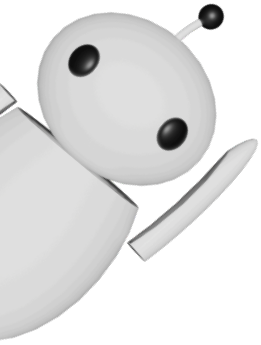
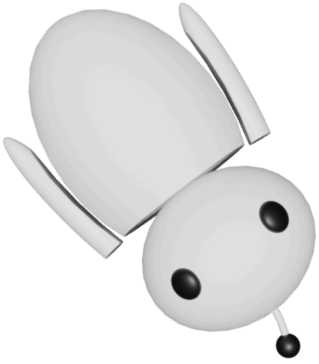
Improving Educational Games





Bachelor Thesis
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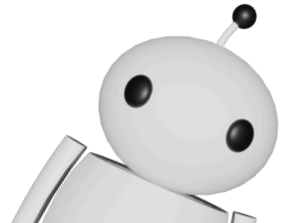

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Abstract

Objective: Research showed the potential positive impact activities outside of the educational game activity could have on knowledge retention and transfer of knowledge into the real world. This research aims to investigate the impact on enjoyment, engagement and effectiveness when adding a digital briefing and debriefing into an educational video game.

Methods: The evaluation uses a between-group study design, with no exclusion criteria for participants except age of informed consent. The evaluation means to establish whether the impact of a digital brief and debrief are positive or negative as opposed to a control group where the briefing and debriefing are paper based interventions. To establish this impact, a custom digital and paper briefing, a custom educational video game, and a custom digital and paper debriefing were created. The briefing contains a clear goal of the learning activity the educational game contains, the educational game teaches the participants Italian words, and the debriefing contains questions that help the participants process what they just learned and experienced in the game. The variables were measured at the hand of a test on vocabulary for effectiveness, and an interview and behavioural notes for the engagement and enjoyment.

Results: 16 participants took part in the evaluation. The experience with the digital brief and debrief was positively received by participants and the digital briefing included in the game showed significant (p=5%) increase in enjoyment (paper group: 3/5 rating, digital group 3.56/5 rating). The effectiveness seemed to be unaffected by the addition of a digital briefing and debriefing (paper group: 66%, digital group 73%). Similarly the digital debriefing did not show any significant increase in enjoyment (paper group: 2.6/5 rating, digital group 2.9/5 rating). The paper control group did however rate the game itself significantly higher than the digital group. (paper group: 4.37/5 rating, digital group 3.75/5 rating).

Conclusion: This shows that digital briefs and debriefs can positively affect educational video games, but also bring along other, perhaps unwanted effects, such as impacting the engagement and enjoyment of the game itself.

Index Terms - Serious games, Educational games, Web sites

Contents

1 Introduction

During my bachelor in Creative Technology, I did a minor in Technical Computer Science (TCS). This minor focussed on computer architecture and basic principles on how computers operate from the ground up. During one of the lectures the topic of logic gates and the binary system came up. These concepts are also extensively used in the popular game Minecraft [83] to make interesting contraptions. Minecraft is a sandbox game that allows you to build almost anything, including technical constructions with their version of electrical wiring, called redstone. Playing this game for a couple of years now, I had learned some of this technical part of the game, and it allowed me to easily grasp the principles discussed in the lecture such as *AND*, *OR* and *XOR* gates. With the help of some logic gates and understanding of binary systems, you can build simple computer parts in Minecraft, and thus calculators. This game allowed me to form a visual and firm understanding of this subject and aided me greatly in my understanding of computer architecture. This experience illustrates the great potential value games have in education and has since fueled my interest and compassion for game based learning.

