was that since we do know the community consensus for specific tasks at any given time, we can show exact percentages for choices by other players.

We felt that since participants expressed excitement in seeing a result screen, we should implement this for unknown tasks, so that the game would not lose the factor of excitement once players reach the stage of solving images that have no known solution. To achieve this, instead of giving players a confirmed correct answer like we do with training tasks, we give players the current consensus of the task at the time the user submitted his solution. This consensus screen can be seen in figure 7. We also make sure to let players know that this consensus is not necessarily correct. That way the player can get a sense of what other players think the solution is and can see if he is in agreement with them or not.

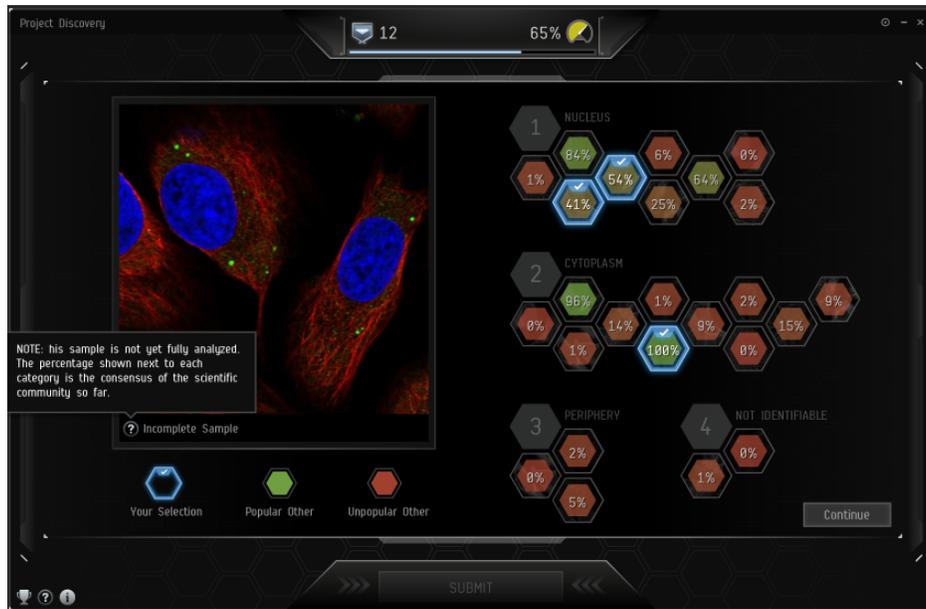


Figure 7: A mock-up of the consensus screen for unknown tasks.

4.3 Conclusion

The user evaluation proved to be very advantageous for us. It gave us great ideas to improve the game which we would probably not have thought of otherwise, since it was impossible for us to experience the game as new players. The participants were overall very positive about the game, four out five played it for longer than we asked them to, because they enjoyed solving the tasks. A majority of the players took great care in solving the tasks by paying close attention to everything. All but one participant expressed interest in playing the finished version of the game.

5 Work schedule and flow

In this section we deviate from talking about citizen science and *Project Discovery* and go over the work schedule and flow we followed during the project. We will discuss the methodology we decided to use to aid us during the project and how that influenced the project. We will go over the work schedule we put together and how we managed to follow that schedule. We will also show the burndown chart for the project as a whole and discuss all of the sprints that we finished while working on the project.

CCP Games graciously allowed us access to two work stations within their headquarters in Reykjavík, and placed us in an EVE development team with senior EVE developers who were available to us when we needed help with the project. They allowed us full access to the headquarters, along with the cafeteria with complementary lunch, which allowed us to stay in house and focus on the development of *Project Discovery*.

5.1 Methodology

For this project we utilized the Scrum methodology to help us document and organize the project and its progress. The appointed Scrum Master was Jóhann and the Product Owner was Hjalti. Pétur Örn Þórarinnsson, a lead game designer at CCP, served as our Project Manager. Since the team only consisted of two people, the Scrum Master and Product Owner made up the the whole team. The project consisted of seven, two week long sprints, with the work divided so that the team could direct enough attention towards other courses, as well as work on the project.

Daily Scrum meetings were held at CCP headquarters every work day. During the final three weeks of the project they took place at 11:30 AM, but they were held at various times of the day during the first 11 weeks, as the team wasn't always present throughout the day. We chose Scrum because it gave us good documentation on the team's progress and an indication of what we could achieve according to our velocity. With each iteration we could track what was going well and what needed improving. Scrum gave us the platform to review and improve on our process during each iteration.

