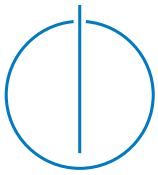
DEPARTMENT OF INFORMATICS

TECHNISCHE UNIVERSITÄT MÜNCHEN

Master's Thesis in Informatics: Games Engineering

Development of a Serious Game to learn Egyptian Language and Culture

Timm Beckmann



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Development of a Serious Game to learn Egyptian Language and Culture

Entwicklung eines Serious Game zur Erlernung ägyptischer Sprache und Kultur

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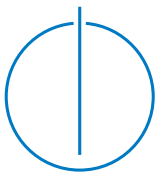

I confirm that this master's thesis is my own work and I have documented all sources and material used.

Munich, 15.04.2018 Timm Beckmann

Acknowledgments

My Advisor David Plecher has my deeply felt gratitude for helping me from the initial start, through to the end, with helping words and actions.
I would also like to thank Daniel Fedh, for the initial prototype of the game HieroQuest, that I could work on. He provided the groundwork on which my thesis is based on.
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Abstract

Serious games are pedagogical tools used to improve the learning experience, by the means of using the fun-to-play, to make learning more exciting. The theory behind this approach is, that by having fun during a play session, the learning effect should be higher, than when learning normally.
Undeniably a good serious game usually provides a higher intrinsic motivation to engage with a certain topic, compared to a traditional learning approach. Therefore, the user of a serious game might spend more time with the topic, by playing, than he would have spent reading a book or learning with flashcards.
Such a serious game can be utilized to teach the Egyptian language and culture. Hieroglyphs, the famous symbols of the Egyptian language, can be learned in an engaging and fun way. And by exploring an Egyptian themed game world, the player can also be familiarized with Egyptian culture.
Riddles and other game mechanics are used to create an engaging experience.
In this thesis an existing Unity3D prototype of a serious game, which is targeted at teaching hieroglyphs, is further developed, improving certain aspects and adding new learning content. For that, certain weaknesses are analyzed and resolved and new engaging game mechanics are conceptualized and implemented.
In the end, the resulting game is to be evaluated by the means of a study, to control the effectiveness of the game in conveying Egyptian hieroglyphics.

Zusammenfassung

Serious games sind pädagogische Werkzeuge, die verwendet werden um die Lernerfahrung zu verbessern, indem sie den Spielspaß ausnutzen um das Lernen spannender zu gestalten. Die Theorie hinter dieser Herangehensweise ist, dass durch den Spaß, den man während einer Spielrunde hat,der Lerneffekt höher ist, als wenn man normal lernt.
Unzweifelhaft bietet ein gutes Serious Game, normalerweise eine höhere grundlegende Motivation, sich mit einem bestimmten Thema auseinanderzusetzen, wenn man es mit traditionellen Lernweisen vergleicht. Daher verbringt der Nutzer eines Serious Game möglicherweise mehr Zeit mit dem Thema, durch das Spielen, als er mit dem Lesen eines Buches oder Lernen mit Karteikarten verbracht hätte.
Solch ein Serious Game, kann dazu verwendet werden, die ägyptische Sprache und Kultur beizubringen. Hieroglyphen, die berühmten Symbole der ägyptischen Sprache, können somit auf einem spannenden und unterhaltsamen Weg gelernt werden und durch die Erforschung einer ägyptisch basierten Spielewelt, kann der Spieler auch an die ägyptische Kultur herangeführt werden.
Rätsel und andere Spielemechaniken, werden verwendet um eine einnehmende Erfahrung zu kreieren.
In dieser Arbeit, wird ein existierender Unity3D Prototyp eines Serious Game, welcher auf das Lehren von Hieroglyphen abzielt, weiterentwickelt werden, um bestimmte Aspekte zu verbessern und neue Lerninhalte hinzuzufügen. Dazu werden bestehende Schwachstellen analysiert und behoben und neue spannende Spielemechaniken konzeptualisiert und implementiert.
Schlussendlich wird das entstandene Spiel durch eine Studie evaluiert, um die Effektivität des Spiels zu kontrollieren, ägyptische Hieroglyphen zu vermitteln.

Contents

1 Introduction

The hieroglyphs were undecipherable for hundreds of years, until Jean-François Champollion finally achieved a translation of hieroglyphs, 1823.

Before that, there were several groups trying to find the key to this language. Philosophers searched to find old forgotten wisdom. Religious scholars hoped they could find the confirmation of biblical stories and the evidence, that people like Abraham, Josef or Moses really existed. Selfish scientists believed, that the deciphering of the hieroglyphs showed them the secret to the treasures of the pharaohs, making them unbelievably rich. Only scientists, who thought of the deciphering itself, as the goal, weren't disappointed.[Wil01]

For people to learn something about this topic, traditional methods are still the way to go. If people want to learn hieroglyphs, they have to use books or flashcards. Digital applications, like Apps, just mimic the those methods. And while those might be effective for some people, dedicated to learning them, there are new possibilities to tackle this. Many people get drawn away from books, more towards digital media. And flashcards can quickly deplete motivation.

Serious games are great tools, to combine the fun of playing games and a pedagogical goal to achieve. The difference between normal games and serious games, is that a normal game in its essence is designed to be fun, without having to include any pedagogical value, while a serious game usually always has a certain pedagogical goal in mind, which is to be enriched with fun gameplay, in order to entice people to engage in the topic.

Flashcards are used to help learning, by using memorization techniques, however there is no specific gameplay behind, that provides fun.

Of course nobody really can say, where serious games start and where mere pedagogical approaches end. The line is blurred, as different people have different meanings about what's fun and what's not.

1.1 Motivation

The topic of ancient Egypt has been used a lot in entertainment. Many movies incorporate it and the Egyptian language, using hieroglyphs is known by many, even if they can't read it.

A lot of people find ancient Egypt mysterious in different ways. How the pyramids got constructed and if they hold secret mysteries, has been in the minds of many.

Also a lot of games use the Egyptian thematic and some apps try to teach Egyptian hieroglyphs.

The younger generation is more accustomed to electronic devices and digital gaming. It is therefore a good idea to use those, in order to engage them with ancient Egypt. Serious games are a good method of engaging people into a certain thematic, as they are fun to play, and therefore even attract people, who might otherwise not be interested in the thematic itself.

Games to learn a certain topic have existed for some time now. Several games try to teach mathematics, languages, informatics or other school topics for a broad range of ages. And while they started very rudimentary, strongly focusing onto the learning goals they tried to convey, they evolved over time. With nowadays engines, even single persons can crate games and there exists a variety of them. However when looking for games, that teach hieroglyphs, you have a hard time to find anything useful. Of course certain Apps exist, that teach them with a flashcard approach or similar. But those are as already said, just copies of analog methods. They can quickly lead to lost motivation of using them, as there are no game mechanics included, that could provide long lasting play fun.

1.2 Goals

Therefore when we assess the current situation with no real fun possibilities out there, that teach Egyptian hieroglyphs, we have found a niche to focus on. We can create a Serious Game, that teaches Egyptian hieroglyphs and that provides an alternative to the existing approaches of learning them.

This thesis is using an existing game prototype "HieroQuest" created for a Master's Thesis from Daniel Fedh[Fed17]. This game, was designed to teach Egyptian hieroglyphs and should now be further developed to address certain weaknesses and add new learning content.

Aside from fixing obvious issues, new riddle types and a new interesting level design, deviating from the existing prototype, should be implemented.

The final game should be able to teach Egyptian hieroglyphs in a fun and entertaining way. Therefore the players of the game should finally be able to recognize most of the learned hieroglyphs and should be able to apply that knowledge to the real world.

With the newly added hieroglyphs, it should also be possible to form some words with them, allowing the player to learn their first Egyptian words.

1.3 Outline

- **Chapter 2:** This chapter presents related work in the thematic of teaching Egyptian Hieroglyphs. Therefore we will look at the 2 components of a Serious Game, games and pedagogical content. Additionally we will have a look at other Serious Games.
- **Chapter 3:** At the beginning of the thesis the final game design had to be conceptualized and targets had to be defined. The existing prototype had to be analyzed and weaknesses addressed. This chapter portrays the thought process behind that and which new elements were added.
- **Chapter 4:** Egyptian Hieroglyphs can have certain difficulties in their use and pronunciation, that make it hard for a simple game to convey those things. This chapter depicts certain anomalies, that we don't have in our normal languages and how they are handled in the game.
- **Chapter 5:** For the serious game, old code from the prototype had to be changed and new system had to be added. Certain hurdles, that became visible during the implementation of the game, are described here in detail.
- **Chapter 6:** In this chapter, the results of the evaluation of the study are presented. The study will provide valuable data to assess, if the serious game was successful in teaching Egyptian hieroglyphs.
- **Chapter 7:** A final conclusion to this thesis is given, as well as a brief summarization for it. Possible future work is outlined.

2 Related Work

In this chapter we elaborate on some of the related work. It'll help to discover the underlying problematic. At first we will look at normal video games, that incorporate hieroglyphs and an Egyptian thematic. Then we will have a look at some Apps with a more traditional flashcard approach. Examples of serious games will help to discover how others have tackled the problem of teaching knowledge. Finally we combine our collected knowledge, to come to an understanding, of how to achieve the goal to create a useful Serious Game, for learning Egyptian hieroglyphs and culture.

2.1 Games

The digital gaming industry has become a big market, with multi-million-dollar companies, so called "Publishers", creating big games with known brands. Triple A (AAA) games, games with a big budget, for large developer teams, with programmers, artists, designers and marketing, are often linked to high sales numbers, because of their massive marketing and mass market appeal. But of course there are also a lot of indie developers and small teams, that create good games and want to partake in the profits of this business. However the main focus most of these games have, is to be sold for profit and not to be educative or pedagogical. In this context, there are existing games, which incorporate ancient Egypt and hieroglyphs, though the main intent there lies in using the mysteries of Egypt and fascination people have for it, to create an appealing game. Not specifically to be educational. Therefore they can't be called Serious Games, as a Serious Game has the entitlement to reach a pedagogical goal. The goal of the presented games however, lies more in the entertainment section. That's not negative in itself, as games can be a nice leisure time activity and many people reduce their stress through gaming. But in our case as we have our pedagogical target, we will look at these games for what they do right and what they miss to be a real Serious game.

2.1.1 Assassin's Creed

Let's start with a recent popular game, named Assassins Creed Origins. This game is the successor of a long line of games in the Assassins Creed series. It definitely falls into the AAA category, with many players and a big publisher behind it: Ubisoft.

The series mainly focuses on the war between two groups of people. The Templars and the Assassins, both groups which have historically really existed, even though not in the way described in the game. The series tries to cleverly mix together real historic events combined with interesting fiction, to draw the player into the world of the game. Templars are mainly depicted as the evil side, wanting to control the world with the help of Ancient Artifacts, holding great power, left behind by an ancient race. The Assassins are fighting the Templars, trying to stop them from their evil world conquering plans. Most of the times, you as a player control an Assassin in this series, whose job is to fulfill a lot of missions, with a lot of them involving some Templar plans and of course assassination. There are exceptions to this though, e.g. in some titles or sections, you are playing as a Templar.

The game actually takes place in the present, with our normal world setting we know, although a machine, called Animus, was invented which allows to relive the memories of ancestors, by gene decoding. The Templars are using it, in order to find the artifacts described before, by finding descendants of assassins, who shall relive their ancestors lives, looking out for those artifacts and where they are hidden, so the Templars can find them in the present.

With this interesting plot idea, it is possible to reasonably connect the series logically, which otherwise takes place in drastically different places and times. This is due to the fact, that Assassins and Templars are said to operate worldwide since a very long time ago, hidden and operating under different names.

Now this recent title, Assassins Creed Origins, is set in Egypt near the end of the Ptolemaic period (49–47 BC). So Egypt is definitely the setting in this game. Ubisoft could have taken the easy way and only include hieroglyphs as background art. Most of the times, when games use an Egyptian setting, they don't make an effort to use real hieroglyphs or when they do, hieroglyphs are mixed together without any meaning.

For Assassins Creed Origins however, Ubisoft spent some time, money and effort to include real hieroglyphs into the game and in a way, that they actually can be translated into meaningful sentences.

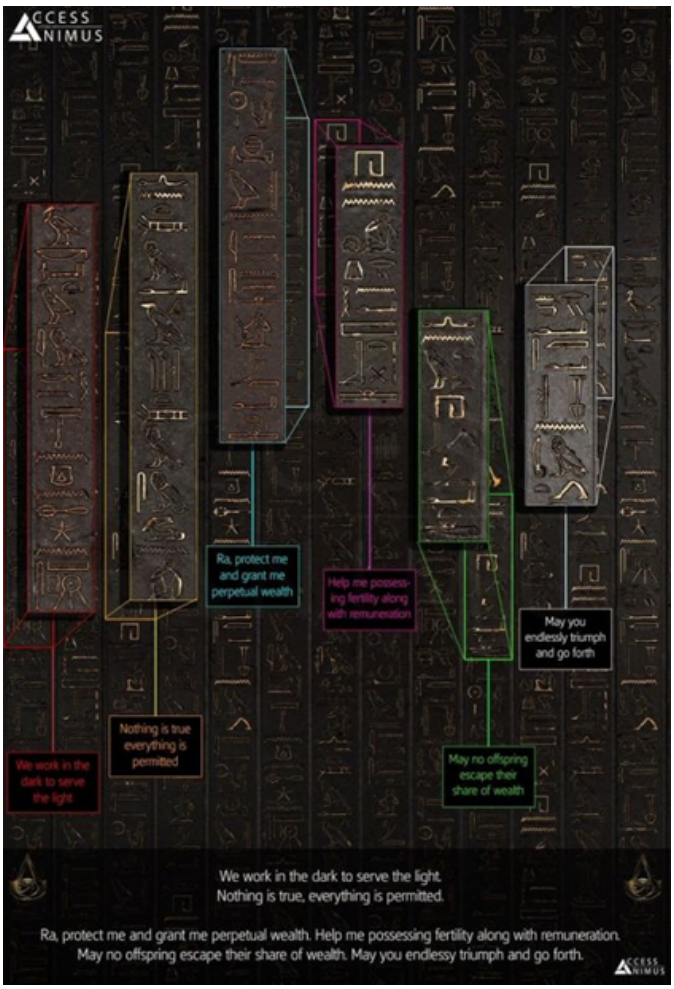


Figure 2.1: Source: `https://council.assassinscreed.com/en/post/46653-ac-origins-hieroglyphics`

They even consulted historians and made available a game-mode in the Discovery tour DLC, without any quests or fights, a virtual museum so to say, to go sight seeing.[1]

Assassins Creed Origins has fun gameplay, correct recreation of old Egyptian sites and actual meaningful hieroglyphs. So with all this good to say about the game, what is wrong with it? Why can't it be called a Serious Game?

Well, Discovery Tour and historians aside, the main intent and gameplay still revolves around the story of Assassins Creed. Even with a lot of real historic events woven in,

[1] `https://www.pcgamesn.com/assassins-creed-origins/assassins-creed-origins-history-egyptologist`, latest access: 10.04.2018

the fictional Assassin and Templar dispute is in focus. Main content is fighting and completing missions. Actually learning hieroglyphs or Egyptian culture is not needed or facilitated. It's not necessary for the story and there are no gameplay elements dedicated to learning them. Ancient Egypt just serves as a setting in this game. And though the Discovery Tour DLC offers at least an option to go sight seeing, without any distractions from missions or fights, it's not like this mode pursues any pedagogical goal. Players are just given the possibility to explore the game world, while hearing commentaries and reading material. And though that might be more interesting for many, than to read a book about Egypt, the actual long term learn effect after the tour, stays in question. Hieroglyphs surely won't be remembered this way.

And therefore even, when we can't call it a Serious Game and it doesn't fulfill the requirements for pedagogical value, what we can learn from this game, is how an interesting storyline, nice art and interesting gameplay mechanics, can attract players to the Egyptian topic.

2.1.2 Ankh

Now with Assassins Creed Origins, being a rather recent game, when looking back into the past we now observe Ankh. Ankh is an old point-and-click adventure series with the third and last game "Ankh: Kampf der Götter" being from 2007. In stark contrast to Ubisoft, the Ankh series is created, by a rather small German studio, Deck 13. It also takes place in old Egypt, however no real point of time can be established, though real Egyptian places, like Kairo, are used as settings.

The game principle is, being a humorous adventure, with a lot of jokes and some riddles to solve. The humorous character can already be seen in the storylines of the games. In the first title for example, just named Ankh, the main character Assil, gets cursed by a mummy, while throwing a wild party in the newly built pyramid. Trying to avert impending death, due to the curse, he simultaneously has to defend an Ankh amulet,a mighty artifact gained during the curse, from the Egyptian god Osiris.

You as the player now get to play Assil, experiencing the story, solving riddles and laughing about the jokes.

Figure 2.2: Source: `http://www.adventurecorner.de/games/ankh/screens/009.jpg`

The first title received good ratings and with two following titles, surely was a success.

What are the reasons, to why we can't call this fun game, a Serious Game?