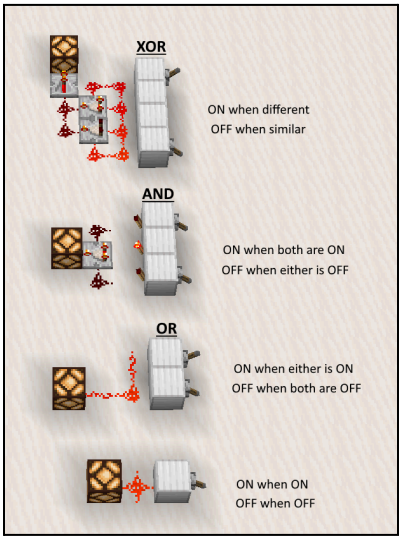


Figure 1: Example of logic gates in the game Minecraft [83]

1.2 Context Analysis

Dutch primary school classes are pretty large. They sometimes contain up to 32 students per teacher, with on average 23 students per Dutch primary school classroom. These sizes allow for teachers to spend way less time on each student, and therefore limits some of the more personal education students could benefit from. In addition to this, Dutch primary school classes on average consist of about 16% gifted students (students with an IQ of 120 and above). These students require and benefit from more challenge [1], [2]. Many of these students can, however, not receive this challenge since schools and teachers are already under an ever growing workload. Here one can look at educational video games as a potential alternative. These video games can provide consistent fitting and tailored education for these students, without requiring much preparation or guidance from teachers.

That video games can be valuable in education, has been broadly confirmed in literature. Games can greatly simplify complex systems for the user to experience and work with in a closeup and engaging manner [43]. For games to present the ability to learn from experimenting and participating rather than just observing a subject matter, is a great

advantage for a learning tool and environment [24], [25], [40]. Besides these positive notes, immersion and engagement is also often something that educators try to achieve in education [7], [42]. Studies show that this engagement is something games can facilitate well during learning [50]. Given all of these advantages, the value that games could bring to education is immense [77], [40]. In addition to the value of video games themselves, video games are also a domain in which the current and coming generations excel [10]. Children can often navigate game environments with ease, while problem solving and communicating effectively with their friends in gaming sessions at home [5], [11], [45]. These properties of problem solving and communication is what education often tries to achieve, which gives a good reason for why people want to use games in education.

In essence, entertainment games include core educational methods and principles such as scaffolding and problem based learning, and they do so quite effectively [42], [43]. An additional argument in favour of games in education is that motivation greatly increases when using games as a medium to interact with the subject matter [9], [29].

1.3 Problem Statement

Educational video games can be approached in many different ways, with certain methods more effective than others. The aim of this graduation project is to answer the research question.

There are standard aspects that greatly impact how well a student retains the learned knowledge in the game environment and how well that knowledge is translated into the real world. One of these important aspects is that instructor or teacher involvement and activities such as a briefing or debriefing, greatly influence the student's learning effectiveness when using video games. The disadvantage is that these activities are often physical and require the teacher or instructor to prepare and guide these activities. This educational game optimization led to the research question on how these valuable activities can be included in the game (environment) without needing preparation from the teachers. So, we want to optimise an educational game. An important part in establishing whether optimization actually took place, is to evaluate whether the impact of these activities remains when they are implemented in a digitised manner.

1.4 Research Question

So, great gain is to be found in activities before, after and during the educational gaming activity. These activities are unfortunately often physical and still require preparation and guidance from a teacher, this lead to the research question:

"Could the addition of a digital brief and debrief positively impact educational video games?"

Activities such as briefing and debriefing impact a students knowledge retention and knowledge transfer into the real world positively. The question is if this positive impact remains when not implementing these activities in a physical standard manner but in the game (environment). In addition, it might be of value to measure this positive impact at the hand of other variables as well. Such as if the user's engagement or enjoyment is enlarged when these activities are processed into the game itself.

In order to answer this question, three sub questions need to be answered first:

1. How to make an optimal briefing?
2. How to make an educational video game?
3. How to make an optimal debriefing?

To evaluate the impact of the activities, we need a game that can facilitate the testing of these activities. An educational game that can support an amount of learning, but also the inclusion of a briefing and debriefing, needs to be developed. With the use of this tool an evaluation of the impact can take place. The condition groups for this evaluation are two groups. One group gets the (de)briefing as proposed with it included into the game, and the other group would get the game as it were to be most likely currently executed. Meaning, the participants get a piece of paper with the briefing on it, and a piece of paper with the debriefing on it. The paper group thereby functions as a control group to see if the digital variant can be seen as an improvement as opposed to how it would currently most likely go, if a teacher is not able to guide and prepare the (de)brief.