5.2 Initial plan

5.2.1 Initial schedule

When we started the project, we estimated how much time we could afford to spend on the project, taking into account the workload from other courses. We ended up estimating that we had a total team capacity of 654 hours to spend during the entire project. A breakdown of how we scheduled those hours can be seen in table 1. Work on the project was essentially split into two phases, the first one being the 12 week semester, from the 17th of August to November the 11th, in which other courses affected work on the project. The second one

being the three week semester, from the 26th of November to December the 16th, where we could focus all our attention on the project.

	Hjalti	Jóhann
Total for 12 week semester	162 hours	192 hours
Total for 3 week semester	150 hours	150 hours
Total for the project	312 hours	342 hours
Total for the project combined	654 hours	

Table 1: Breakdown of the initial schedule.

5.2.2 Initial stories

At the beginning of the project we, in collaboration with our project manager, populated a backlog of stories we felt we needed to implement. The backlog included 35 A stories, 9 B stories and 6 C stories, totaling 50 stories. Our goal was to at least finish all the A stories, any B or C stories would be a bonus. The A stories totaled 458 story points, the B stories totaled 106 story points and the C stories totaled 89 story points. Altogether the stories came to a total of 653 story points.

5.3 Progress during the project

5.3.1 Actual hours spent

We ended up spending some more time on the project than was scheduled, we spent 685 hours in total and went 31 hours over the plan to be specific. Most of the difference was during the 12 week term when we sometimes had crunch periods, for example getting features ready in time for EVE Vegas. A detailed view of the time we spent on the project can be seen in figure 8 where the x-axis represents each week during the project's time span and the y-axis represents the hours spent on the project each week. Overall we were both very pleased with each other's contribution and dedication to the project.

2015-08-25 - 2015-12-14
Total 685 h 49 min

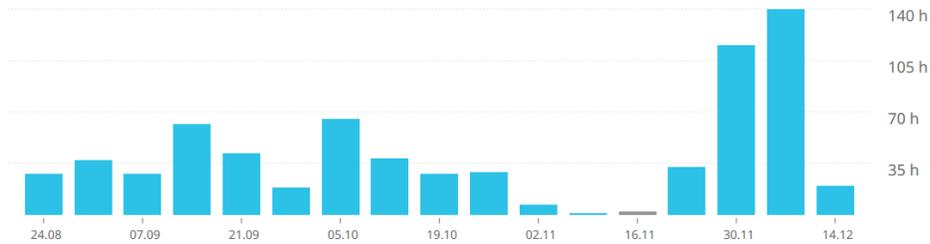


Figure 8: Breakdown of the hours we spent on the project.

5.3.2 Actual stories

The stories we ended up implementing changed quite a lot from what we had planned. A lot of stories got added during the project and a few got dropped because of changes to the project's focus. The main reason for this deviation from the plan was the user test we performed, it spawned a lot of new ideas and features that we hadn't even thought of before. At the end of the project we had 50 A stories, totaling 570 story points, 18 B stories with 251 story points and 5 C stories that totaled 64 story points. We decided to focus on finishing all the A stories, which we managed to do. Finishing those 570 story points gave us a velocity of 81.4 story points per sprint. The remaining B and C stories will hopefully be implemented in the near future, which we discuss in greater detail in section 6.

5.3.3 Project burndown chart

The burndown chart for the entire project can be seen in figure 9. We estimated our velocity to be quite low for the first sprint since we figured it would take time to get acquainted with the project, the work environment and the tools we would need to work with. After that we estimated that our velocity would increase and average out to about 77 story points per sprint during the 12 week semester. For the last two sprints we estimated our velocity to be 114 story points per sprint as we would have more capacity during those sprints.

Our estimate was not far off the mark, although we sometimes did get behind schedule, we always managed to make up for it and we ultimately reached our goal.

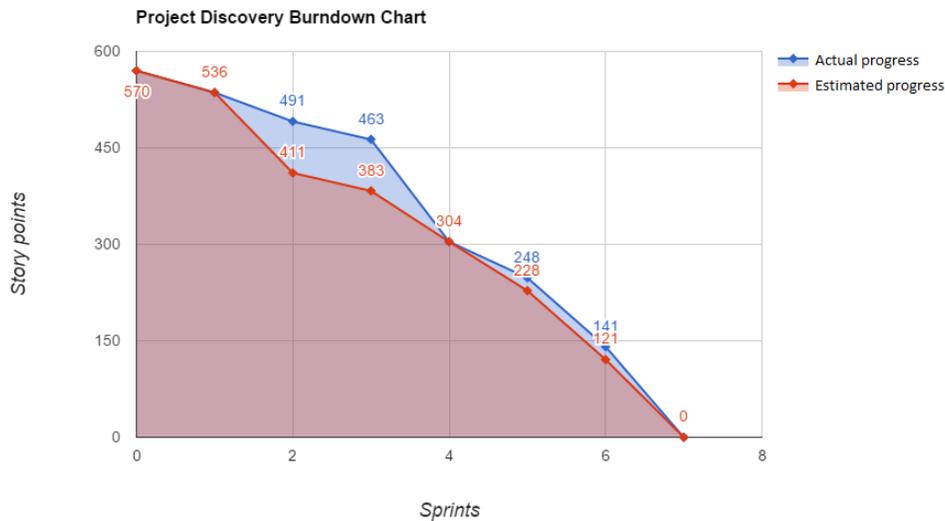


Figure 9: Burndown chart for the whole project.