Well, this game certainly only used Egypt to have an interesting background, to create a storyline around. With the humorous character of the game, a lot of historical facts are drastically distorted, towards a more fun and fitting direction. Luxor for example is depicted as a gambling casino hotel, a parody version of Las Vegas. And certainly mummy curses and gods trapped in Ankh amulets are not historically correct.

The game really has no intention to be historically acurate or of any pedagogical value. The games main intention is to be an entertaining adventure and the Egyptian setting is merely used to drive the story and gameplay elements.

Hieroglyphs in the game, also are just used as background decoration. There is no way dedicated to learning them.

That doesn't mean however that we can't take any lessons for our Serious Game. A Serious Game clearly distinguishes itself from more mundane approaches, like flashcard learning or books, because it's also a game designed to be fun. And Ankh being a fun game, can be used as a reference, to how Egypt as a topic can be made engaging for a Serious Game.

2.2 Traditional approaches

Now with games, being the more entertaining side of the spectrum, we come to the other side of it. Purely educational. Books have always been a popular choice to learn something about a certain topic. However with the internet and new electronic devices new possibilities have come up to increase the personal knowledge. Flashcards are not only paper cards, which we used to learn with, when we were young. They represent a certain type of pedagogical approach. Rember through repetition. And with digital media at our side, of course Flashcards can now be experienced with Apps in AppStores.

2.2.1 Hieroglyph Flash Cards

One of these Apps is called Hieroglyph Flash Cards and can be found on the Google Play Store. It has a very good rating of 4,8 stars and was created by Damien Daniel O'Neill, who also created another App on the store, English/Hieroglyph Dictionary, like the name says, a dictionary for hieroglyph words to English.

Hieroglyph Flash Cards is an app that tries, to teach hieroglyphs with the traditional flashcard approach, combining the hieroglyphs with the correct literals. So the player can learn Uniliterals, hieroglyphs with the translation being one letter, Biliterals, with the translation being two letters and Triliterals, consequently consisting of three letters.

The knowledge can be tested, by the App showing a hieroglyph or literal and the player having to select the according other part. Through repeating this process many times, the player, after awhile, should be able to successfully remember the translations.

Figure 2.3: Source: Android App Store

The App has received no observable comments, but the good rating indicates, that the App has the desired effect and no major bugs or flaws.

People could come to the conclusion, that Serious Games might be a nice to have, but with the seemingly effective flashcard approach, are not really needed. When people want to learn hieroglyphs, they can use Apps like these. Simple, effective and no time spent on game flavor.

Now to hold against that, even if this might be an effective learning method, for people who want to learn hieroglyphs, it's not a very fun approach. There are no gameplay elements that provide inherent play fun. It's just a simple flashcard approach. People usually wouldn't use this app if they aren't already trying to learn hieroglyphs anyway. And that's a nice benefit of Serious Games, as they can attract people to a certain thematic, due to it being a game, providing fun, that even people who didn't initially plan to learn something do so, as a side effect.

Additionally it can be said without a doubt, that many people would rather play a game and learn hieroglyphs that way, than to just use flashcards over and over again. So while they might drop the flashcard App after awhile, cause they got bored or frustrated, a game has the benefit of offering entertaining content. In the end the theory is, that a person has more motivation to use a Serious Game, than flashcards, learning more, due to longer exposure. And studies show, that happy people learn better.[2]

[2] `http://theconversation.com/its-true-happier-students-get-higher-grades-41488`, 11.04.2018

2.2.2 Ägyptische Hieroglyphen Lehrer

Coming to another Android App, Ägyptische Hieroglyphen Lehrer, which is a quiz app, about hieroglyphs. It was created by Burian Media, a company hard to find information about.

The App is built in a way to learn the Alphabet and Numbers, from German to Egyptian Hieroglyphs. After that tests can be taken for them, where the App asks for the correct hieroglyph given a number or letter.

The learning method is very similar to the flashcard approach, as continuous repetition is the way of learning.

Figure 2.4: Source: Android App Store

The rating this time only has 3,6 stars. It's hard to determine why, but one 1-star-comment states, that some hieroglyphs and their meaning are wrong. However Egyptian hieroglyphs have some specialties and ambiguities, explained in more detail in chapter 4. And looking through the various translations of the App, they seem correct, when those specialities are considered.

The App however is really restricted to most of the letters of the alphabet, so only Uniliterals and Numbers can be learned and no Multiliterals. Also some little details are lost, as for example, the **s** is said to be the literal for both the cloth hieroglyph, as well as the pool basin, although the pool basins Uniliteral is **š**. The same problem exists for other Uniliteral hieroglyphs.

The conclusion from the other app can also be drawn here. It might be a good way to learn hieroglyphs if the interest was already there from the beginning, but there are no methods behind it, that could provide long lasting play-fun.

And what we certainly have to care for, is for our Serious Game to try to be as exact as possible, when it comes to offering translations.

After looking at some games and pedagogical approaches, we should now observe some Serious Games, which try to combine a pedagogical approach with the fun of playing a game.

2.3 Serious Games

To improve the learning experience, Serious Games are conceived. They try to combine learning approaches and pedagogical mechanics with classical games. Through more exciting gameplay, the desired effect is, that a player spends more time with a topic, than he would otherwise have spent on it. And as already mentioned in 2.2.1, certain studies have shown, that happiness helps with learning.

It is without a doubt that for a Serious Game, to be successful, it has to provide a higher intrinsic motivation to engage with a certain topic, than other learning methods. On the other side it shouldn't fixate so much on the pedagogical value, that the fun to play it, is neglected. A good mix should be achieved.

We now want to look at some existing Serious Games, in order to observe, how they try to accomplish this combination.

2.3.1 MIDDWorld Online

As we are trying to build a good Serious Game for learning another language, in this case the Egyptian language with hieroglyphs, it might be a good idea to look at other Serious Games, which try to teach foreign languages.

MIDDWorld Online is a Serious Game, presented at the Serious Game Showcase, at I/ITSEC 2011. It was created in collaboration with a company named Muzzy Lane and Middlebury Interactive Languages (MIL), a joint venture of Middlebury College and K12 Inc., a provider of online education programs. The game won a Bronze award at a Serious Play conference. [3]

This games target is to teach foreign languages in a natural environment. It currently supports French and Spanish, with Chinese and Arabic planned in future releases.

[3] `https://www.businesswire.com/news/home/20110829006082/en/Middlebury-Interactive-Languages-Wins-Play-Bronze-Award`, 11.04.2018

For that a 3D virtual environment was developed, in which the player can move in. It is designed in a way to represent really being abroad, so a player can visit a French or Spanish plaza. Communication is based on the target language **only**. Therefore guesswork is also involved, like when visiting another country in reality, trying to guess other peoples sentences.

The game can be played in a quest-based multiplayer online roleplay game (MORPG) mode, with NPCS and other users and a café mini-game, which is designed to learn about ethnic foods.

Figure 2.5: Source: `http://seriousgamesnet.eu/games/view/766`

While playing the game, fulfilling quests or serving customers, the player is exposed to colloquialisms, further learning correct use of the desired language.

The idea behind this game is, as the player is moving in the foreign environment only using the target language and trying to operate in this scenario, that the language is learned best in the way of using it in real life scenarios. The game is trying to recreate that.

The graphic seems not very elaborate, however it tries to give the impression of real life cities, offering an accurate resemblance of how a real situation might look like.

Trying to grasp the essence of this Serious Game, it seems like a good approach to use an environment, fitting the language, that is to be learned. If the approach, to have everything available only in the target language, is useful however, I dare to doubt. Of course if some basic language skills in the language are already available it might be a viable approach. Getting someone with no prior knowledge into such an environment

however, can be doomed to be a failure. As our Serious Game has a broad target and most of those people, surely have no prior knowledge about Egyptian hieroglyphs, let alone words, we will omit this aspect, certainly.

2.3.2 Microsoft Flight Simulator

When searching for the Top 10 of Serious Games, very quickly this can be found high on the list. And while many people wouldn't have thought of it as a Serious Game and might debate on it, it certainly has the features of one. It surely has all the elements of a game, because many people have played it for just the fun of playing and figuring out, which button does what, myself included.

On the other side, the required procedures and details for starting and flying an airplane were implemented as detailed as possible. Certainly it can't reach real flight experience or using an advanced simulation. Both with mechanical toggles and switches, other than when compared to playing it on a normal desktop computer. However the pedagogical value, of learning how to operate the different implemented machines, can't be dismissed.

We speak of the Microsoft Flight Simulator. One of the longest-running series of home flight simulator programs and very popular. The earliest release started at 1982, with the newest one being the Microsoft Flight Simulator X from 2006. Microsoft as the Publisher, certainly doesn't need an explanation.

The game itself hasn't changed much over the years. Graphics improved over time and new machines were included.

Figure 2.6: Source: https://www.instant-gaming.com/images/products/675/screenshot/675-1.jpg

It is interesting to see, how a digital simulation of knobs and switches, fascinates millions of people.

Now it certainly can be hard to make a connection, from a flight simulator, to a Serious Game trying to teach Egyptian hieroglyphs. What wisdom can be gained from this Serious game to be used on our own? The same of course can be said, when looking at a dozen of other Serious Games, having nothing to do with languages, but with teaching nonviolent methods for waging conflicts or deciphering crystal structures of viruses.

Having pondered over this quite awhile, thinking about an answer not sounding too far-fetched, I have come to the conclusion, that a Serious Game like the flight simulator from Microsoft, shows us, that a lot of people can have fun with complex systems, trying out multiple scenarios. I myself certainly didn't play it, because I wanted to actually learn how to fly a real aircraft and become a pilot, but because it just made so much fun, trying out all of those buttons, trying to safely start and especially land.

In that way, for our Serious Game, we can take that deduction and say, that we have the possibility to include complex riddles, which involve a little bit of try out, to reach a correct result. Trying to combine multiple hieroglyphs to form words, is one example for that.

2.4 Conclusion

Now, after we have looked at the major components of a Serious Game, for one having to be a fun game and secondly to incorporate some pedagogical value and after having examined some other Serious Games, we want to use the knowledge gathered.

An ideal Serious Game, would incorporate the goal to teach hieroglyphs, while at the same time achieve an intrinsic motivation to play the game. Therefore the game should be enough fun to be played, such that even players would be interested in playing it, when they initially didn't plan to learn hieroglyphs.

The serious game, developed together with this thesis, is trying to achieve exactly that goal. It is built upon an existing prototype, that already teaches most of the uniliterals, hieroglyphs with their according translation being one letter.

The prototype should be analyzed and improved in sections where weaknesses, can be found. It also has to be extended with more hieroglyphs, adding Biliterals with 2 letters and Triliterals with 3 letters. With the right choice of added hieroglyphs, the first words can be formed, too. The goal is to further build a more and more complete game, that at the end will be a valid tool for Egyptian hieroglyph and language learning.

3 Concept and Analysis

After looking at the related work, we now have to possibility to use what we have learned and apply it to our game. We have to create some concepts, for planned features.

In order to do that, we first have to analyze the already existing prototype HieroQuest, from Daniel Fedh, as we want to extend it into a fully fledged game. Therefore we have to analyze and address certain weaknesses, that we can find first.

3.1 Prototype Analysis

The existing HieroQuest version has already a playable build, that is available in the Android and iOS Store. It offers most of the available Egyptian Uniliteral hieroglyphs.

The level design is based on some labyrinthine schema, with multiple doors hindering the player from reaching the goal. In order to open the doors, the hieroglyphs depicted on the door have to be collected and applied. Through repetition of the hieroglyphs on the doors and other riddles, the player shall remember the collected hieroglyphs.

Each time a hieroglyph is collected, it gets added to the literal picker, an inventory for all collected hieroglyphs. In order to proceed, the player has to click on the hieroglyph, converting it into the literal.

To give an example, the player places a hand, that some statue has lost, back to the arm and receives the hand hieroglyph. It's then pulsating in the literal picker, waiting for the player to be clicked on. After he has done that, it transforms into a **d**, the Uniliteral for the hand hieroglyph.

For future applications, where the player has to use the hand hieroglyph, he has to remember the according literal, in order to select it in the literal picker and only then he can successfully use riddles, requiring the hand hieroglyph. The only exception to that, is the easy mode, as the solution is always depicted, so the hand hieroglyph is shown, when the **d** literal is selected.

The prototype version was certainly enjoyable and could be completed to the end, where almost all Egyptian Uniliterals have been collected.

But there were of course some flaws, that now want to be addressed.

3.1.1 Saving

Most games usually always have some kind of save function. Either the game can be saved at any time, or the there are certain positions, stages or achievements, at which the game is saved and the player can continue to play.

Of course there are also games, that don't have such a save functionality, but they are mostly designed in a way, to not need one. League of Legends is a famous example, where a typical 40 minute play session has no need for a save function. It wouldn't even make sense in such a multiplayer environment, that is based on quick sessions. The HieroQuest prototype had no save functionality whatsoever. The player could play the game and had to play through it in one go, or had to begin from anew. On a smartphone, just switching the app, would hold the game in the background, allowing the player to play on when switching back. However, this keeps the app in memory and when the app was closed in any way, if any error crashed the app or the smartphone had to be restarted, the game hadn't been saved and the player would have to start a new game.

In this case, that's not a really good situation, as the game is no little casual game, that is intended to be played in independent small sessions. It is a progress-based single-player riddle game. The player has to solve certain riddles, progressing through the world. Depending on the skill, knowledge and intelligence of the player, it could take more than an hour to complete. With no possibility to save, the player has to play the game in one go. Keeping the game open all the time, just to be able to pause and play on later, is not a really good solution. And any error, electricity problem or other issue, could mean, that the progress was lost. While a good player might be quick to reach the end in 40 minutes, others could easily take hours to do so. And while some players might want to try that in one go, more casual players would certainly like to pause the game and play on at another time.

Especially keeping in mind, that the content is likely to grow, when adding new content and riddles, the time to reach the end of the game increases, making a save system even more important.

Due to these reasons, we decided in our concept phase to implement a save functionality. The problems we faced with saving game objects and how it was finally implemented, can be read in chapter 5.

3.1.2 Tutorial and Hints

A lot of young people, grew up with different gaming systems and are profound in adapting to new games without any help or tutorials. Even some older people have a certain affinity to games. Also trying around to solve certain problems, that the game

provides in form of riddles, might be normal for them.

HieroQuest however should be a Serious Game, that is not only targeted at those people, but should be able to be played by persons of almost any age and people with no background in gaming. Certain concepts in the prototype however, could cause problems with that. Some people might already fail to grasp the concept of movement in the game or how the UI works, while others might get stuck at certain riddles and game situations.

Some people having already played other games before and using computers regularly, had huge problems, when it comes to the controls, that the game utilizes, in the desktop version. For most gamers, controlling a character with the w, a, s and d buttons on the keyboard and looking and interacting with the mouse is pretty standard. However when observing the above mentioned people, they had trouble getting accustomed to this control system. Without any tutorial, explaining the control system, they were outright lost, if nobody was there to tell them the controls.

For certain riddles, even some experienced gamers, who have also played adventures and other riddle games, got stuck, not knowing what to do in a certain situation. As the game provided no helpful methodology at all, and with nobody near to help out, the player couldn't proceed.

There are some gamers out there, who will try to solve the problem on themselves for a rather long time, but certainly a huge chunk of players won't be so patient.

In order to open up the game, to all types of people people and to prevent them from dropping the game out of frustration, 2 important systems had been implemented. The first one, is a basic tutorial, that introduces the player into the game, by explaining the control system, UI and game rules. The second one, is a hint system, that helps out the player with helpful messages for certain riddles.

Tutorial

Figure 3.1: One page of the tutorial

In the figure above, you can see an example of one page, of the newly implemented tutorial, explaining the controls.

When starting a new game, the player is asked if he wants to see the tutorial or not. If he chooses to see it, several pages, explain certain things about the game, like the controls, UI and game rules.

After that, the difficulty selection opens up, before the game starts. If the player, skips the tutorial, the difficulty selection comes right away.

This will help people playing the game, who might not even have any background in gaming and who might have severe problems figuring out the game mechanics on their own.

Especially there is that rule, that if a hieroglyph with an according object is found, e.g. the mouth object of a statue and the mouth hieroglyph, in all future situations, mouth items have to be picked up with this hieroglyph in the literal picker selected. Even players who had this tutorial, sometimes forgot the rule and tried to pick up the object without the correct hieroglyph. A newly added helping error sound, further educated the player about that situation.

However without any tutorial explaining this rule and no error sound, the player surely has not a clue, to what is wrong. He might more likely think, that he can't pick up the object, due to a bug or something similar.

With this new tutorial those problems, now should be a thing of the past.

Hints

A hint system was implemented in the form of a hieroglyph, that appears after a while of the player not having done anything useful.

The hieroglyph is the symbol of Toth, one of the Egyptian gods, that is said to be the inventor of the hieroglyphs.

Figure 3.2: Hieroglyph of Toth for hints

When the player clicks on the hieroglyph, a text box appears, giving the player hints about the current riddle.