1.5 Key Findings

Some of the key findings that are established in this report, are that the addition of a briefing and debriefing to the video game do not confirm findings about better knowledge retention and transfer. This could either be because the briefing and debriefing in fact do not improve knowledge retention and transfer, or if they were not executed or realised well enough. Interesting to note is the data found in relation to engagement and enjoyment. Based on the gradings that participants provided, they did like the addition of the briefing into the game itself, as opposed to just having a separate briefing. However, the group having the (de)brief separate from the game did provide a higher grading of the game itself, so the contrast that a less enjoyable (de)brief might have given, could have increased the enjoyment of the consequent game activity.

1.6 Thesis Structure

This thesis has 9 chapters in which the research question will be answered.

- **Chapter 2: Background Research & Approach**
  This chapter consists of a literature review to identify how educational games are often approached and what points of attention to take into account. It contains a State of the art to look at how existing educational games take important attributes of educational games into account. Lastly, the chapter draws a conclusion of the two.

- **Chapter 3: Methods and Techniques**
  This chapter contains the methods and techniques utilised during the execution of this thesis.

- **Chapter 4: Ideation**
  This chapter consists of three main parts. The first entails the analysis of stakeholders, the second entails the requirements that can be elicited from the background research and the stakeholders, and the third consists of concept generation and chosen concept.

- **Chapter 5: Specification**
  In this chapter personas and scenarios are presented which are used to establish requirements. Furthermore design specifications are established for the project.

- **Chapter 6: Realisation**
  In this chapter the tools used for realising the project are shown, the assets used in the project, the actual presentation of the project and lastly an evaluation of requirements in relation to the functionality of the project.

- **Chapter 7: Evaluation**
  The evaluation contains the user evaluation of the project and the results which followed from it. A statistical analysis is performed to establish the significance of the results.

- **Chapter 8: Conclusion**
  In this chapter an overview of the contents of this thesis is provided, and an answer to the research question.

- **Chapter 9: Future Work**
  In the future work chapter recommendations are made for future work to be done on educational video games and improvements of them.

2 Background Research & Approach

The background research and approach chapter will first take a look at the available literature and existing interventions (state of the art) in the field of educational video game design. Chapter 1 provided a few reasons behind the potential value of video games in education, to nuance this, the literature review digs a bit deeper and also looks at drawbacks and critiques.

2.1 Literature Review.

Children that are part of special education programs (students with severe autism, A.D.H.D. or gifted students) tend to encounter challenges with conventional teaching strategies (e.g. books and videos, due to for example short attention span or disinterest), urging the exploration of alternative teaching strategies to accommodate more to their unique learning needs [1], [2]. Within special education, serious video games have a large potential. They offer higher levels of engagement for students [3], [50], [52], but more notably, they can be of value in an educational setting, since they deliver content more effectively than non-game-based learning [4]. Games have an unique ability to represent complex systems and to simplify them to their essence. Presenting it for a player to experience and manipulate in an engaging way [43]-[45]. In addition, the ability of video games to invite a player to form an understanding on a subject matter based on participation and experimentation rather than observation [25], [47], [49], is why Briljant Onderwijs, an enterprise that has gifted children as their target group, is interested in looking into the possible contributions of serious video games to the education of gifted children.

The aim of this review is to systematically investigate and analyse elements and principles involved in the design, development, and implementation of educational video games. Thus an evaluation of existing research and potential pitfalls the research ran into when designing an educational video game is in order. Therefore the first part of the review will focus on common methods of educating through video games and the drawbacks or advantages these methods offer, and the second section will focus on pitfalls or issues other researchers and papers encountered when developing educational video games, and the recommendations they have.