5.3.4 Sprint summary

We did seven sprints in total and were able to refine our process and learn from our mistakes along the way. Early mistakes we made included underestimating stories which affected the consistency of our velocity, we also should have broken up larger stories to be able to finish them in a single sprint. The latter mistake resulted in us being behind schedule for sprints two and three but we managed to catch up in sprint four when we temporarily had more capacity and finished a lot of stories. In sprint five we again fell behind schedule as demands from other courses affected our capacity. We made up for it in sprints six and seven when we had a much greater capacity and no other courses to worry about. Those sprints went really well as by that time we had improved our process.

5.4 Schedule summary

The initial plan changed quite a lot during the project, so the plan we set out with didn't really come to fruition. A lot of stories got added, we dropped a few stories and a lot of stories were set aside to be implemented in the future. We constantly adapted the backlog and the stories to the continually evolving design of *Project Discovery*. In the end we felt we met all our objectives and the plan worked out for us, as we delivered a game worthy of release to the *EVE Online* test server.

The Scrum methodology proved effective for the team. We were able to closely monitor our progress and make adjustments when necessary, it really helped to alert us when we were perhaps falling behind on our objectives.

6 Future Work

Development of *Project Discovery* will not end with this final project. Hjalti has already accepted an internship at CCP and will continue to develop the game with the ultimate goal of releasing it on Tranquility, *EVE Online*'s main server cluster [8]. Before that can be realized, a few objectives must be met. The game is currently out on Singularity [18], *EVE Online*'s biggest test server, which allows thousands of players to access the game. When those players play the game it will generate a huge amount of data and feedback, which could be very influential on the future and direction of the game. Responding to that data and feedback is one of the objectives that must be met before the Tranquility release. The other objectives are features that were planned at the start of this final project, but because of time constraints and changes to the focus of the game, were not implemented before the Singularity release. Those features include leaderboards, daily challenges and a more interactive tutorial.

The subcellular protein atlas, the current project from the Human Protein Atlas that *Project Discovery* is being utilized for, has a finite number of images. Therefore analysis of those images will at some point conclude, which could actually happen fairly early in the lifespan of the game if *EVE Online* players embrace the feature. Once that point is reached there is the possibility to adapt *Project Discovery* to work with other citizen science projects. The Human Protein Atlas, for an example, has other atlases that could potentially be the focus of *Project Discovery* in the future. MMOS designed their API with this in mind, they expect the subcellular atlas to be the first of many scientific projects that *Project Discovery* assists. The game client has also been structured with regard to this possibility. Any project that involves analysis of images in a similar way to the subcellular atlas could therefore replace that project once it has been completed. To use the client for another project would certainly need substantial customization for that project, so it's not something that is quick and easy to do, but it is definitely possible.

7 Conclusion

This section concludes the report, going over in summary what it contains and what we learned from the project. We also speak about our experience with the project and how working with people from all over the world affected the project.

In section 2, we explained why *Project Discovery* is a GWAP, and how we will use it to get ordinary citizens to classify all of the images of human cells in the subcellular atlas. We also discuss the partners of the project, the Swedish research program the HPA, the Swiss startup MMOS, and the game developer and producer of *EVE Online*, CCP Games.

In section 3, we explained the gameplay of *Project Discovery*, describing in detail the game's prominent features, especially the tutorial phase and the difference between the known results screens and the unknown result screens. Next we discussed the network communications necessary for *Project Discovery* to connect to the API that MMOS provided, and the architecture of the *Project Discovery* code within the *EVE Online* client. Finally we went over the *Project Discovery* website we designed alongside the client, to provide information about *Project Discovery* and the science behind the project.

In section 4, we went into detail about the preliminary, in-house user test that we performed within CCP Games, with their employees as participants. We explained the implementation of the test and its results.

In section 5, we explained the work flow of the project, how we scheduled the time we had available for the project, and how we actually wound up spending the time we had. We also explained the methodology we used for managing the work on this project as well as managing the team itself, and we discussed how it worked out for us.

Finally, in section 6, we discussed the future of *Project Discovery*, and what it entails, whether or not the project will be continued by CCP Games, and how the *Project Discovery* client has actually been carefully designed with the express goal in mind of solving other scientific problems as well, not just the subcellular atlas, a small part of The Human Protein Atlas.