The system is implemented with box colliders, which are placed in a certain area and when the player moves into them or stays there, the corresponding hint can be displayed, after clicking the Toth symbol. A timer of 15 seconds has to tick down for the hieroglyph to appear. Every time the player enters a new hint area, the timer is

reset, as well as it is, with every successfully solved riddle.

Some hints have multiple stages, so that for example the first time the player uses a hint in a certain area, the hint reveals as little information as possible, to give the player the chance, to figure out the rest. When the hint has multiple stages, then the next time the player uses the hint, the text has changed with more specific information about the riddle.

With this hint system, it is ensured, that the player will eventually find the correct solution and doesn't have to give up.

Without the hint system for example, there was the stool riddle, where you have 3 stools with the stool hieroglyph on them. In order to find and get it, you have to stand at 3 specific positions looking at these stools. And even then, the outline of the hieroglyphs could easily be overlooked, if the player doesn't know what to look for. Many players either spent a very long time there or simply gave up.

Even with the first iteration of the hint system, the hint regarding this specific riddle, was written too ambiguous and some players were still struggling, although having seen the hint. Therefore the text was rewritten to be more helpful in this situation, without outright telling the solution.

Overall these 2 additions, the tutorial and hints, were definitely very important for getting a Serious Game, that can be played by a broad audience.

3.1.3 Customizable Walk Speed

The walk speed in the prototype was set to a certain speed, with which the player could move through the level. On desktop computers, the shift key, allowed to walk a little faster.

In the difficulty level "Hard", the speed was increased by a certain factor automatically, arguably because of the time limit, that exists in the hard difficulty level.

In order to allow the player, to walk a little faster, if they want, but keep it as it is, when not, a slider was added to the options menu, that allowed to customize the walk speed to a certain degree. In the script controlling the player character, the walks speed was already a variable, that could be set to any value and the only thing that had to be done, was to link that variable to the slider.

The reason to why this was a feature, that we thought was worth it to be implemented, is that, the standard walking speed, was subjectively very slow. Especially for more experienced or inpatient players, the walk speed felt like a crawl, even with the shift button pressed. With the new level, being a rather big and open game, walking from one end of the map to the other end, could take a very long time. Walking is not especially enjoyable as a game action and when taking too much time can frustrate people. That's why the customizable walk speed helped out in that regard. But in the

user study done on this game, some people still found that the walking speed should be even faster, than they could set it to. The maximum possible speed that can be set, is now 3 times the original one.

The intent to not outright set a higher walk speed, but to make it able for the player to choose himself, is because there are players out there who have no complaint about the standard walk speed, but could be overwhelmed, by the quicker version of it, making it too fast for them.

Tabular Hieroglyph Selection

In order to select the literals of the hieroglyphs in the literal picker, the player had to scroll through them, until reaching the desired one. At the beginning with only a few collected hieroglyphs, that is all right, but with more and more of them added, the selection becomes increasingly tedious.

At the end of the prototype level, the player had already collected more than 20 hieroglyphs. Scrolling through all of them in the literal picker in order to reach the desired one, turned out to be a laborious and time consuming action.

In order to improve that situation, the alternative tabular selection has been implemented.

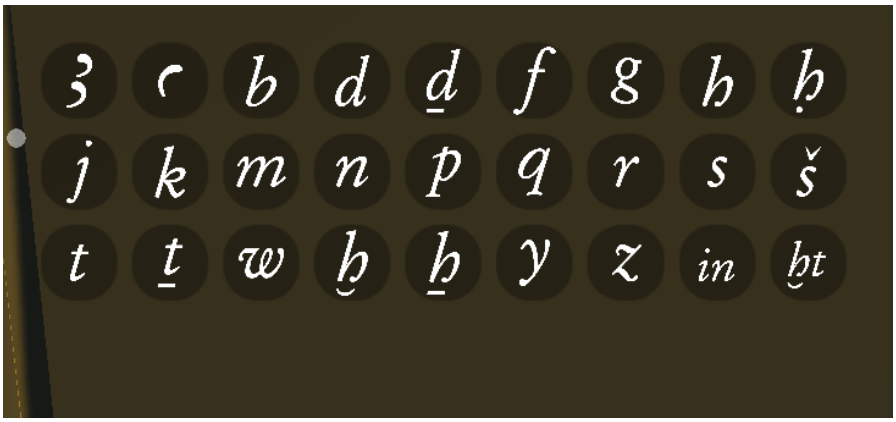


Figure 3.3: Tabular literal view

When the player clicks on the literal picker the tabular view opens, allowing the player to select any of the available literals. The literal picker then quickly spins automatically to that literal.

This saves the player some time and effort to get to the correct literal, especially with more and more hieroglyphs added to the game.

Music

The game included certain sound effects, but no music. There are some games out there, that don't have any music and surely some players dislike music anyway and shut it off, if possible.

Music in a game is not a must have, but if the music fits the game it can increase the gaming experience. Therefore most of the games have some sort of music built in.

The space simulation game, Star Citizen, got implemented a dedicated music system, that fades in and out certain cues, when the player is under attack, in certain situations, positions and so on.

Many games have their own sound department, creating fitting music for their game.

For this thesis, we have not the same amount of resources. Neither time, nor money, to spend on a feature, that many might not find particularly important.

Creating own music can take some time. But we have the possibility to search for certain already available pieces on the internet, that are copyright free.

Exactly such a piece, that fits the Egyptian style of the game, has been found and added to the game.

The music volume can be regulated in the option menu, for those who need it. All in all, the music should increase the atmospheric value of the game.

3.2 Concept Phase

In addition to the improvements made to the prototype, addressing the weaknesses we found, that have come up during analysis, additional game elements have to be conceptualized in order, to add new content.

3.2.1 Multiliterals

The prototype of the game only consisted of most of the uniliterals. Egyptian Hieroglyphs can be translated into certain letters, called literals. Uniliterals have one letter, while multiliterals have more than one. Biliterals for example have two, and triliterals have three.

For the Egyptian writing to be useful, in addition to the uniliterals, the multiliterals have to be known, in order to form proper words.

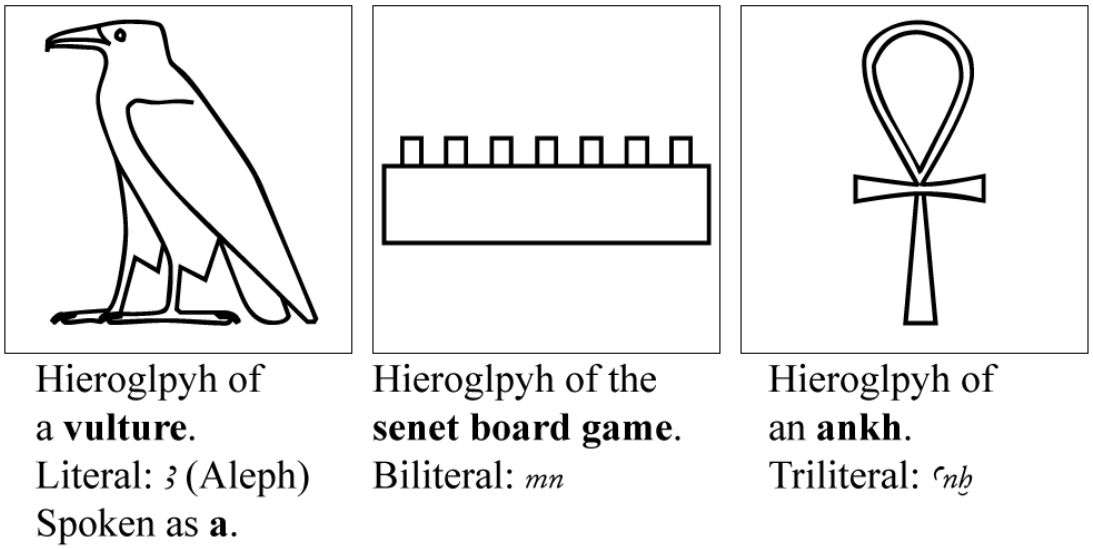


Figure 3.4: Egyptian literals

To extend the prototype and to add new learning content, in addition to the already introduced uniliterals, multiliterals shall be included.

However, there are thousands of multiliterals and coming up with new riddle ideas for all of them and implementing all of them takes too much time for this thesis.

The prototype used a weird way to load the hieroglyphs in the game. Instead of just loading the sprite and somehow defining the according literal in some script, the hieroglyphs were loaded out of a text file. That text file contained the Unicode code

of the hieroglyph, a description, the unicode code of the transliteral and some other information. The sprites for the hieroglyphs and Transliterals had to be named after the unicode code. This way, to add a new hieroglyph to the game, the according Unicode symbol first had to be found and copied. For the transliteral, that was very problematic, as all existing hieroglpyhs in the prototype were uniliterals, only having a single unicode symbol for the transliteral. And that's the way the code was designed. So now with more hieroglyphs coming in, using multiple unicode symbols for the transliteral, the code wouldn't work anymore. A better long time solution would have been to redesign that whole sytem, but with the time constraint in mind, the hotfix, was to use the same unicode code for the transliteral as for the hieroglyph and therefore name the sprites equally. Fortunately the sprites of hieroglpyhs and transliterals resided in different folders.

In addition to saving hieroglyph and translation to a sprite and adding the text file entry, a new lexicon entry, describing pronunciation and hieroglyph, has to be added and some materials had to be created. This whole procedure alone takes some considerable amount of time, for each hieroglyph.

But then the hieroglyph just is able to be used in the game. In order to reasonably use it, a riddle idea has to be thought up, or another riddle has to be reused and implemented, for the player to be able to collect this new hieroglyph. Additionally the new hieroglyph has to be reused several times throughout the game, otherwise the player could easily forget about the translation.

Due to this reason, only some of the multiliterals could be implemented during the time frame of this thesis. They have been thoughtfully selected, because they either had an interesting riddle idea available for them, or they were needed in some Egyptian words or other riddles.

One example of that is the Was scepter hieroglyph, that is depicted on a Senet board.

3.2.2 Senet

The Senet board is an old Egypt board game, as well as a multiliteral hieroglyph. The translation of the hieroglyph is **mn**. One of the very first ideas that have come up at the beginning of the thesis, was to introduce a mini-game into the game, in the form of Senet. In ancient Egypt, Senet was a very popular board game, that has been played by pharaohs as well as by normal people.

Many remnants of this board game have been found, for example in grave chambers. One of them has been found in the chamber of Tutanchamun, one of the more famous pharaohs.

Therefore it was the idea to introduce that board game into our Serious Game, to be one of the many obstacles, the player has to overcome, by having to win one round of

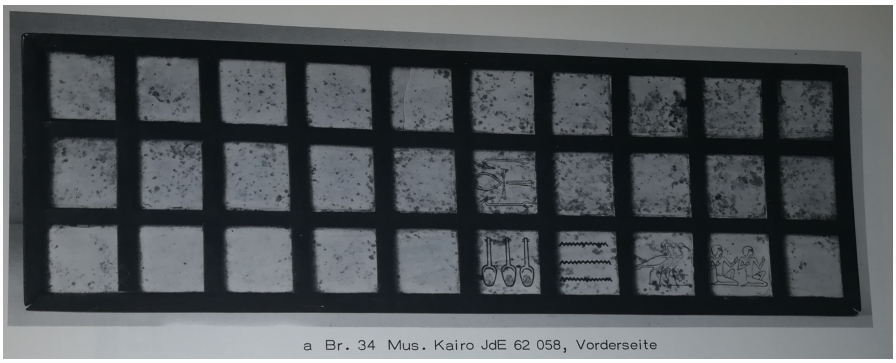


Figure 3.5: Senet board of Tutanchamuns grave chamber[Pus79]

Senet, receiving the multiliteral in return.

The Senet board game could be a whole game in itself. It is played one on one, has 30 fields, some "dices" (at the Egyptian time being animal bones or painted and carved sticks) and several rules on how to play.

And that's where the problems start, as that's basically all that can be said for sure at this time. How the rules really look like and even how many figures are used or how the dice roll is counted, is not clearly defined.

There where no real rules written down, so everything that's being known about the Senet rules involves a lot of guesswork. The rules had to be reconstructed out of several pictures or writings describing specific game situations around the game, but not the rules themselves. It is assumed, that the rules also changed over time, being an explanation to why sometimes, 6, 10 or 14 figures have been used (3, 5, 7 for each player).

There exist 3 major rule-sets from famous archaeologists, (aside from several mixtures and other created rule-sets on the internet and in games). But even finding those rule-sets in any book or paper has been proven insanely hard. Only various websites showing different rules, with some of them claiming to be the original or a variant of those 3 rule-sets. An OPAC search with keywords brought up almost nothing. One book "Ancient Egyptians at play: board games across borders"[**Wal06**] looked promising, but only contained a rough description of the Senet board and the Egyptian social and cultural conditions at that time. No rules at all. Another promising book "Das Senet-Brettspiel im Alten Ägypten"[Pus79], just turned out as descriptions of archaeological findings and some pictures. Also no rules to be found there. The paper "Passing Through the Netherworld: The Meaning and Play of Senet, an Ancient Egyptian Funerary Game"[Ken78], looked like it might contain some of the much

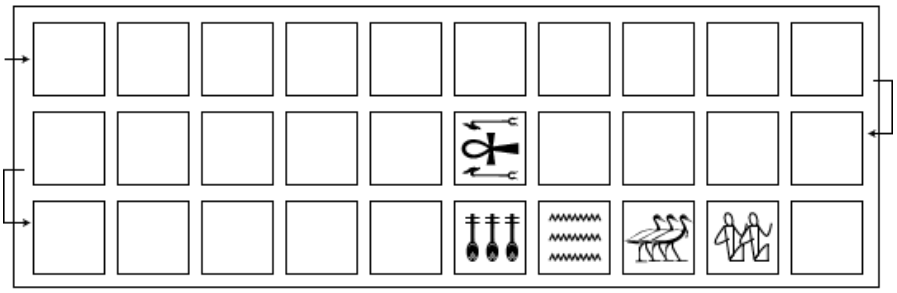


Figure 3.6: Senet board movement

needed information, but ended up not being available anywhere. The "Bayerische Staatsbibliothek" didn't have it and it couldn't be found available anywhere else.

In the end the only possibility left, was to create an own meaningful rule-set.

The rules can be roughly described as follows.
Each player starts with 5 figures on the field. They are placed on the first row of the board. The figures are placed alternating after each other.

The goal is to bring all 5 figures out of the field, before the opponent achieves this, by throwing the exact amount of points standing on one of the last 3 fields.

4 sticks, with one white side on them, are thrown. Each white side up of the 4 sticks, that points upwards after throwing, is one point to move. No white sides up, equates to 5 points.

The turn changes to the opponent, when a 2 or 3 is thrown.

One figure has to be always moved, when possible. On reaching a field with an opponent on it, the positions of the figures are switched.

2 adjacent same figures, can't be thrown. 3 adjacent same figures can't be leapfrogged.

Figures on field 15 (House of Rebirth) and above 26 can't be thrown.

A figure can only enter fields above 26, when standing on field 26 (House of Beauty).

When landing on field 25 (House of Water), the figure goes back to field 15 or before that, if the field is blocked.

Figures on fields 28, 29 and 30 can be taken out of game, with exact points thrown.

There are multiple reasons, as to why the rules have been chosen to be this way.

When being presented the choice to give the players 3, 5 or 7 figures each, the decision to take 5 was made, because 7 would make the game, take too long of a time, for a mini-game in a Serious Game. If the Senet board game was to be presented as a game on its own, the decision could be to take 7 figures for each player or to let the player choose. 3 figures however would be too short for one of the final riddles of the game.

The rest of the rules were mixed out of all the rules, that have been found during research of multiple online sources and Senet implementations. The reasons to why

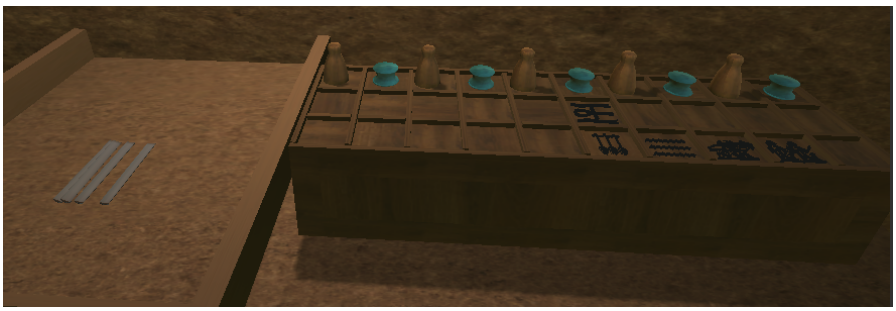


Figure 3.7: Senet implementation

they were taken specifically are manifold.

For example, to give each of the special fields with hieroglyphs on them a meaning, they are fields on which figures can't be thrown. The house of water is a trap field, to make the game a little more interesting, presenting a final hurdle for the last fields. The only possibility to enter the last 4 fields, is to get on the house of beauty. With the figure on that field, throwing a one and with no other possibility to move, the player has to move onto the house of water. This presents a good obstacle to the end of the game.