2.1.1 Common Methods

Common approaches taken in educational game design can be divided into four camps that encompass all methods: the learning-first camp, the learning-in-gameplay camp, the gameplay-in-learning camp and the gameplay-first camp. These classifications are derived by Berg-Marklund [6] from Egenfeldt-Nielsens' oversight of research on educational use of video games [5]. According to Berg-Marklund [6] these camps are somewhat simplistic and do not do justice to all the nuances found in Egenfeldt-Nielsens' research. However these camps do provide a clear overview to aid with understanding

different design approaches and implementations of educational video games. The listed camps will be described, and the advantages and drawbacks associated with these methods.

The learning-first camp prioritises the representation of the learning content above the gameplay quality. In this camp the educational content is the main focus and the gameplay is added as an attractive package on top. Games developed that reside in the learning first camp can be referred to with the term *edutainment*. Edutainment as a term refers to early game types where regular school exercises, such as maths exercises, were tied to popular entertainment games. Amy Bruckman [8] refers to products that take this approach as a "chocolate-covered broccoli". Habgood and Ainsworth [7] and Bruckman [8] critique edutainment because it relies too heavily on extrinsic rather than intrinsic motivation. Similar to Bruckman, Habgood and Ainsworth refer to it as sugar coating learning content. And as Klopfer *et al.* [9] and Ito [60] note, this approach to educational game design rarely leads to successful products. So although this approach used to be a popular approach in educational game design, in the context of scientific studies it is quite heavily critiqued.

Within the learning-in-gameplay camp the focus is on how to appropriately tie gameplay elements to learning content, hereby it is a response to the critiques given to edutainment games and the learning-first camp. The learning-in-gameplay camp tries to balance the approach the learning-first camp and edutainment take (e.g. adding games as an attractive layer on top), by paying closer attention to how the specific subject matter can be translated into gameplay mechanics. Most importantly, it is crucial to understand that not all game mechanics are fitting for certain subject matters [7], [61]. The learning-in-gameplay camp focuses on the inherent intrinsic parts of a game's specific mechanics and justly integrating those with learning contents, to harness the power of intrinsic motivation in learning.

The gameplay-in-learning camp sees gameplay as part of an educational experience, where the game needs to accommodate the educational experience in different ways. Relevant to note about this approach is that it acknowledges that not all aspects of a learning process can be within the game itself. Taylor [30] and Crookall [62] note that there is great gain from having the student step out of the gaming context, by for example, discussing, reflecting and analysing the material they have been taught or have encountered in the game, or to have the instructor (teacher) play a role. According to Taylor [30] and Crookall [62] this gain could entail better knowledge retention or translation of skills into the real world. This gain could be achieved by including intermissions in the gaming activity, or to use real world knowledge (e.g. knowledge they received when discussing challenges in the class or during a lecture) in the game. The gameplay-in-learning camp tries to encourage reflection and consideration. The value of relating the game to the real world and making it part of a larger experience, is thus considered an important aspect of designing an educational game.

The gameplay-first camp contains the idea that in order to create a good educational game, engaging gameplay should be prioritised over the accuracy of the

teaching material. This way the game can function as an entry-way for the student to grow interested in a topic they might previously not have been inclined to take an interest in. As Ruggiero [63] points out, there is much interest in the field of education to use games, but not much knowledge or expertise on how to. By prioritising engaging gameplay over accuracy of teaching material, it would require less preparation and lower standards. According to Ruggiero [63] this means that this approach can be a valuable addition to the curriculum. Similarly to the gameplay-in-learning camp, the gameplay-first camp acknowledges that the joining of the gameplay sessions with class discussions might be of value. However an important distinction between the two is that the gameplay first camp emphasises the use of gameplay as an introductory tool rather than a learning tool. So games within the gameplay-first camp are being used more as a tool to get students interested, instead of these games necessarily being the educational medium through which the actual learning takes place.

To recap, these four approaches to designing an educational game have their shortcomings, and might function more effectively depending on the different context they can be placed in. As Egenfeldt-Nielsens' oversight of research on educational use of video games [5] states as well, throughout the years both the expectations of games and the change of pedagogical processes, have impacted the popularity of certain camps or approaches. As the four different camps show, a common point of difficulty is how each of them balance gameplay and educational content. A few of the approaches, such as learning-first camp have a larger focus toward the educational side of the spectrum and the other approaches, such as the gameplay-first camp focus more toward designing engaging gameplay. The two remaining camps (The gameplay-in-learning and learning-in-gameplay camp) each try to optimise both gameplay and education, either through designing the game with more fitting gameplay mechanics or by utilising the value of placing the game in a larger context.