The status of *Project Discovery* as of December 2015 is really positive. The game has strong support from CCP and has already been released on the Singularity test server. Hjalti will continue working on the game as an intern at CCP, with the goal of releasing it on the Tranquility server cluster. Furthermore, the game has received considerable attention both in Iceland and internationally. The game was mentioned in *Nature Magazine* [10] which is one of the most established and respected scientific journals in the world. The game featured heavily at the EVE Vegas conference in October 2015, where it was presented at the keynote speech and it was also playable for attendees of the conference. After EVE Vegas there were several articles about the game online, Discovery.com [12] being the most prominent. The project also garnered attention from the university, being featured in both the Reykjavík University Magazine [3] and RU.is [13], it was also represented at the CADIA (Reykjavík University's artificial intelligence research center) festival in October 2015.

This project was nothing short of an amazing experience, getting to go outside of the university and working in the field of computer science with such incredible partners can hardly be described. We felt lucky to be a part of such a big project, that would surely touch hundreds, if not thousands of people if we were successful in the development of *Project Discovery*, which surely added a level of stress. It has been very rewarding and motivating to work on a project like this that has garnered the type of attention that it has, being presented in the keynote at EVE Vegas 2015, and being mentioned in *Nature Magazine* are such huge things for students like us to be a part of. All this aside, we met our intended goals and are happy with the outcome of the project, we would not change much if we could do it again, although being preoccupied with other university courses was hindering at times.

Finally, we would like to thank all our partners, CCP Games for hosting this project and supporting us all the way, MMOS for working with us this closely to achieve the best quality of the project, and the Human Protein Atlas for providing us with material to best teach new players how to classify the images. Special thanks go to Pétur Órn Þórarinnsson from CCP, our project manager, for helping us with game design and prioritizing tasks, David Thue from CADIA for connecting us with the project and supporting it, Attila Szantner from MMOS for the weekly meetings and coming to Iceland to work with us more closely, Emma Lundberg from the HPA for coming to Iceland and working closely with us on how to best teach classification of images, Team Space Glitter (our EVE development team) for answering all our questions, and assisting us with EVE related programming problems, Helga Bjarnadóttir for supporting us and providing us with the necessary resources, Sergey Trubetskoy for designing and providing all the assets for *Project Discovery*, and finally, our supervisor Hlynur Sigurþórsson for guiding us through the process and providing us with invaluable advice.

Everyone was a delight to work with and we could not have asked for a better team for this project. Surely, the experience we gathered from this project will pay off immensely in the future. This project was very special to us and we hope it will become something great within the *EVE Online* world, helping the scientific community and setting a precedent for other game developers to follow, designing games with the purpose of helping the world.

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A User test data

In this section we outline the data received from each of the testers, this data is comprised of a list of questions we asked the testers after the test was performed, and their answers.

Table 2: The first user test question

Did you find the tutorial helpful?	
Tester 1	NA
Tester 2	Yes, but it was way too simple compared to the real game.
Tester 3	No, I breezed through it and didn't pay attention to it.
Tester 4	Yes, I liked it.
Tester 5	Yes, but I felt that it didn't scale up in difficulty enough.

Table 3: The second user test question

Did you understand the aim of the game?	
Tester 1	Yes.
Tester 2	Yes.
Tester 3	No.
Tester 4	Yes.
Tester 5	Yes.

Table 4: The third user test question

Did you feel a sense of accomplishment when you were correct?	
Tester 1	Sure, it's pretty hard to get it right, but rewarding when you do.
Tester 2	It's okay, I thought the result screen could show some more fanfare if you are correct.
Tester 3	I did not feel accomplished.
Tester 4	Yes!
Tester 5	Yeah totally! It's always fun to be 100% correct.

Table 5: The fourth user test question

Do you think the interface was easy to understand?

Tester 1	Yes, but the color selection channels were not explained, so I didn't know what they were for.
Tester 2	Yes.
Tester 3	Yes.
Tester 4	Sure, I think it could have been explained a little more though.
Tester 5	Yes.

Table 6: The fifth user test question

Did you feel a sense of excitement when waiting to see if your answer was correct?

Tester 1	Yes.
Tester 2	Yes.
Tester 3	Yes.
Tester 4	Yes.
Tester 5	Yes.

Table 7: The sixth user test question

Any thoughts or comments?

Tester 1	Overall I thought it was really great, just a bit confusing at first.
Tester 2	The tool-tips were too long and technical, so I ignored them. I really would have liked to be able to zoom in on the main image.
Tester 3	I would like a better tutorial, more information on what I should have been doing.
Tester 4	I would like a zoom feature for the images.
Tester 5	A zoom function would have been great, and simpler tutorial tooltips.