To include some strategy into the game, the player has the possibility to protect his figures with a blockade of 2 figures adjacent or to even prevent the enemy from proceeding with a blockade of 3 adjacent figures.

An interesting way to implement the dice function to the game, was to use the game engine physics and to actually throw 4 sticks onto a flat plate. In the times of ancient Egypt, sticks were used, along with animal bones, as dices for the Senet game.

In the game implementation, the player has to win the round against AI, in order to receive the hieroglyph.

The AI was given some intelligence towards certain rules, in order to make it not just move randomly, which would be too easy to win against. For example, if given the choice to move onto the house of water or another figure, the AI should move the other figure.

Or when the AI has the possibility to enter the house of beauty, which is the only field which you can't skip, it will do so and when having a figure standing on this field, it'll move it across the house of water if possible.

A rather low priority, but still preferred by the AI over any other non-important move, is to throw the figure of a player, if presented the option.

Additional intelligence, was not needed, as with the luck factor of the game, it could already be hard to beat the AI. If the AI could for example also try to form blockades, it might be unbeatable, when the luck isn't in favor of the player. That shouldn't be the

case for a mini-game, which is required to be won, for receiving a hieroglyph.

3.2.3 Game Mechanics

This senet board game, is one example of the more elaborate new riddle ideas for the game. The existing prototype used simple techniques to introduce new hieroglyphs and to reuse already collected hieroglyphs. For example, to get new hieroglyphs, the hieroglyph had to be found as an outline of the depicted object, or a tile puzzle had to be solved, where either the missing pieces were lying around somewhere and just had to be placed, like a puzzle, or the tiles had to be shifted around, with only the last correct tile, having to be placed. Then there were items, that had to be picked up and placed correctly, e.g. the hand of a statue to it's arm.

Hieroglyph reuse was done by applying them on doors or vases with the hieroglyph on them. To get through the doors, the correct hieroglyphs had to be selected or to get a vase out of the way, it had to be destroyed by applying the depicted hieroglyph. For some items, being resemblances of already collected hieroglyphs, e.g. the hand, it had to be picked up, while having the hand hieroglyph selected.

For our final Serious Game, new mechanics are to be introduced, that deviate from the concept of reaching each new area through a door with hieroglyphs on it and by implementing different new riddle types.

Apply hieroglyphs

One of the ideas that has been thought of, is the direct application of hieroglyphs. For example the already found water hieroglyph could be used to increase a water level, to water plants or distinguish a fire. Similarly a fire hieroglyph could be used to light up a fire or a torch.

This way a hieroglyph can be used in a way, that will familiarize the player with the depicted or symbolic meaning of the hieroglyph.

In the prototype, hieroglyphs are only found by either an unrelated riddle or by a direct connection. For example, the bread hieroglyph is collected by placing bread halves together and by finding the bread shape on one half bread. Or the cow belly is found by solving a tile puzzle. The hand hieroglyph is collected by placing a hand on the position of a missing hand, at a statue.

Some hieroglyphs like the Ankh for example have also a symbolic meaning. The Ankh hieroglyph actually represents a sandal strap and could be implemented in the game as such, by finding it on some sandal. But as the Ankh in Egypt was used as a symbol of life, a riddle to get this hieroglyph in game, could for example be, to give new life to plants or help plants grow, in order to receive the Ankh.

In the final game this method is used on a little pond of an oasis to rise the water level. After applying the water hieroglyph 3 times, the water level is high enough to water some plants. They grow and the player receives the Ankh hieroglyph, representing life.

The fire hieroglyph is received after collecting some wood for a campfire and spelling the word fire. It can be used in the pyramid to light up 3 torches. Without them burning, the player can't play the Senet game, as it's too dark.

In a labyrinth, in order to reach another hieroglyph, a stone wall has to be lowered. In order to do that, the player has to apply the wall hieroglyph.

This mechanic is a simple connection of a hieroglyph, with some type of action and can be extended to other hieroglyphs.

Trap tile floor

In some games or movies, there is that famous tile floor, sometimes with certain symbols on them. To reach the other side, the correct path has to be taken or the trap is to be triggered.

For this game, the tile pattern is filled with hieroglyphs, only some of them known to the player, where the player has to apply the correct literal in order to step onto a tile and get to the other side.

This is one of the final riddles and it must be crossed to be able to reach the pyramid entrance.

Tiles on the floor with hieroglyphs on them can't be stepped on without dying and beginning anew in front of the riddle, when not previously applying the correct hieroglyphs. Some of those hieroglyphs are never available to the player in order to create a path, the player has to follow.

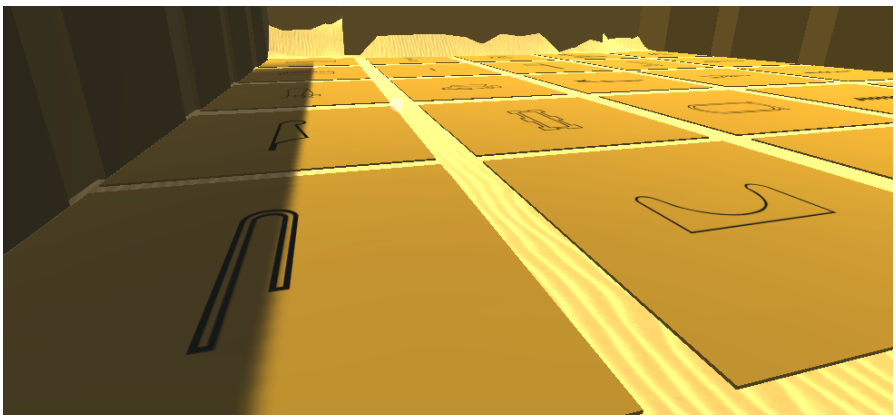


Figure 3.8: Floor tile riddle

This riddle necessitates from the player, to remember many of the collected hieroglyphs. Trying out is possible, but as the player will die and has to start anew from the beginning, will take some time. To the end of the path, the player therefore has to remember at least 9 hieroglyphs and their according literals.

If the player doesn't know the correct translations, he can use the hieroglyph lexicon or has to try and restart. This will provide some repetition, which will help to remember the corresponding literals.

Words

Hieroglyphs themselves, are combined to form words. In order to really learn the Egyptian language, it is not enough to learn the hieroglyphs and their literals, but the combination of hieroglyphs and the translation of the word that is formed by them.

So a new important riddle type in the game, is to spell some words with the correct hieroglyph combination, for example to spell Tutanchamun.

Already collected hieroglyphs can be combined together to form words.

The way that is done, is by providing blocks for each hieroglyph of the word, so that the player knows how many hieroglyphs are needed and where to place them.

For the player to know what to spell, message blocks, that provide instructions when being touched with the eye hieroglyph, tell the player what to do, e.g. to spell the word **wall** or **fire**. However surely most of the players, don't know the Egyptian translation for the word, so it is given too.

Figure 3.9: Riddle to write down **Ineb** for **wall**

To make the riddle a little harder, than to just choose the correct literals for the given word, the Egyptian word is given in its normal form, meaning like we write it out with vowels, and not the exact transliterals needed. These two deviate quite often, as for example, we add the letter **e** between consonants to be able to properly speak out the word. The Egyptians however never really used vowels.

So instead of telling the player to write down **Jinnb**, which is the exact translation of each hieroglyph clumped together, for the word **wall**, the player is told to write **Ineb**, the word, how we would write and speak it. If the player can't solve the riddle, because, they can't infer the written down version from the spoken one, or because the word has certain specialties, hints will tell the player the correct literal writing.

In chapter 4, we will have a more detailed look at some of these specialties, making it harder to teach or learn Egyptian words.

Bridge

A simple little idea for a riddle, to accustom the player with the stick hieroglyph, a Biliteral with the letters **ḫt**, is a bridge, that has to be crossed in order to reach another section of the level. The bridge however is broken, missing some wood planks. The player has to search the whole level for the planks in order to repair the bridge and has to pick up those planks, with the stick hieroglyph.

Figure 3.10: Bridge to be repaired

The planks are hidden in certain vases around the level. Some of the needed hieroglyphs on those vases have to be found first.

This ensures, that the player discovers the whole level area and finds all of the hieroglyphs spread throughout. Also, as the player has to crack open, the vases with the depicted hieroglyphs, he reuses them, further manifesting the literal-hieroglyph connection.

3.2.4 Lexicon

As already mentioned a few times, there is a lexicon, a new mechanic, that wasn't there in the prototype, but has been added to this Serious Game.

There were multiple problems with the hieroglyphs and literals in the prototype. For example, the cow belly hieroglyph was introduced by a tile riddle. Therefore most people couldn't actually recognize the hieroglyph as a representation of a cow belly, but they thought it was a rattle or something else. Other hieroglyphs had similar problems, with future multiliteral implementation just increasing the problematic.

Another thing is the pronunciation. The vulture hieroglyph is translated with the uniliteral of the Egyptian Aleph. A symbol unknown to most of the players. So they might not know how to pronounce it (as an 'A'). There are also other literals, where players could face this problem.

To solve that, the idea was to implement a Lexicon, which showed all collected hieroglyphs and their literals, as well as what the hieroglyph represents and the pronunciation.

Therefore in the Menu, the Lexicon can be selected, which opens a view of all hieroglyphs collected, until that point in time, with the information above.

A player might use it to look up, what the hieroglyph he just collected actually depicts, if he is not sure. Additionally, it helps to get the correct pronunciation. For the Ankh hieroglyph, the player finds out, that it is not only a sandal strap depicted, but that it was a symbol of life, for the Egyptians.

Of course this is a useful addition to the game, but the player could use it at any time to look up the translation of the hieroglyph to the according literal. So even if the difficulty wasn't set to easy, there now was this possibility to look up all the translations at any time.

In order to prevent that and to force the player to rather remember the hieroglyph and literal translations, a cost was introduced in the form of points, in the normal or hard difficulty. That way, the player has to have enough points to open the lexicon and looses some of them, encouraging the player to use it less often.

3.2.5 Game setting

As already mentioned in the analysis of the prototype, the level design, was fashioned in a labyrinthine way, with a lot of doors. The task was to deviate from that.

In order to do that, some kind of scenario has to be thought of, that is reasonable to be placed in the old Egyptian time. Therefore after reaching the end of the prototype level, the player is thrown into a new environment.

The idea for this new environment, was for the player to be on a boat on the Nile moving to the shore, where the player could walk around and finally enter some pyramid. The Giza plateau is a good place for that, as the pyramids there have a reasonably near location to the Nile. And the player can walk through the deserted area, solving riddles until reaching the pyramid.

Figure 3.11: Game concept: Giza plateau
Source: `http://www.ask-aladdin.com/blog/page/4/`

The resulting level ended up, with the player starting on a little boat, that sails in circles, until the player has fished enough planks out of the open water.

The boat then moves the shore, where a little wood acts as a jetty for the player to walk off the boat.

He then is able to freely explore the desert, with the riddles within. The area ended up pretty large, so that the new customizable walk speed really helps to cover the distance, when setting it to a higher pace.

The land area and Nile is approximated to the real Giza plateau, complete with 3 pyramids and sphinx, however certain elements have been changed to fit the gameplay. So for example the deep canyon, that has to be passed over in the game, with the help of the bridge, isn't really there in reality.

Also the area has been restricted with walls in order to not allow the player to wander off too far, which would otherwise drastically increase the game time, by wandering around. It also eased up some level design, as the water line hasn't had to be blocked off, with thousand invisible walls, in order to represent the rounded shore line.

A little labyrinth was also included, that didn't exist in reality, with the trap tile pattern at the end, before reaching the pyramid of Khafre, which can be entered.

The game then ends in the pyramid, after spelling the name of Tutanchamun, with a dark room and a scale in it, representing the Egyptian believe of the heart getting weighted against the feather of truth.

After elaborating on the newly added game content, in the following chapter, wee will have a look at some of the specialities, the Egyptian hieroglyphs and language has.

4 The Egyptian language

In this chapter, we will present some of the specialities, which make it hard for a game to teach Egyptian hieroglyphs and language.

Unfortunately Egyptian hieroglyphs have no terminatory research result and are still debated on, with different interpretations about phonetics and translation.

The prototype already contained the implementation of almost all hieroglyph uniliterals. Therefore the final game should additionally contain mulitliterals, like the biliterals and triliterals. Of course it was not possible to include all of the existing ones in the short time frame provided and there are hundreds of hieroglyphs. The task was to come up with innovative riddle ideas for new hieroglpyhs introduced.

4.1 Uniliterals

Even for uniliterals some phonetics and transliteral are unclear and confusing. The reed hieroglyph for example is said to be a **j** in the prototype, while the double reed is said to be the **y** and the door lock is defined as **z**. The Book "Hieroglyphen lesen"[Wil01] however states, that the reed is an **i**, the double reed the **j**, while both of them representing **y**, depending on how the **y** is spoken out.

It also states, that the **z** isn't the door lock, but actually 2 hieroglyphs together, the bread and cloth, being **t** and **s** combined, while the door lock represents an alternative version of **s**, which is a soft **s**, while the clock is a hard **s**.

Now one could simply state, that the prototype is wrong or simplified this topic in order to get a simpler game. Having the door lock being a **z** instead of an **s**, prevents the problem of having two **s** in the game, which are just spoken out differently. I don't know the source material, but I have to say here, that those two might not apply and the source material used, just defines those hieroglyphs that way. Seeing how many different interpretations are there about hieroglyphs in books, and various internet sources, it is obvious that this doesn't have to be an error.

This already shows difficulties with the Unilterals, of which there are not so many. Then there are the multiliterals and words.

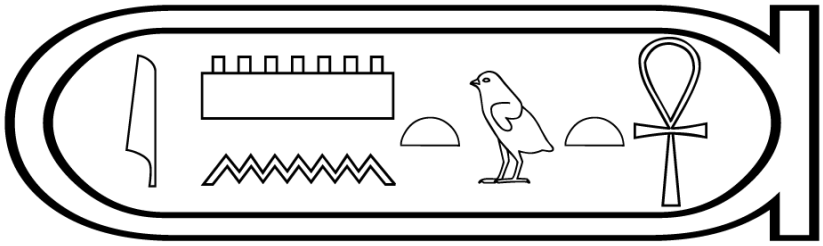


Figure 4.1: Tutanchamuns name in hieroglyphs

4.2 Multiliterals and words

Now when thinking about introducing multilaterals, and new innovative riddle ideas, a simple but effective mechanic came up.

One of the names of the pharaoh Tutanchamun is spelled with many of the already learned uniliterals of the prototype and two new multilaterals. It became already a fixed idea very early on in the design stage, to include the riddle to spell Tutanchamun's name.

Now unfortunately, as this isn't some lexicon or book, but a simplistic game, a problem became apparent, when implementing the riddle. Tut in Tutanchamun for example is written like **twt**, as there is no **u** in the egyptian language, but the quail chick, being transliterated as **w** is a replacement of the **u**.

However, how would the player know, that Tut is written with the quail chick, when he just learned, the transliteral is the **w** and he has no **u** in his inventory.

Of course we couldn't just outright tell the player the solution, as that would destroy the riddle.

With the lexicon we introduced, that not only showed the transliteral, but also the phonetics, the problem was mitigated. This way, the player could look up, that the **w** literal of the quail chick is spoken like **u**.

Now the Tut part being written **twt**, was solved. However the **Amun** part is actually being written as **Jmnn**, with the reed hieroglyph and then the senet hieroglyph above the water hieroglpyh. Now by putting two empty hieroglyph slots the player might try to put an owl for **m** and water for **n** instead of senet for **mn** and the water hieroglpyh, but with the hint system or maybe some guesswork, the player would have solved that

part.

However, why the reed symbol represents an **a** in **Amun** can't simply be explained to the player.

The Egyptian language actually has no **a** but two similar sounding hieroglyphs/-transliterals, the vulture and the arm hieroglyph ,as Aleph and Ain.

The reed symbol was defined in the prototype and remaineed unchanged as a **j**. In the book[Wil01] an **i**, sometimes a **y** and spoken like an **i**. However this would lead to **Amun** actually being spoken **Imun**.

Very weird problematic and a though problem for how to get this across to the player. Basically there was no choice left, but to have this being tackled in the hint system. This system didn't exist in the prototype. However it was much needed in the prototype section of the game already, even more so for new content.

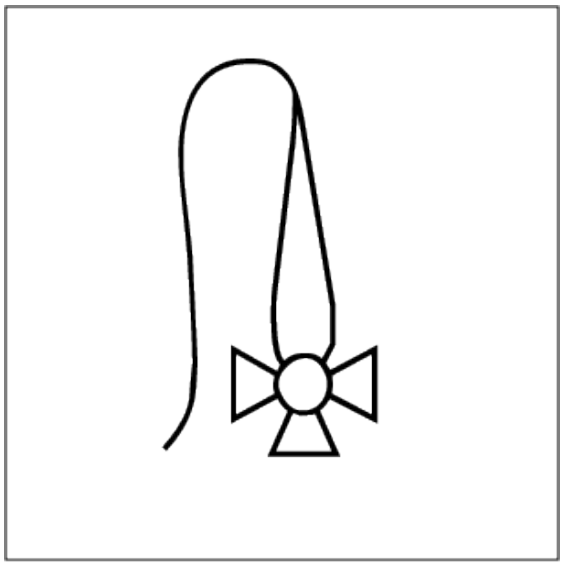
In this cases, clearly telling the player that **Amun** is written **Jmnn** and that, the Egyptians think that **Amun**, meaning god, is so important, that it comes in front.