2.1.2 Pitfalls and Recommendations

This part of the review takes a look at a few well known or extensive papers or reviews on the design and application of educational video games. At the hand of these papers pitfalls are often identified researchers ran into, or recommendations they have for future research or products. These pitfalls and recommendations can be conjoined under the title: points of attention, since a few pitfalls are the cause of subsequent recommendations. With this naming in place, five main points of attention were identified using literature in the field of educational game design: *superficial and faulty understandings*, *translation to real world*, *user-centred design*, *intrinsic and extrinsic motivation* and *technical limitations*.

Superficial and faulty understanding of subject matters is the first of five main points of attention that educational games might and currently struggle with. Turkle [22] states a few observations of the game *SimLife: The Genetic Playground* [23]. She concludes that

there could be a problem of knowledge transfer between simulations and reality, because of *opaqueness* in game systems. Turkle states that, even though certain games teach players to actively think about complex cases, they bring along the complexity that the user gets used to *manipulating a system* [22, p.70] which core assumptions they are unaware of and may be built on false information. The manipulation of the game mechanics would lead players to only gain a superficial understanding of the subject matter represented in the game. Besides this superficial understanding, Turkle [22] mentions that the body of knowledge the players learn from could be based on a fundament of assumptions and compromises made during the design and development process. To conclude: knowledge of games transferred to the real world could be superficial, and in the worst case scenario be incorrect and faulty information. This would lead to the conclusion that games as an educational medium can be dangerous teaching tools. These concerns have been ratified by other researchers as well [25], [26], [28], they note that learning could occur in ways not meant by the system. Which is why Ko [25] and Linderoth [26] say that educators should take a careful look at games before they include them in the learning environment. Similarly to Turkle [22], Linderoth [26], [28] specifically states that if a game is not designed properly to facilitate education, the player is unlikely to learn anything more than the manipulation of the game mechanics. As Berg-Marklund [6] paraphrases the conclusion of Linderoth: *"If the skills and knowledge a student has learned inside the game environment cannot transcend the virtual world and become useful applicable knowledge in the real world, the learning activity has, in the end, been a failure"* [6,p.44]. However, Barnett and Ceci [55] point out that in the field of psychology, researchers still disagree on whether knowledge transfer is even possible from text-books, educational films or classroom instructions. So, educational games are not the only medium that struggle with potential superficial or faulty understanding, as effectiveness of traditional educational procedures are questioned on the same basis.

This superficial understanding can also be mediated with the second point of attention raised by literature: translating knowledge into the real world. Thus a branch of research looks into Young *et al.*'s [15] suggestion that "game play may need to be investigated as situated learning" [15, p.62]. Situated learning refers to learning with emphasis on that it is most effective when in a context or environment that closely resembles the real world. The relation of players to the environment, objects and each other is of importance in situated learning. Chen *et al.* [16] state that players' interrelation also has an impact on knowledge retention. This branch of research emphasises that education through video games is heavily influenced by aspects that extend beyond the act of playing the game itself. Including the processes of debriefing and instructor involvement or presence [17], [19], [21], as mentioned in the gameplay-in-learning camp. Frank [17] describes a 'gamer mode' where the player is focussed on the game rules and not the real world scenario it is meant to represent, but according to Frank [17], Ketamo *et al.* [19] and Stieler-Hunt and Jones [21], teachers and instructors play a valuable role in helping translate skills and knowledge into the real world. Taylor [30, p.218] states:

> *"several examples of off-game activities which are performed before, during or after the actual gaming activity and affect the end result in profound ways. For instance, debriefing helps learners to de-role or detach from, as well as critically reflect upon, the gaming experience. Without this activity, transfer of knowledge from the gaming situation to the real world is unlikely to occur."*

Thus a point generally advocated for in multiple papers [18], [19], [21], [30], [62] is the effect of activities before, during and after the gaming activity and its impact on knowledge retention and transfer.

User-centred design is the third important point of attention raised by literature. Educational game development tends to not take its stakeholders into account, which leads to unsuccessful products. It has already been made clear how teachers or instructors affect the impact of the educational game. Berg-Marklund [6] does something interesting and takes a look at the field of information systems, because it is similar in user acceptance to a new teaching tool. This review will do something similar by specifically looking at user participation among information systems and their impact. In information systems it is recognized that end-users of their product are unpredictable and will not always act logical [64]. If a new system impacts an end user's working habits, the user might feel that they are being burdened with even more labour to change their routine, or as if their independence is compromised. This can lead to resistance of the information system, and thus hugely impact the effectiveness of the product. These issues also translate into the use of video games in classrooms for teachers. Even though the tool is meant in a good way, if an organisation imposes its employees, it can have adverse effects. As Avison and Fitzgerald state [64, p.81]:

> *"User involvement should mean much more than agreeing to be interviewed by the analyst… This is 'pseudo-participation' because users are not playing a very active role. If users participated more, even being responsible for the design, they are far more likely to be satisfied with, and committed to, the system once it is implemented."*

So a user is more likely to use a system if they are involved in the development. An older paper by Mumford [65] describes three methods of involving the end user in development: *consultative participation*, *representative participation*, and *consensus participation*. Consultative participation can be defined as the lowest form of user participation, where the user is continuously asked for feedback through the whole process, from design to implementation. Representative participation actively includes the users in the process, by for example letting them make design decisions. And lastly consensus participation entails a democratic way of letting the user participate. In consensus participation the users are personally involved and invested in the project, which can make them more accepting in the end. To recap, not involving the users in the

process might have detrimental effects on the effectiveness of the product. However, there are different ways of including end users to guarantee a larger chance of success and effectiveness of the product.

The fourth point of attention is the use of intrinsic and extrinsic motivation in educational video games. In accordance with previous statements, Habgood and Ainsworth [7] and Bruckman [8] critique games that rely too heavily on extrinsic motivation. Habgood's and Ainsworth's [7] study shows that children with the intrinsic version of the game in their study did significantly better than the other groups. As Maguire *et al.* [61] state as well, extrinsic motivation tends to work better in the short term than long periods. In the context of intrinsic and extrinsic motivation, the term gamification is worth considering, the term is quite popular and responds to many different definitions. In a paper looking into the origins of the term [14] it is defined as *"the use of game design elements in non-game contexts"* [14, p.10]. In its current state the term gamification signifies applying a reward system to an activity with the intention that the reward makes the activity more entertaining or enticing. This type of game design received much interest from corporations, educational institutions and municipalities. However, the approach of applying a reward system, is also where the critique comes into play. By reducing the game definition to a behaviourist application it is indifferent to the fundamental qualities of video games, which is to be inherently rewarding and to instil a sense of intrinsic motivation in the player [7]. However, this is a bit of a purist approach to the critique. To substantiate this critique, studies [47], [59] frequently show that extrinsic motivation has a negative impact on enjoyment, performance, knowledge retention and reflection. So, as Maguire [61] states that extrinsic motivation is not necessarily bad, other papers seem to disagree, but it is generally agreed on that intrinsic motivation is an important element in educational games in terms of effectiveness of learning.

A final point of attention is the technical limitations of educational video games. These limitations signify educational institutions sometimes struggling to supply the basic technological infrastructure for supporting video games as an educational medium. E.g. bad hardware, internet connection, etc. [31]-[34]. These limitations in combination with the teachers understanding of the game [35], [36], the students ability to navigate a game [37], [38] and a schedule on which a game has to be played in an educational setting, are practical considerations to take into account when wanting to use games in an educational setting [31], [32], [39]-[41]. As Egenfield-Nielsen [13] says, game based learning "has become easier with online solutions, but it is still a costly and difficult investment for teachers" [13, p.69]. Technical limitations are not a main point of discussion in the field of educational game design, but they can have a large impact on the implementation and use of the product.