Basically Tutanchamun, really is **Jmmntwtanch** or **Immntwtanch**, when interpreting the reed as an I as in the book.

This should already tell you how hard it is to create an innovative game for teaching hieroglyphs. There is more to it, when considering, that for example, the word for fire, could be written in several different ways and that the hieroglyph representing fire or a brazier, actually doesn't seem to have a transliteral.

In this case, the game just converted one of the hieroglyph writings into a triliteral for the fire hieroglyph. **rkḥ** or if written out **Rekhu**.

In the following chapter, we will look at some of the game system that had to be changed or added, the problems that became apparent and how they were solved.



Triliteral used: *rkḥ*

Figure 4.2: Flame/Brazier hieroglyph

5 Game implementation

When programming and designing a game, it is common knowledge that bugs are part of that process. With this serious game using the codebase of the HieroQuest prototype, there of course were additional problems with that, getting accustomed to the codebase and solving several preexisting bugs or desing faults.

At first let's look into the programming problems that came up, during the implementation of the systems or even at the beginning of testing the received protoype code.

5.1 Programming

Programming always leads to certain problems. Bugs, that have to be fixed, are one part of that. Especially with game programming, multiple sources of bugs can pop up, as a game has complex behavior and multiple types of input. When working with a game engine, errors are introduced, that lie outside of the hands of the game designer/programmer.

Then there are performance problems, that can pop up. When having a powerful PC, those aren't really visible or important, on a game, like the one that has been developed during this thesis. The reason for this is, because this game really isn't that demanding on the visuals. It doesn't have a lot of realtime lighting, high resolution textures or high poly counts. However as the game also is meant to be playable on a mobile platform, the problems become obvious, when switching from the PC editor to a test mobile build.

And finally, the game produced during this thesis, was based on a prototype from another thesis. Having to acclimate with the existing codebase and meeting questionable design decisions, can lead to problems. Especially, when something isn't working the way it's supposed to work.

5.1.1 Missing References

In Unity, all entities or game objects in the game can have multiple components attached to them. Components can have public variables, like strings or numbers, being visible in the editor, so that those values can be directly changed, even during runtime. That

helps with game debugging and game design. Then there can be public references to other gameobjects or component instances (further on called dependables), that can be used in a script to operate on that said dependables. In the editor they can be dragged into the appropriate position and are now available in the script. This of course helps with programming, as the reference can simply be used with the assigned variable name and doesn't have to be searched for in the whole game scene by some attribute, which is inefficient.

However, that also means, that when initially adding a component to a gameobject, that uses public references, those references are unassigned. They have a null value. If you need that value to be not null, it can lead to multiple problems. Either directly resulting in errors, when the code just assumes a non-null value and tries to operate on a null value or in unexpected or unwanted behavior.

When designing a game with such references, the meaning of the reference normally is known, and the reference is filled with the appropriate dependable. One example, for that, could be a boat script, that is managing how the boat works and moves. But now it might need to access data of some gameobject or a script from the components. When the boat should e.g. move to a certain position, it has to somehow get that information. Searching for the position object, in the whole scene, by the tag "BoatTarget" might work in this case, but it's an inefficient method and might not work for other situations, where multiple similar objects exist and a specific one of those has to be referenced. So the boat script now gets a public gamobject variable, named "target". The editor shows that field and the game designer, can drag the target object into the slot and everything works.

The game of this thesis is based on an already existing prototype and therefore of course includes several already preexisting objects and scripts. After loading the prototype codebase in Unity and upgrading to the current Unity version, the first problem that approached, was that several references were missing. In some cases it directly lead to errors, when starting the game, as a null value was operated on and in other cases it simply meant, things, weren't working anymore.

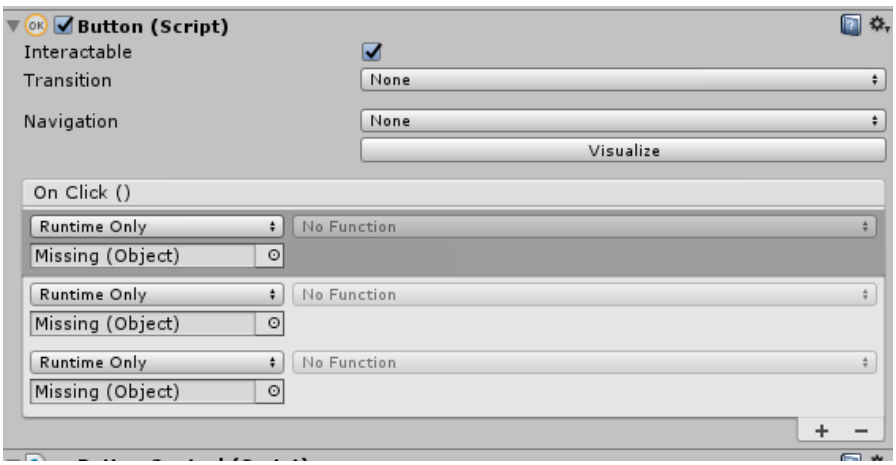


Figure 5.1: Missing References

If such a problem occurs, on a completely self-programmed game, the correct references, are usually still known quite well or can quickly be rediscovered and can be repaired.

However in this case, it sometimes could be really hard to figure out which was the correct reference.

For example, a button could have several actions, acted out when clicking on it. Those actions usually involve the gameobject, that the button should access and the appropriate function and function value, if applicable. So if you want to open some menu after the button has been clicked, you have to drag in that other menu and the function "Open()". However as the reference is missing, the gameobject slot simply states "Missing (Object)", and the according function and values are empty. The solution can be simple, if the button, for example, says "Options" and there is one empty reference to it. With a high chance, the options menu and the "Open()" function has to be used. However, when the button says "Start Game" and has 4 empty actions waiting to be filled, it can be really hard to figure out the correct values. There can be dozens of possible objects, that could come into considerations, from a game control, to some UI elements, over player scripts and so on.

It's obvious that this problem, leads to an impact on time spent. Even repairing all the references, when everything is known, can be time consuming. When it's a foreign codebase, even more so.

There is no real explanation to why this is happening in the Unity Engine, or a real solution. Of course installing the latest version and having to upgrade the project had it's impact here. The takeaway from this is, that when attempting an upgrade on a Unity project, first make a backup, as everything is overwritten. When something isn't

working the way like before, keep an old version of the Engine and open the backup. Now you can simply lookup all the missing references. It may still take time to repair, but not as much as if a lot of guesswork is involved.

5.1.2 Broken gameplay

Another problem that came up early, was that certain gameplay elements, weren't working as they were before. The prototype had a playable build on the App store, being completely fine to be played through. However in the newest version that we got to work on, after fixing the reference problem and playing through, several things were wrong.

Examples for that are: One of the gameplay mechanics, is to break certain vases, by using the depicted hieroglyph on the vase. After the introduction of the mechanic, those vases contain important gameobjects, for other riddles. At one point of the gameplay, the hieroglyph depicted on the vase, wasn't available at that point. It was introduced later. This resulted in a dead end. There were no indications to why that was the case. It couldn't have been a missing reference, as the material clearly was assigned, it was just the wrong one. Most likely, due to some reason the previous programmer, just dropped in the wrong material, when changing certain game elements.

Another mechanic of the game is, to solve several riddles, to receive a certain hieroglyph. At one part of the game, solving only some of those riddles, already led to receiving the hieroglyph, while at other times, solving the riddle, did nothing. This of course breaks gameplay. It may have been caused, by missing references. There were no empty slots stating "Missing reference", however the component holding an array of riddles, just didn't include the problematic one.

Such problems can be easy to fix on themselves. But they pile up, resulting in a lot of spent time.

5.1.3 Literal Picker

The literal picker is one of the main elements of the game. It contains collected hieroglyphs or rather their literal, like an inventory, letting the player use those literals on certain gameobjects. The prototype unfortunately had no possibility to save. This was a much needed improvement. However on the design of the prototype the possibility to save, seems to not even have been considered in the design choices, including the literal picker.

When loading a saved game, of course all the collected hieroglyphs had to be there. So the whole script had to be analyzed and reformed in order to allow saving and

loading the inventory. This led to a multitude of bugs and workarounds, to get the save system working, with the literal picker.

Saving and loading is one of the most important features in games. Even small simple games, like tile puzzles, have the ability to stop the game and go on playing later. A game like this, which in the prototype phase, already could last an hour for new players, not familiar with the type of puzzles and not familiar with hieroglyphs. Having to replay the whole game, from the beginning, when stopping it or on unexpected errors stopping it, is not viable.

The save system was finnally handled in a way to save all the picker hieroglyph codes into an array. To make that possible, they had to be saved in order, by their slot code, or when loading they were switched around in the inventory. On load, this array then was used to add the hieroglyphs by their code, one by one. A lot of stuff had to be rewritten in order for that to work, as the code didn't seem to have thought of any way to save or load hieroglyphs.

What is to learn from this is, to always design certain classes, especially for games, with future improvements in mind.

5.1.4 Script Execution Order

Another whole line of bugs, that popped up during the programming phase, had to do with Unity's Script Execution Order and scripts depending on each other. A Script has the possibility to initialize values in the "Awake" and "Start" function, automatically getting called by Unity. Awake is usually always started, when the script is initialized and before Start, which also only get's called, if the script is checked as "enabled" in the editor or set so in the code. However when a script has a certain function, that can be called on another script, there is a dependence. This can be problematic. For example, a Menu class contains an image, and when opening the Menu, the image is displayed. A script getting started at the beginning of the game, now calls the the "Open()" function of that Menu class. It could be that the Menu script on the accessed gameobject, wasn't enabled. So only "Awake", has been called but not "Start". The image, that has to be displayed, when opening however, was initialized in the "Start" function, of course leading to accessing a null value and errors.

The prototype project had dozens of scripts, with this behaviour, leading to a lot of errors and rewriting. Mysteriously this problem began to start, when using Unitys function to load a level. Sometimes moving the Initialization from "Start" to "Awake" solved the problem. Sometimes however and with no apparent reason, the values hasn't even been initialzed, when accessing the opening function, even if the Initialization has been defined in "Awake". One would assume, that such problems shouldn't be possible, and that Awake should always be executed first. Programmers usually expect their

values to be defined in the rest of their code to use, if the initialized them in "Awake". There normally is no need, to encapsulate every variable with a null-check, wich would also lead to a huge chunk of garbage code and performance decrease.

Another way to solve this problem, is to define a Script Execution Order, where you can manually define the order in which scripts execute. This helped sometimes and other times, it didn't anymore or even made the problem worse, by showing more and more dependencies, leading to more and more scripts having to be manually added to the script execution order. However even, that couldn't solve the problem in some, cases, such that an Update function still called another scripts function, with variables being null, even if the initialization was defined in "Awake". This was especially happening, when using Unity's function to load a scene, which was used to reload the scene, for example after pressing the "Load" or "New Game" Button.

With enough time spent fiddling around and using the script execution order, switching some initializations into the "Awake" function and inserting several not-null checks, the problem got solved.

What is to learn here, is that every possible function, called from another script is always to be seen critical and should be avoided or the function should include several not-null checks.

5.1.5 Dust Riddle

The prototype included a riddle with a custom created shader, called "Dust Shader", which is used to cover a hieroglyph with dust, that has to be cleaned away. At first, the riddle didn't work at all, after the import. Looking into the code lead to finding the culprit, of one line missing, that correctly subtracts the opacity of the dust on user drag. After that in the editor all occurrences of that riddle worked very well in all cases.

However after creating a build version, the dust shader, wasn't visible at all in some cases. The riddle still worked, as after some cleaning invisible dust, the hieroglyph got into the inventory. However as no dust was visible and other riddles, for the same hieroglyph were in the area, the playtesters, missinterpreted the hieroglyph just as some symbol on the wall, rather than a riddle to solve, even having already been in contact with the same riddle before, but in a working condition.

Dust Riddle working like intended

Dust shader not visible

Figure 5.2: Dust riddle comparison

Research led to sources stating, that some shaders don't work anymore in the build versions in some cases and provided different solutions for that. However in most of those described cases, the shaders didn't work at all. In this case however, the shader was working completely fine in some instances, but not on others. So the solutions didn't help. Other sources, mentioned, that on custom shaders, certain very high or low values, led to the shader not working. However fiddling around with the shader values in the editor and even setting all values exactly the same, as on the working instance, didn't help at all.

In the end, deleting the not working riddle, copying the working riddle and then changing the properties to their needed values, solved the problem. There were however no clues, indicators or hints as to what was happening there. There is no real takeaway from this, just that the Unity Engine has its weird quirks, that have to be dealt with.

5.1.6 AABB problem

Another one of those Unity quirks, is the AABB problem. It came up, as one of the playtesters had found a bug, that a certain wall didn't stop them, and they ended up in level areas, they shouldn't be in. Seemed simple to fix, as the wall collider just had to be extended. However using the savegame on the editor, showed a lot more unrelated bugs. Suddenly the game was unplayable, with Unity showing hundreds of errors

piling up and the framerate dropping to unplayable values. The build version just seemed to ignore the problem and had no performance problems, whatsoever, but the editor version did.

This unity error, was not really meaningful, as it didn't include the usual stacktrace and just stated "Invalid AABB a" or "Invalid AABB, value too low or too high". In the end, clicking on the message revealed, that it was totally unrelated to the problem with the wall collider. It had to do with multiple other gameobjects, containing rigidbody components. The position of those gameobjects, showed NaN (Not a Number) for x, y an z. The problem was solved, by replacing all those NaN, for hundreds of objects, with 0 or another valid number. The problem here lies within the Unity Engine. Apparently after some research, sometimes rigidbody calculations can get out of hand, leading to this error. There is nothing that could be done about it, as not using rigidbodies is no solution, therefore the position has to be set in code. A future update in the Unity engine code, might fix this. Gladly, this is a non-issue in the build version and doesn't happen that often. However the current code just sets the objects to the game center position, to prevent the issue. This also leads to some of the objects disappearing, which is another advantage, as for example the vase shards that get created when destroying a vase, are now vanishing after awhile, better making, the items that were in the vase, visible.

5.2 Design

In addition to programming and performance problems that come up, because there are bugs, there can be design problems. If certain aspects of the game code are not designed in a certain way or designed in a weird way, it increases several factors. Time to debug, complexity or duplicated code, just to name a few of them.

The prototype had several questionalbe design choices, which lead to some problems, described in the following text.

5.2.1 No centrality

The prototype was designed in a way, such that multiple different scripts were managing certain game aspects, that could be handled much better in a central instance. Having multiple scripts manage, several aspects, is not bad in itself. However splitting those with no apparent reason, makes no sense and makes future things harder.

One example is the sound system. Multiple riddles, had sound sources, playing certain audio files. Now there were hundreds of riddles, with Audio sources spread around. And there was no way to set the volume in the game for these sounds. The game had no music before, but for atmospheric value music was included, with the

additional option to turn down the volume. For all those sound effects there was no viable way to access the volume. So to turn the volume of those effects, the whole sound had to be turned down on the speakers, together with the music. Not a good solution. A central sound controller was introduced, that holds possible audio files, to be played from any script. And the volume of that one instance can easily be controlled. However in the final version of the game now, there is still no volume controller for effects, as it would take a long time to convert all of those sound sources to the central system and that time had to be spent on more important stuff.

Another example, is a central game controller, which controls saving, loading, tracking points, winning, loosing, starting a new game and quitting the game, and so on. In the prototype it didn't exist. Each of the behaviors were in their own script. A win script, a loose script, a script to quit the game and one to start a new game. All of that with no apparent reason. As there is only one main game to quit or start, to loose or win, a central instance, designed as Singleton is the usual design pattern.

The conclusion of this. For cleaner code and better usability, pack together what belongs together and crate a central Singleton, when applicable.

5.2.2 Lighting

Unity offers the possibility to bake lighting into light maps. Using this should have led to better performance on mobile, as less realtime lighting could be used. A problem that came up with this is, that at first it can really take a long time to bake. One bake could last hours, depending on the values. This in itself isn't really a problem, wouldn't a bake have to be redone on every light or value change.

Another problem, was that, regardless of whichever values were tried, the result looked drastically worse. In the end the solution was to deactivate baking altogether and being economical, with using lights.

Also a problem, that came up, when setting lighting values, was that a dark room, which should be dark, was brightly lit, because of ambient light, affecting all objects in Unity. After a lot of research and trying different solutions, there seems to be no real solution to not have ambient lighting affect a certain part or certain objects of the game, other than turning the shader into an unlight one, that's not really usable for our intent.