2.1.3 Conclusion

The aim of this literature review was to investigate and analyse principles involved in the design, development and implementation of educational video games. The available literature revealed four camps that encompass different approaches to educational video game design: the learning-first camp, the learning-in-gameplay camp, the gameplay-in-learning camp and the gameplay-first camp. Each with their own merits and shortcomings, some more than others. But it is clear that they all focus on a different balance between gameplay and educational content. Certain approaches, like the learning-first camp, prioritise education, while others, such as the gameplay-first camp, focus on creating engaging gameplay. The gameplay-in-learning camp and learning-in-gameplay camp, try to balance both gameplay and education by refining gameplay mechanics or integrating the game into a broader educational context.

From the five points established under 2.1.2, it can be concluded that there are five points of attention to take into account in educational video game design. Developers should check their own biases and understandings of subject matters before they include them in games, and they should evaluate whether their game might have unintended learning consequences. Either the knowledge being learned being incorrectly understood, or the user having a superficial understanding of a topic which causes it to not be usable outside of the game medium. This translation of information into the real world is another point the literature raised. If a player only learns a manipulation of the game and this manipulated knowledge or skill is not useful in the real world, the learning activity has not been useful. Different types of activities before, during and after the gameplay strongly affect how well the learner retains knowledge and how well the knowledge can be used in the real world. The effectiveness of video games are strongly influenced by teachers or instructor presence, that is why it is important to make sure these stakeholders are taken into account when developing and implementing, because it can grant better effectiveness of the product. Lastly, developers should be careful when using gamification practices or applying extrinsic motivators to their educational game, since they can be detrimental to multiple factors, such as knowledge retention, or enjoyment. They should use frameworks or elements that instil intrinsic motivation in the learner or player, since the effects of intrinsic motivation generally have a positive impact on learning. Besides these points, technical limitations can also be important to take into account when developing the game. If the technical aspects are not utilised or made appropriately, it might actually have large consequences for the effectiveness of the game.

2.2 State of the Art.

C.A. Libbi [76] takes an interesting but valuable approach to creating a state of the art, where she not only evaluates existing products, but also existing frameworks for creation of educational video games. This report will take a similar approach, because it could offer valuable insight that might be more concrete than simply weighing advantages and disadvantages of products against each other. Therefore, under the state of the art, not only existing interventions will be discussed, but existing frameworks as well. These frameworks, similar to entertainment games, contain a set of principles serious games should contain. A general consensus that can be made among these frameworks, is that they argue that a serious game is more effective the more of the principles in their framework it utilises. Therefore the state of the art will be divided into two parts, where the first parts will discuss these frameworks and what they entail, and a summarising oversight will be constructed to prevent repeating explanations. The second part will focus on actual products on the market that target education through video games, and they will be evaluated at the hand of these frameworks to assess their effectiveness. These products will both encapsulate serious video games in general, but also specifically a few vocabulary acquisition games in relation to the clients wishes.

2.2.1 Frameworks

Whyte *et al.* [66] proposes a framework, with the focus on elements relevant to game design, as they phrase it: *"that are likely to be particularly relevant to enhancing motivation to play… ,as well as those that are likely to support generalisation of learning"* [66, p.2]. This is more of a broader framework targeting serious game design and not necessarily just educational game design, but might still be relevant since it is still about targeting skill and learning acquisition. They propose six design elements: immersive storylines, goals directed around targeted skills, rewards and feedback about goal progress, increasing levels of difficulty, individualised training, and the provision of choice.

To give correct credit where it is due it is relevant to note that these six principles do not stem originally from Whyte *et al.* [66] but from Baranowski *et al.* [67] and Kapp [68]. These criteria are established at the hand of existing literature, such as [67] and [68], but also literature discussed in the literature review are credited. For example the value of intrinsic motivation mentioned by Habgood and Ainsworth [7] is also mentioned in Whyte *et al.'s* explanation of goals directed around targeted skills.