Therefore ambient light had to be completely or almost completely turned off, which then on the other hand, led to another problem. The one light source (sun), lit all of the game objects in the lighting direction, but on the other side walls and objects were black, looking very bad. Decreasing the shadow strength mitigated that problem, but then again led to dark rooms being bright again, as the room being dark, was an effect of a total shadow decreasing light in rooms. The final approach was to add 3 more light sources (suns), that lit all other 3 sides of objects, for an ambient light natural

look. With shadows on however, the result looked exactly like 4 suns shining down, so those 3 lights had shadows turned completely off, which then lit, the dark rooms again. Fortunately, it was possible to switch the dark room to another layer and setting the 3 lights, to not affect that layer at all.

5.2.3 Save system

Unity has no built-in save functionality. Everything that has to be saved, has to be implemented. That in itself, wouldn't have been the huge problem, when Unity wouldn't have laid addditional stones in the path.

One part of the problem is, that there is no way to simply serialize gameobjects or standard components. Strings, Arrays and a lot of other important properties can be serialized to be saved into a file, but gameobjects and standard components can't. Research lead to the conclusion, that on Unitys side, it could be a simple fix, by adding a "[Serializable]" code line to gameobjects and components. However nothing, can be done on the user side in that regard.

Therefore to even save something as simple as a Transform, which basically is just a position, a rotation, the class had to be reimplemented, with the code line there. All that said and done, in the end one thing turned out to be almost impossible or too complicated to be viable. Saving parent-child relations. If a unity gameobject is placed under another gameobject, moving the parent, automatically moves the child. This is useful and often needed. For example a moving vehicle should carry the player with it. In this game, a boat carries the player and some collected wood. Now without the possibility to save this relationship, in a viable way, when loading a level, the objects, may be placed on the same coordinates as before, but the relationship isn't there anymore, meaning for one, that the boat is floating away, leaving the player and wood behind, as they are falling in the water, introducing a bug. And additionally, the coordinates for childs, are calculated based on the parent, so that when loading the "correct" coordinates, the items, end up in the wrong place, because, the child isn't under the same parent anymore.

Gladly, this issue was only present, for this one boat in the game, and could be solved with a workaround, by disabling saving, during the boat tour. For some other more complex game, where more child-parent relationships have to be saved, another solution might have to be found, for example, by always saving a reference ID for the parent, and on load looking for the parent in the whole scene, by ID and setting it as parent for the child.

Now we come to the other part of the proplem, the ID's. Initially Unity's component ID's were used to save the gameobject under that ID to load the values to that ID again. Only to find out, that those ID's are in no way consistent. The ID could change from

one run to the other, from one system to the other or for other various reasons, making this ID unusable for a savesystem which needs consistent IDs.

Research, brought up, that Unity also doesn't seem to have any other way for having such IDs.

To solve this problem an own implementation had to be used, which uses the GUID class of C#. This class can create unique IDs and therefore was used to create such an ID for every Object that had to be saved.

5.2.4 Resources

Usually games are either created in large teams, or large time frames. Those teams not only include programmers, but also modellers and artists. And if the game is programmed by one person, that has to do everything himself, he can at least take time to get it right or if the game might be financially successful buy, the needed resources. For this project, there was one person, that can program and has experience in image edition, sound creation/editing and even modeling. So basically everything a game might need, like textures, game models, game code and audio can be created. There are two problems though. This game has no financial budget, and it's limited to the time frame of a master's thesis.

So, when there is no money and not a lot of time, some trade-offs have to be made. Modeling for example takes a lot of time. There are free models available on the internet, but they are sparse in certain areas or unusable quality wise.

The game design had the intention of mimicking the Giza plateau with those 3 pyramids, the Nile and a boat sailing on that Nile to the shore. At least one of the pyramids should be entered. Looking for a free pyramid 3D model on the internet, either turned out as a costly adventure or receiving a simple flat pyramid shape with a flat texture, which could be spat out by anyone in some minutes. They looked really bad and had no interior. So there was no alternative, than to model that pyramid, which occupied dozens of hours, building the pyramid out of single stones, with an interior and an entrance. Fortunately the game didn't need much more of such time consuming unavailable models, but some little ones. Being an amateur modeler, definitely a lot more time was invested in modeling these things, in comparison to the time more advanced modelers would have needed.

Some comments in the study mentioned, to make the graphics better or to make the game VR. With more time and people for this task, that might be a good future work. And with that, we will come to the study in the next chapter.

6 Study

The study, that was conducted can be found, in full, at the end of this thesis. While the study stays open, the results we present in this thesis are taken at the date of 15.04.2018. The study was open for 4 days, during which the participants could freely choose their time to play the game and answer the study. People could get help during the study time, in which bugs were also fixed quickly and the new version was uploaded. We will now see, what the players of the game have answered to the study.

6.1 General

We proposed some general questions and had some demographic ones, which we now will look at the statistics to.

For the gender of participants it is to say, that we mainly had male ones, with only $\frac{1}{6}$ being female participants to this date. The reasons for this, can only be theorized about. One of the reasons could be that the gender demographics for the used channels to which the study was posted to, mainly consisted of male members. As this data is not publicly available, it is only a theory, though. As the study was a free choice to participate, reasons also could be that females in the targeted channels, are not as readily available to partake in such studies, including playing a game.

For the age, we mainly have a large chunk of participants being in the group from 18 - 30, which is no miracle, as the used channels, mainly included students. When more channels could be used, like publishing the game to the Android AppStore and iOS store, a more general audience could be reached. The time for doing this and awaiting the results, however isn't available for this thesis.

The amount of times, the players played the game until they took the survey was a good mix, with $\frac{1}{4}$ having played the game more than 3 times and $\frac{1}{3}$ having played the game two times. The rest played it only once. Most likely those, who have played the game more than once, tested the waters with the easy mode or wanted to try out the hard mode, after their first playthrough.

$\frac{1}{4}$ of the players, played the hard difficulty, before answering the survey, while $\frac{1}{3}$ chose the easy mode and the rest the normal difficulty.

This distribution seems normal. The percentage of player having played 3 or more times, is exactly the same as the percentage for the hard difficulty, meaning they

played the game a few times and wanted to try the hard mode. As the percentage of players who played only once is bigger, than those having answered they chose the easy difficulty, means some have played the game in normal difficulty for their only playthrough.

6.2 Previous Experience

With some questions we wanted to estimate the previous experience with games and the thematic of Egypt and hieroglyphs.

All of the participants answered, that they have experienced digital games before. In nowadays times, this is not really astonishing, as digital games are everywhere and even mothers or business people play games on their smartphone.

When it comes to the amount of minutes they play, the answers were wildly mixed. The group of people who play less than 60 minutes per week, are at 41,7%, 33,3% have played 2 to 8 hours a week, 16,7% spend more than 8 hours a week gaming and only 8,3%, play from 1 to 2 hours a week.

For previous experience with Egypt or hieroglyphs, all participants answered, that they have not previously engaged in Egyptian hieroglyphs and only 83,3% of them have engaged in the topic of Egypt before. Those who have done so, answered that they have touched the topic in school, art exhibitions or visited the pyramids.

6.3 Hieroglyphs

Regarding the hieroglyphs, there were multiple different types of questions, which afforded participants to answer differently.

6.3.1 Warm up - Which hieroglyphs did the game contain?

For the first question, where players had to name all of the hieroglyphs they could remember, the answers were mixed. Some could describe and name a large number of hieroglyphs, for them having never experienced hieroglyphs before. The average lies at about 17 hieroglyphs, with 36 hieroglyphs that can be collected in the game. Taking into consideration, that people wouldn't spend too much time on the task and rather quickly wrote everything down they could remember, without trying too hard, this result is pretty good. Also some participants didn't reach the end of the game, so they couldn't know all of the hieroglyphs.

6.3.2 Recall Hieroglyphs by category

For the second chapters, hieroglyphs for certain categories should be named out of memory. The first category was plants and food. The answers we searched for could be: stick, reed, bread, double reed, pair of reeds or similar words to describe those. Most successfully named the reed or double reed and bread, while some didn't use the exact words from the lexicon, but named barm, weed or plant.

Some interesting answers, included snake and bird and similar words, which certainly can be considered food in some sense, but weren't hieroglyphs we expected.

In the second category "parts of the body", most of the people could name almost all of the hieroglyphs, them being, arm, hand, leg, mouth, eye and lastly heart and windpipe. The last one wasn't named by almost anyone. For the hieroglyph to be recognized as heart an windpipe, the person had to look into the lexicon, to know the correct description.

For the house and furniture, possible answers we expected were: house, wall, jar stand, basket, stool, cloth, or the door lock. The answers were mostly in those bounds, with some interesting ones, naming the hill or the well as being included and one answer naming an oven, which wasn't available in the game and was most likely mixed up with the jar stand.

For the animals, we had the vulture, fish, cobra, viper, owl, quail chick and cow as possible answers, of course with certain variations possible in the wording, like bird or snake. All answers were in those bounds with no outliers.

6.3.3 Which Hieroglyphs do you recognize?

In the third section we showed a picture, with a wall full of hieroglyphs and the participants should name the hieroglyphs they could recognize from the game. 17 hieroglyphs on that picture were available in the game, if looking vigilantly. On average 8 hieroglyphs have been found. With some being exceptionally good, even finding all of them and some only being able to recognize 4 hieroglyphs.

6.3.4 Which literals can you match to the Hieroglyph?

Then we showed the participants certain hieroglyphs and asked for the according literal. For the Senet board mn, many didn't know the answer, but those who answered, did

correctly. As this was the last hieroglyph in the game and it only is repeated in the final riddle, some people just didn't reach that part or couldn't remember, due to not many occurrences.

For the water hieroglyph, the majority answered correctly, with the n literal.

The cobra hieroglyph got mixed results. The literal is an unusual ḏ, so some forgot the stroke under the letter and others mixed it up with the f, for the other snake hieroglyph, the viper. Interestingly, some answered J, the literal for the reed hieroglyph.

The hill hieroglyph was answered correctly, by all who gave an answer, which was half of the participants.

The arm hieroglyph, being spoken an A, but the literal being the Egyptian symbol, named Ain, got mostly correct results with some trying to represent the Ain, with an apostrophe or a c and some just naming it A. A part misjudged the arm with the hand, which has the literal d.

Listing all the answers would be too long. To give a general tendency, the majority of the answers was correct. Some trick questions were hard for the participants. C16 for example depicted a bent leg and not the real leg hieroglyph, but people mistook it for the leg hieroglyph and answered the b literal.

6.3.5 Which literals can you match to the partially shown Hieroglyph?

In the next part, we showed partially visible hieroglyphs and again wanted to know the corresponding literal.

And though the question explicitly stated, that we wanted to know the literal to the glyph, some of participants, didn't answer with the literal, but with a description for the hieroglyph or what the missing parts would show. So for example instead of answering with **ṯ** for the cattle rope D12, or something like "t with stroke", some answered things like "circles added" or "two balls left", which described the missing part of the hieroglyph. This part of the survey should be renamed, if future studies reuse the questionnaire.

Most of the answers given however matched the question, with some of them giving the literal and others describing the hieroglyph.

6.3.6 Choose the literal(s) that fit the hieroglyph

Then we changed the type to multiple-choice, were we showed a hieroglyph and 3 possible literals or as 4th choice, that none of the shown literals fit.

This section overall was answered very well, with most of the answers being correct, especially for the early hieroglyphs. As the participants had the solution as a possible

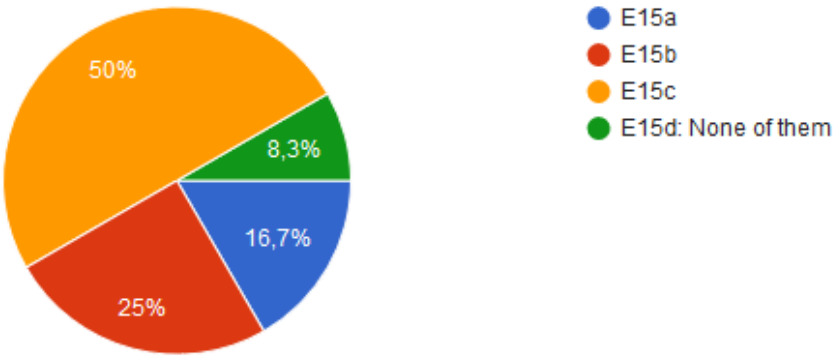


Figure 6.1: E15 Well lid. Answer: E15c

choice out of a restricted set of answers, they could better match the correct literal and hieroglyphs.

Interestingly two of the hieroglyphs, of the early section of the game, the pool basin, E13, a rectangle and the well lid, being a circle with 4 horizontal stripes, E15. Only half of the participants chose the correct answer for both. It could be due to the special literals, being **ŝ** and **ḫ**.

6.3.7 Choose the hieroglyph that fits the literal(s)

Now we switched around the task and people had to choose the right hieroglyph for the literal(s).

The results in this section were very similar to the one before, meaning that most of the overall answers were correct, with the participants having some more problems with later hieroglyphs.

On both, the questions, F14 and F19, only half of the players could answer correctly. F14, was a trick literal not in the game, where some people answered with a hieroglyph not in the game and the anch, a late in the game hieroglyph. F19, was the was-scepter, not used often and very late in the game, where some people answered with the anch or "None of them".

6.3.8 From which object was the hieroglyph derived from?

In the final section, regarding the hieroglyphs, the participants were given the pictures of hieroglyphs and should name the real object, that matches the outline of it.

It seems, that many have only read the title and skipped the instructions, as there was a clear statement, that the object is searched for, that the hieroglyph originates from.

Most named the correct object, that the hieroglyph originated from. Some people however named object, that the hieroglyphs could be seen as and not the original ones we searched for.

For the hill, G10, for example, some named a chair or seat. The pool hieroglyph, G11, was described as Block, Package or Box. G22, the jar stand, was described as symbol, vase, oven or urn. And the heart and windpipe hieroglyph, G23, was named as shovel, by a majority, though that is no wonder, as only a look into the lexicon would have revealed, the name and it's hard to identify otherwise.

All in all it is to say, that the original purpose of teaching hieroglyphs worked. Most of the answers were correct for matching literal and hieroglyphs, considered that nobody had any previous knowledge about hieroglyphs and that they just played the game for a short amount of time, to partake in the study. Many didn't even get to the end of the game. It is to expect, if the game is played more often, that the players, would remember more and more hieroglyphs and could actually name the correct terms and definitions of the hieroglyphs.

That was the most problematic area, that people didn't use the proper words, like they were given in the lexicon. Therefore the use of the lexicon should somehow be more enticed or forced. For example by opening the lexicon for each new hieroglyph automatically.

6.4 Improvements

As we had a previous prototype, that we have extended with certain improvements, like the tutorial, hint system and lexicon, we wanted to know what the study participants thought about those, in K12.

For the tutorial, we wanted to know if the players thought the tutorial successfully explained the basics of the game and in another similar question, if the tutorial was helpful. Gladly the huge majority agreed and when asked, if the tutorial should be longer only a fraction of participants agreed. This means, that the tutorial seems to have fulfilled it's purpose with explaining the game principles and has the right length.

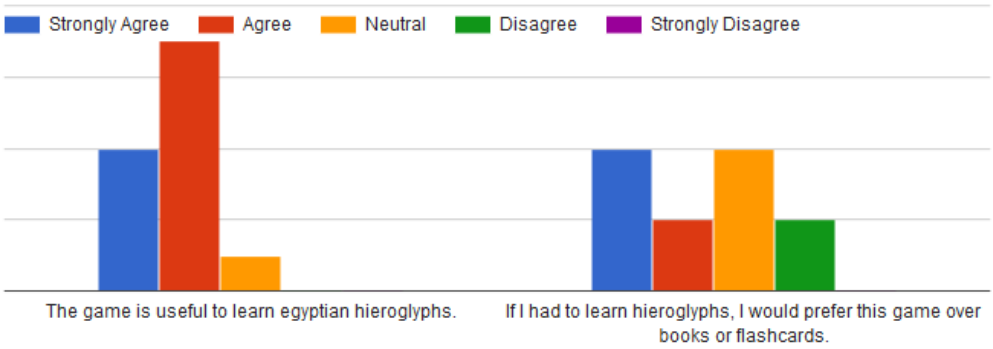


Figure 6.2: K10 Educational value

Also the hints were seen as useful, with nobody disagreeing. However when we wanted to know if they couldn't have proceeded, without the hints and if they used them often, only $\frac{1}{4}$ said so, which indicates, that the game wasn't too hard and that they could figure out most of the riddles, themselves.

Similar results we see for the lexicon. Most of the players think of it as a useful tool and some of them even used it often.

These results can be interpreted in a way, that we successfully analyzed the weaknesses of the prototype and that the mechanics we implemented to solve those problems, were a huge success.

6.5 Game value

In the "About the game" section in K10, we presented the question if the game is useful to learn Egyptian hieroglyphs In the study, there were no people disagreeing or strongly disagreeing. The majority of people chose to agree. This shows, that most of the players of the game, think that the game is helpful in learning hieroglyphs.

However for the next question at K10, we wanted to know if the players, would prefer the game over learning with books or flashcards. 16,6% answered that they disagree, which is interesting, because that means, while they agree, that the game is useful to learn hieroglyphs, this part indicates, they would rather like to use traditional learning methods. With some people staying neutral, about the half, would definitely prefer the game over books or hieroglyphs.

When asked if they think, that other people would prefer the game over books or flashcards in K13, 75% of the participants thought so. That's an interesting change from some neutral people who couldn't decide from themselves, would think that other

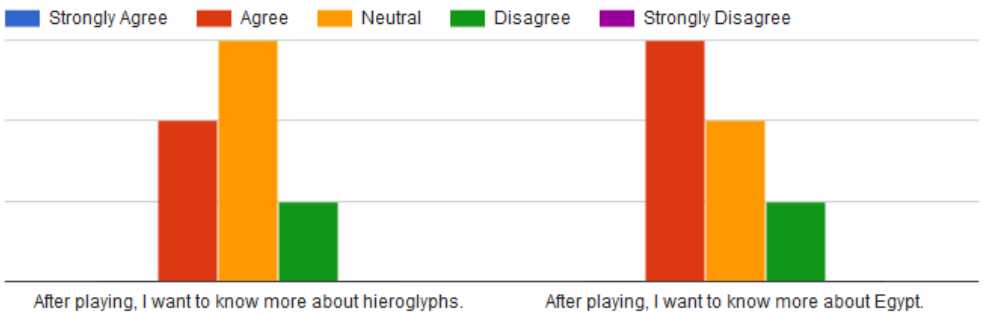


Figure 6.3: K14 Motivation

people would prefer the game.

With the question in K11, the participants were asked to tell if they have learned something about hieroglyphs, and while nobody disagreed, roughly $\frac{1}{4}$ answered, that they are not confident that they can remember, what they have learned, over a longer period of time. Half of the people, stayed neutral, suggesting, they can't evaluate if they could remember or not. The rest seemed to be confident, they could remember.

Of course these answers are subjective from the participants point of view. If another study would be conducted some time after the first, questions like these could be observed more objectively.

In K13, we also wanted to know, whether the game was fun to play, and it seems that almost all agreed, with no disagreements. A huge success for a Serious Game, which has the intent to be fun.

When we wanted to know if they thought, that other people would play the game in their free time, even if they have no interest in hieroglyphs, 58% agreed and 25% disagreed. An interesting correlation for this question is, that people who chose to strongly disagree, also seemed to have problems or bugs with the game, as can be seen in the comment section. Also they belonged the group of people who played more digital games per week, than the average. This game, therefore could be a type of game more hardcore players don't like as a leisure time activity, with it not having very elaborate graphics and them having experienced problems with it.

What's nice to see is, that more than 40% of the players answered in K14, that they want to know more about hieroglyphs and half of the players, that they want to know more about Egypt, after playing the game. These answers tell us, that the game was successful in inspiring people to engage in the topic, just by playing the Serious Game, even if they had previously not been engaged in Egypt or Egyptian hieroglyphs before, as seen in J10 and J12.

6.6 Comments

We also offered the possibility to give comments, for suggestions or if there were any problems with the game. There were many entries, and we will only list some of them here.

Regarding problems, there were some minor bugs, some of them already having been able to be solved during the study time.

Some wanted to have the possibility to increase the walk speed and camera sensitivity even higher, as they found it still too low. Combined with comments, stating the game takes too long or, that the desert level is too big, this could be correlated.

There were suggestions of making the game VR and some people have complained about some of the prototype riddles. Finding the shapes, e.g. for the 3 stools is one of them and the dust riddle another.

Now that we have looked at the study results, we will come to the final conclusion.

7 Conclusion

With this final chapter, we now come to the conclusion and possible future work. The goal of this thesis was to extend and improve the HieroQuest Prototype, in order to create a Serious Game that is able to teach Egyptian hieroglyphs and to be fun at the same time.

7.1 Summarization

We have elaborated on the advantages of Serious Games, when compared to traditional learning approaches. In the limited period of a Master Thesis we successfully created a Serious Game, that contains all planned features and is a complete experience. Biliterals and Triliterals have been added and new riddle mechanics were implemented. The player was challenged to form their first words in Egyptian language with hieroglyphs. The Egyptian board game Senet, was included as a mini-game in what in itself could have been exported as a whole game on itself. A whole new level with the giza plateau was implemented, which could be further used in future versions to explore more of.

The study showed, that the game was fun to play, that the hieroglyphs could mostly be remembered and that it even enticed people to spend more time with Egypt and hieroglyphs. The new additions, to improve the prototype, like the tutorial, hints and lexicon, were helpful, in the eyes of the participants. With the results of the study, it can be said, that the project was a success. Only the long-time effects couldn't be shown by the study, as for that another later study, would be needed and didn't fit in the available time span of this thesis.

Leaving the results from the study aside, speaking from personal experience, the game was certainly fun to play and due to the extensive testing throughout the programming phase and therefore frequent test plays, remembering all of the included hieroglyphs is no problem at all anymore. Even as no previous knowledge about hieroglyphs existed, before the work for this thesis began. Personally, this was thus a successful and fun way to learn Egyptian hieroglyphs.

Now with this version of the game, possible future versions can extend on it.

7.2 Future work

If we are examining the implementation that has resulted during this thesis, we could think of certain improvements and additions, that would be possible.

The Egyptian hieroglyphs have some of them being used as determinatives, which are hieroglyphs at the end of the word, that define the word before, to help with disambiguation. This aspect could be teached in a more extended version of the game.

Also other specialties and grammar could be introduced, for example, the direction of writing, being determined, by the looking direction of hieroglyphs.

The game already tracks points, which are only used to give the player a rough clue, about how good they have done and to pay for hints and the use of the lexicon in the medium and hard difficulty. A sort of multiplayer integration could be implemented in the future, for example just a simple highscore board, for players to compete with each other. Another possibility would be a ghost mode, where 2 players play through the game, seeing each other as ghosts, while they solve their riddles. The first one to reach the goal, wins. Ideas like this will help with replayability, further helping to remember hieroglyphs through repetition.

As it has been shown, that a lot of players struggled, when it came to using the correct terms for the hieroglyphs, the lexicon should somehow be more in the focus of the game and used more often. It could be automatically opened, for every new hieroglyph or it could be extended with some interesting features, like a short audio description for each hieroglyph.

Certainly more hieroglyphs and words can be implemented, along with more riddles. The final game would finally involve enough hieroglyphs and words, that a player of HieroQuest could actually read Egyptian sources written in hieroglyphs.

Designers and artists or programmers with enough experience in that field, could help to make this game more artistically pleasing. This game is held very simplistic, due to various reasons. Time constraints, mobile compatibility and because of lacking artistic and modeling skills. Some models could be refined, textures polished and with enough effort, the walls could therefore hold actual hieroglyphic writing on it, that can be translated. If the whole environment is covered with walls, that have hieroglyphs on them, there could be hidden Easter eggs between.

And like some comments mentioned, a VR version could be designed. As this game is in first person and has interactions, that would also work in VR, that's an interesting suggestion.

For another project, there could be conducted 2 studies. One directly after playing the game to test the short-time memory and another, a while later, in order to check the long-time memory. For this thesis unfortunately, the time wasn't sufficient to conduct the second study.

List of Figures

8 Used Programs

8.1 Software Development

Unity3D `https://unity3d.com/de`
Game Engine used to create the game.
Visual Studio 2017 `https://www.visualstudio.com/de/`
IDE to program for different languages.

8.2 Software Resources

Photoshop `http://www.adobe.com/de/products/photoshop.html`
Adobes famous Image software.
Illustrator `https://www.adobe.com/de/products/illustrator.html`
Adobes Image software for certain designs.

8.3 Regarding this Document

MiKTEX `http://www.miktex.org/`
Free implementation of TEXand related programs for Windows.
TEXmaker `http://www.xm1math.net/texmaker/`
TEXmaker is a free editor (IDE) for developing LATEXdocuments under Windows.

Bibliography

[al16] C. W. et. al. *Ancient Egyptians at play: board games across borders*. New York Bloomsbury Academic, 2016.

[Fed17] D. Fedh. "Designing and Implementing a Serious Games for Learning Hieroglyphs." MA thesis. Technische Universität München, 2017.

[Ken78] T. Kendall. *Passing Through the Netherworld: The Meaning and Play of Senet, an Ancient Egyptian Funerary Game*. Kirk Game Company, 1978.

[Mul17] Mulderbizkor. *Assassins Creed*. June 2017. URL: `https://council.assassinscreed.com/en/post/46653-ac-origins-hieroglyphics`.

[Pus79] E. B. Pusch. *Das Senet-Brettspiel im Alten Ägypten*. Dt. Kunstverl., 1979.

[Wil01] H. Wilson. *Hieroglyphen lesen*. Berchtermünz, 2001.

HieroQuest Survey

Chapter 1 - Egyptian hieroglyphs

The focus of the game was to teach you hieroglyphs.
Let's have a look how well you can do.

Warm up - Which hieroglyphs did the game contain?

Try to name every hieroglyph that you collected in the game.Just describe them with a few words and separate them with a semicolon: 'Car; Potato; Horse;'If you can't remember any just insert a minus sign: - *

Recall Hieroglyphs by category

Try to match the hieroglyph from the game to the following categories.
Just describe them with a few words and separate them with a semicolon: 'Maple; Dog; Window;'
If you can't remember any just insert a minus sign: -

A10: Glyphs that fit the category "Plants and Food" *

A11: Glyphs that fit the category "Parts of the Body" *

A12: Glyphs that fit the category "House and Furniture" *

A13: Glyphs that fit the category "Animals" *

Which Hieroglyphs do you recognize?

Try to name every Hieroglyph from the game that you recognize in the following picture.
Just describe them with a few words and separate them with a semicolon: 'Cow; Robot; Acorn;'
If you can't remember any just insert a minus sign: -

B10: Look for Hieroglyphs from the game and name them separate by a semicolon.

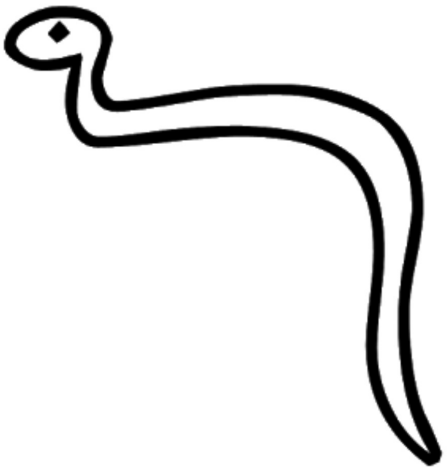
Which literals can you match to the Hieroglyph?

Try to figure the according literal(s), that match the hieroglyph.
If the letters have any special features describe them: 'z with wave above'
If you can't recall the letters or if you don't recognize the glyph answer with a minus sign: -

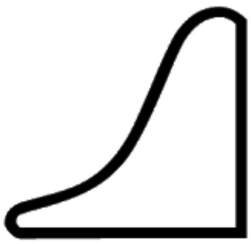
C10: Which letter(s) would match this hieroglyph?

C11: Which letter(s) would match this hieroglyph?

C12: Which letter(s) would match this hieroglyph?



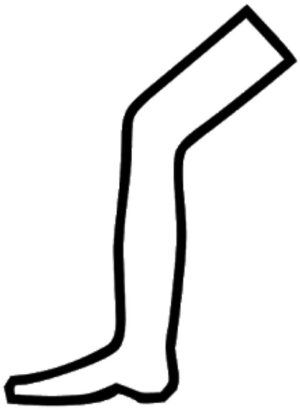
C13: Which letter(s) would match this hieroglyph?



C14: Which letter(s) would match this hieroglyph?

C15: Which letter(s) would match this hieroglyph?

C16: Which letter(s) would match this hieroglyph?



C17: Which letter(s) would match this hieroglyph?

C18: Which letter(s) would match this hieroglyph?

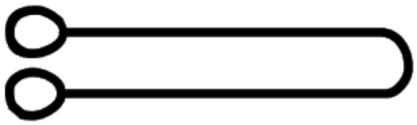
C19: Which letter(s) would match this hieroglyph?

C20: Which letter(s) would match this hieroglyph?

C21: Which letter(s) would match this hieroglyph?

C22: Which letter(s) would match this hieroglyph?

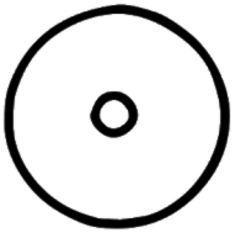
C23: Which letter(s) would match this hieroglyph?



C24: Which letter(s) would match this hieroglyph?

C25: Which letter(s) would match this hieroglyph?

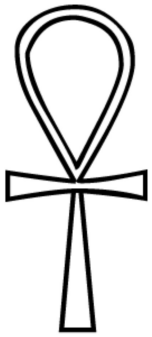
C26: Which letter(s) would match this hieroglyph?



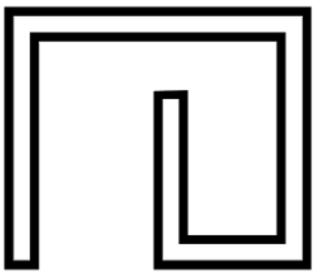
C27: Which letter(s) would match this hieroglyph?

C28: Which letter(s) would match this hieroglyph?

C29: Which letter(s) would match this hieroglyph?



C30: Which letter(s) would match this hieroglyph?



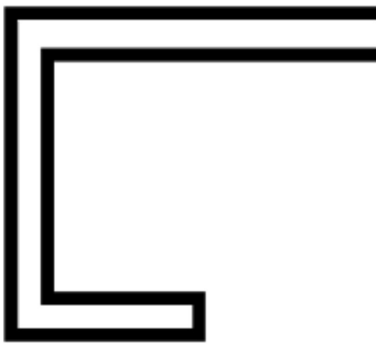
C31: Which letter(s) would match this hieroglyph?

C32: Which letter(s) would match this hieroglyph?

Which literals can you match to the partially shown Hieroglyph?

Try to figure out from what glyph the picture was cut out and write down the according literal(s).
If the letters have any special features describe them: 'z with wave above'
If you can't recall the letters or if you don't recognize the glyph answer with a minus sign: -

D10: Which literal(s) would match the actual glyph?



D11: Which literal(s) would match the actual glyph?

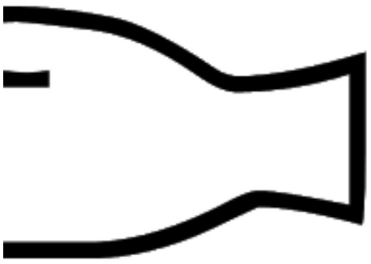
D12: Which literal(s) would match the actual glyph?

D13: Which literal(s) would match the actual glyph?

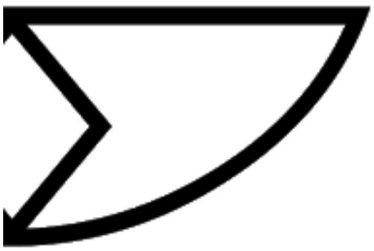
D14: Which literal(s) would match the actual glyph?

D15: Which literal(s) would match the actual glyph?

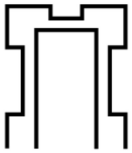
D16: Which literal(s) would match the actual glyph?



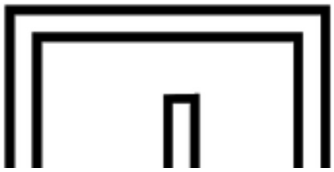
D17: Which literal(s) would match the actual glyph?



D18: Which literal(s) would match the actual glyph?



D19: Which literal(s) would match the actual glyph?



D20: Which literal(s) would match the actual glyph?

D21: Which literal(s) would match the actual glyph?

Choose the literal(s) that fit the hieroglyph

Choose the literal(s) that the Hieroglyph represents.
If none of the shown fit, select 'None of them'.

E10: Which fits this hieroglyph?

t	*pr*	*z*	
E10a	E10b	E10c	E10d: None of them

E11: Which fits this hieroglyph?

h	*q*	*p*	
E11a	E11b	E11c	E11d: None of them

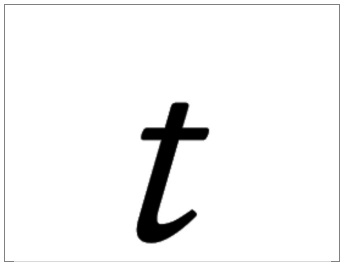
E12: Which fits this hieroglyph?

inb	*a*	*ꜥnh*	
E12a	E12b	E12c	E12d: None of them

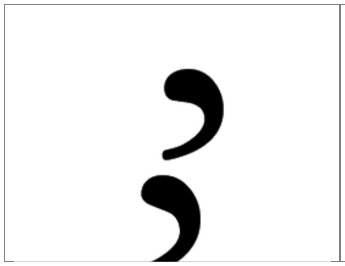
E13: Which fits this hieroglyph?

mn	*d*	*š*	
E13a	E13b	E13c	E13d: None of them

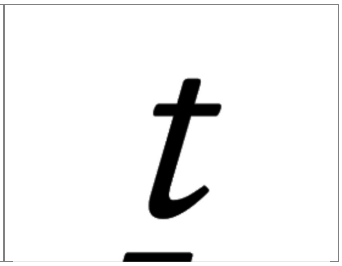
E14: Which fits this hieroglyph?



E14a



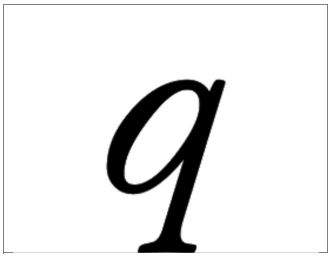
E14b



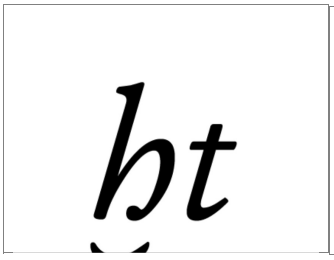
E14c

E14d: None of them

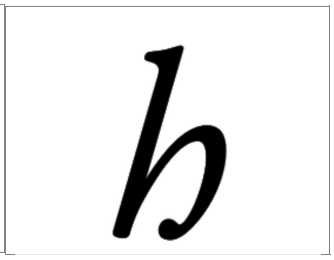
E15: Which fits this hieroglyph?



E15a



E15b



E15c

E15d: None of them

E16: Which fits this hieroglyph?

l	*g*	*rkh*	
E16a	E16b	E16c	E16d: None of them

E17: Which fits this hieroglyph?

p	*r*	*q*	
E17a	E17b	E17c	E17d: None of them

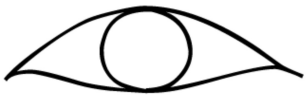
E18: Which fits this hieroglyph?

ḥ	*ḥt*	*rkḥ*	
E18a	E18b	E18c	E18d: None of them

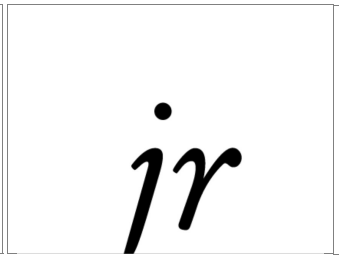
E19: Which fits this hieroglyph?

n	*š*	*s*	
E19a	E19b	E19c	E19d: None of them

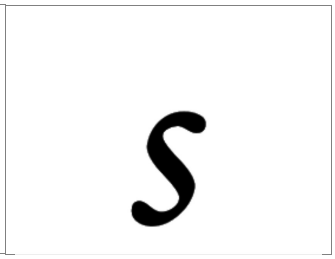
E20: Which fits this hieroglyph?



E20a



E20b



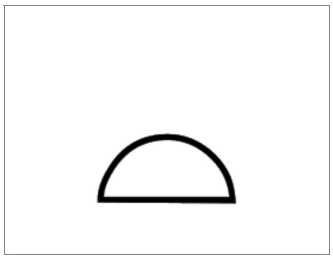
E20c

E20d: None of them

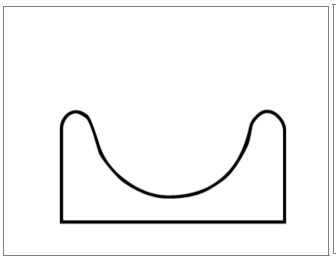
Choose the hieroglyph that fits the literal(s)

Choose the Hieroglyph which corresponds to the literal(s).
If none of the shown fit, select 'None of them'.

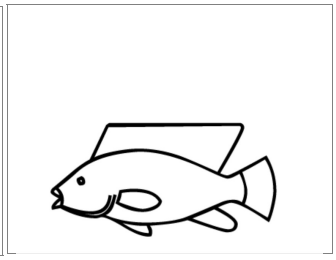
F10: Which hieroglyph fits this literal?



F10a



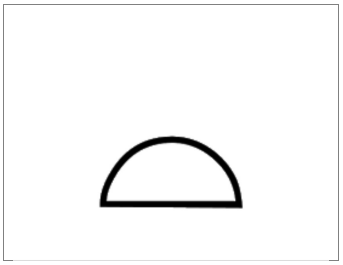
F10b



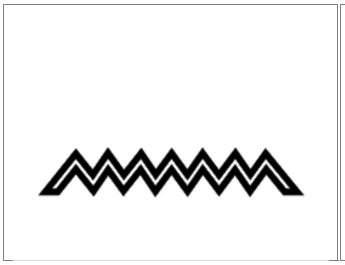
F10c

F10d: None of them

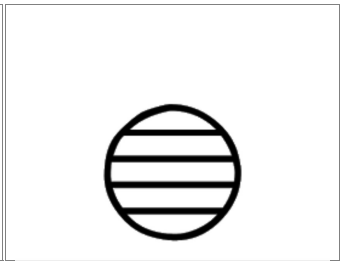
F11: Which hieroglyph fits this literal?



F11a



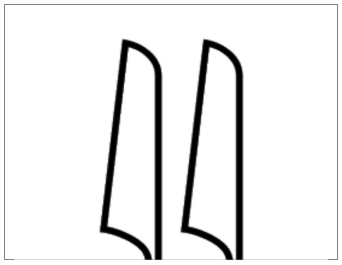
F11b



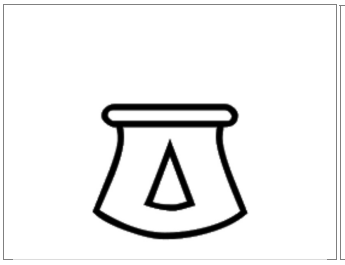
F11c

F11d: None of them

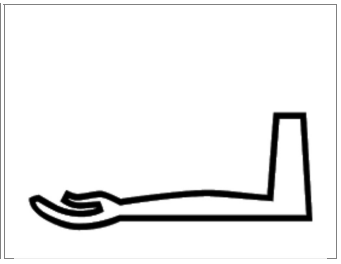
F12: Which hieroglyph fits this literal?



F12a



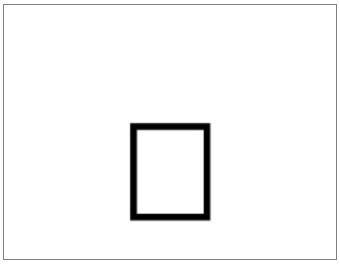
F12b



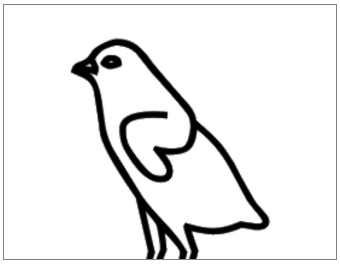
F12c

F12d: None of them

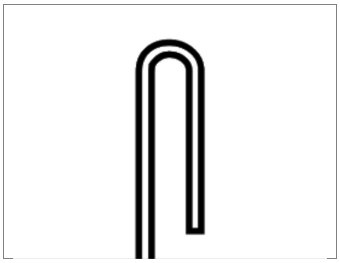
F13: Which hieroglyph fits this literal?



F13a



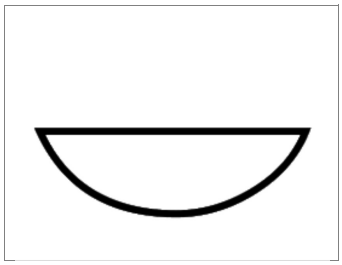
F13b



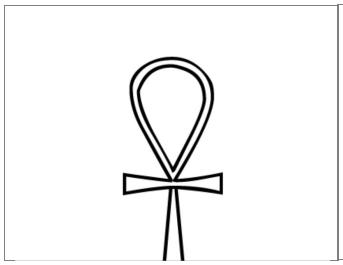
F13c

F13d: None of them

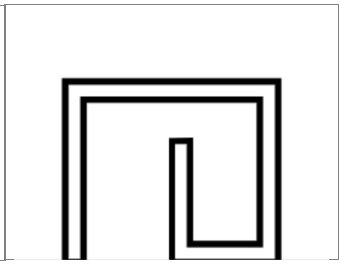
F14: Which hieroglyph fits this literal?



F14a



F14b

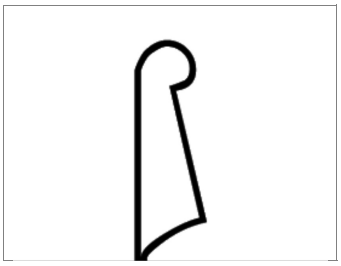


F14c

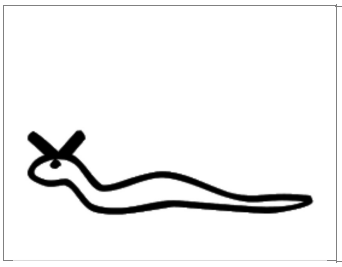
F14d: None of them

F15: Which hieroglyph fits this literal?

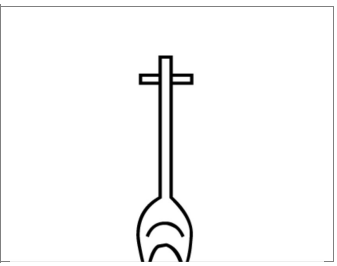
nfr



F15a



F15b

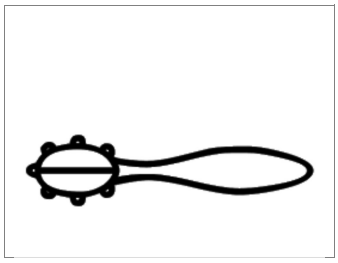


F15c

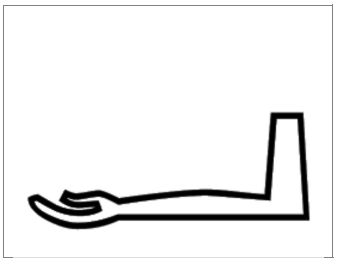
F15d: None of them

F16: Which hieroglyph fits this literal?

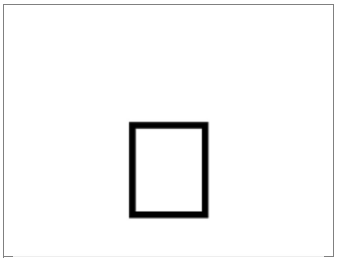
ḫ



F16a



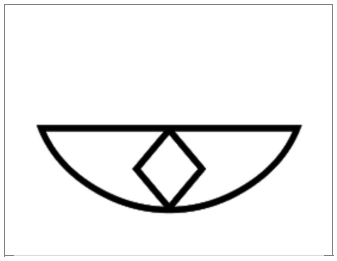
F16b



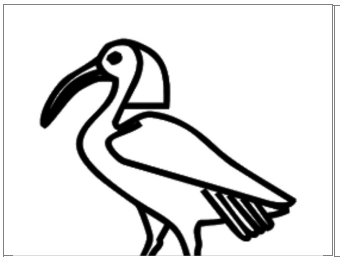
F16c

F16d: None of them

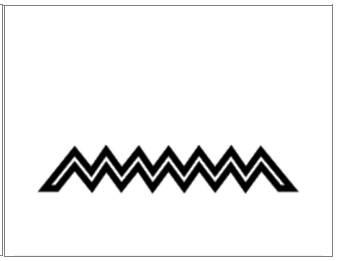
F17: Which hieroglyph fits this literal?



F17a



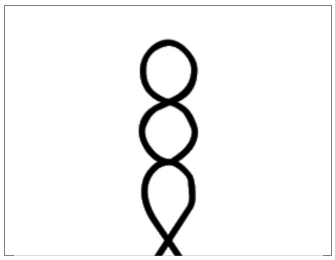
F17b



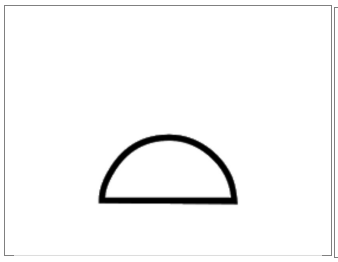
F17c

F17d: None of them

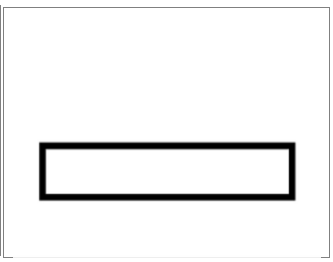
F18: Which hieroglyph fits this literal?



F18a



F18b

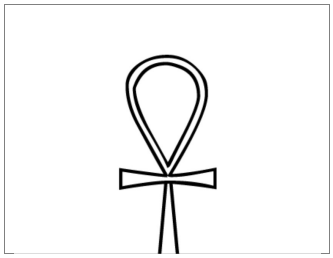


F18c

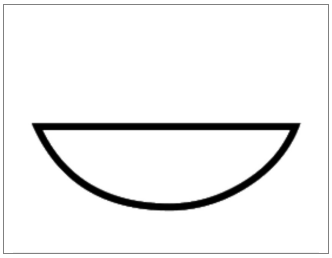
F18d: None of them

F19: Which hieroglyph fits this literal?

F19a



F19b



F19c

F19d: None of them

From which object was the hieroglyph derived from?

Try to name or describe the real object from which the hieroglyph visually originates.

As Example: Write 'bucket' if you think that the actual object that was used for the hieroglyph was a bucket.
If you can't recall the original object from the game or if you can't think of anything that would fit, answer with a minus sign: -

G10: Which real object would match the outline of the hieroglyph?

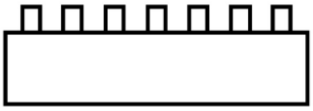
G11: Which real object would match the outline of the hieroglyph?

G12: Which real object would match the outline of the hieroglyph?

G13: Which real object would match the outline of the hieroglyph?

G14: Which real object would match the outline of the hieroglyph?

G15: Which real object would match the outline of the hieroglyph?



G16: Which real object would match the outline of the hieroglyph?

G17: Which real object would match the outline of the hieroglyph?

G18: Which real object would match the outline of the hieroglyph?

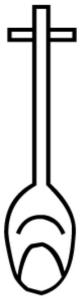
G19: Which real object would match the outline of the hieroglyph?

G20: Which real object would match the outline of the hieroglyph?

G21: Which real object would match the outline of the hieroglyph?

G22: Which real object would match the outline of the hieroglyph?

G23: Which real object would match the outline of the hieroglyph?



Questions about the game

You're close to the end.
Just a few more question about the game itself.

General Questions

How often did you play HieroQuest until this point? *

- ◯ 1
- ◯ 2
- ◯ >3

Which was the difficulty you chose? *

- ◯ Easy
- ◯ Normal
- ◯ Hard

What's your gender?

- ◯ Male
- ◯ Female
- ◯ Sonstiges: _____

What's your age? *

- ◯ <12
- ◯ 12 - 18
- ◯ 18 - 30
- ◯ 30 - 60
- ◯ > 60

Experience with digital games

I10: I have experienced digital games before *

Note: This includes games on computers, consoles and mobile platforms

- ◯ Yes
- ◯ No

I11: How many minutes do you play digital games on average per week? *

Note: This includes games on computers, consoles and mobile platforms

- ◯ I don't play digital games.
- ◯ < 60 minutes
- ◯ 60 - 120 minutes
- ◯ 120 - 480 minutes
- ◯ > 480 minutes

Knowledge about 'Egypt and Hieroglyphs'

J10: I explicitly engaged myself with Egypt before *

Note: by traveling, watching or reading a documentation, reading special books

- ◯ Yes
- ◯ No

J11: Describe your experience if your last answer was 'Yes'

J12: I explicitly engaged myself with egyptian hieroglyphs *

- ◯ Yes: Reading, writing is no problem
- ◯ Yes, but only partial knowledge
- ◯ No

J13: Describe your experience if you last answer was 'Yes'

About the game

K10: Educational value *

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The game is useful to learn egyptian hieroglyphs.					
If I had to learn hieroglyphs, I would prefer this game over books or flashcards.					

K11: Personal impressions *

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I learned something about hieroglyphs.					
I am confident, that I can remember what I have learned, over a longer period of time.					

K12: Functionality *

Choose "n.a." if you have not used any of these functionalities.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	n.a.
The tutorial successfully explained the basics of the game.						
I think the tutorial should be longer.						
I think the tutorial is helpful.						
The hints in the game, provided useful information.						
Without hints, I couldn't have proceeded.						
I used many hints.						
I used the lexicon often.						
I think the lexicon is a useful game element.						

K13: Fun *

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The game was fun to play.					
I think that people would prefer this game over learning with books or flashcards.					
I think people would play this game in their free time, even if they have no interest in hieroglyphs.					

K14: Motivation *

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
After playing, I want to know more about hieroglyphs.					
After playing, I want to know more about Egypt.					

Final Feedback

L10: Any problems while playing the game?

L11: Suggestions for the game?

L12: Anything else?