Yussof [69] developed a framework to address problems caused by unclear standards, his proposed model includes learning and pedagogy theory combined with gaming requirements, therefore it should help developers of games ensure that their game will provide effective learning. He offers a list of twelve 'game attributes' that support learning and engagement: incremental learning, linearity, attention span, scaffolding,

transfer of learning skills, interaction, learner control, practice and drill, intermittent feedback, reward, situated and authentic learning and accommodating the learner. These criteria are based on: “the critical thinking resulting from the literature review on behaviourist, cognitive, constructivist, educationist, and neuroscience perspectives”

Since a few of the the six principles of Whyte *et al.* and Yussof’s twelve principles overlap or are similar, it can be brought down to seven key principles. This is done to allow for quicker evaluation and use of both frameworks diminishing the amount of double work and repetition. These seven key principles are elaborated on in Table 1.

Table 1: Summary and combination of criteria for serious games based on Whyte *et al.* [66] and Yussof [69]

Name	**Definition**
Immersive Storylines	One takeaway from Whyte *et al.’s* description of this criteria [66] is that when learning elements are integrated well with the storyline, they enhance the intrinsic motivation for learning. This critique of Whyte *et al.* also overlaps with Yussof’s game attribute of linearity. Which signifies the extent to which the player is able themselves to construct their own sequence or the game does this for them.
Goals directed around target skills	Whyte *et al.* mention that when the combination of medium-term and long-term and integration with the storyline are implemented correctly, more intrinsic motivation to keep playing occurs among players. This is not necessarily a direct point for educational learning, but can be crucial for a long-term behaviour change.
Rewards and feedback about goal progress	Whyte *et al.* state that rewards are commonly, and almost exclusively used in entertainment games. They continue to state that traditional learning theory shows that behaviours formed with these kinds of conditional, immediate reinforcements, stop the behaviour rather quickly when the reward is no longer present. They state that providing feedback to long-term goals, and improving intrinsic motivation for learning by providing them this feedback on their progress as, when these factors are not implemented correctly, could diminish a player's learning potential. However Yussof also states rewards as a game attribute that should be implemented to keep player motivation. The other attribute described by Yussof that overlaps here is *intermittent feedback* which signifies the amount of feedback each game action or the game in general gives.
Increasing levels of difficulty	Serious games should not be too difficult nor too easy, to not frustrate the user into stopping or that the user learns nothing new. Theories like Vygotsky's Zone of Proximal Development and the concept of 'flow' theory both suggest that a wrong balance between level of the player and game difficulty can reduce motivation, engagement and learning. This point aligns/overlaps with Yussof’s game attribute of *incremental*

	learning and *practice and drill* which state that the game should introduce "learning activities incrementally" [69, p.22] and difficulty, and not all at once
Individualization	As Whyte *et al*. continues to state however, because this level of skill differs greatly between players the game should support players in an individual manner, examples of this are that the game should start and increase difficulty in a personal manner, either by changing game elements difficulties in levels are changing the player to different levels depending on their skill. This way it supports scaffolding learning. This point aligns/overlaps with Yussof's game attributes of *scaffolding*, *accommodating the learning* and *situated and authentic learning*. Which states that the game should support and help during the learning activity. For example the game's ability to address different learning styles by offering variation in the gameplay. But also whether the gaming environment can relate to the players interests of the outside world.
Learner Control and Provision of choice	Self-determination theory makes the suggestion that giving a person the provision of choice is an important part of enhancing intrinsic motivation and enjoyment. Furthermore it is stated that providing a choice on elements of the game environment that are relevant to the targeted knowledge or skill, is when provision of choice is most efficient in enhancing intrinsic motivation and enjoyment. This overlaps with Yussof's attribute of learner control which entails the players ability to direct the learning in the game, providing them with the ability to explore at their own pace and experience. This also overlaps a bit with Yussof's attribute of *interaction*, which signifies the extent to which the game requires engagement and input from the player
Attention span	This game attribute concerns, as Yussof states it: "the cognitive processing and short-term memory loads" [69, p.22] that the player has to deal with during the game. The target group is something that should be taken into account when calibrating this game attribute.

Relevant to note is that these criteria and attributes are often not independent of each other, for example game difficulty is greatly influenced by individuality and vice versa. To establish a form of evaluation for these criteria, in Table 2 different levels of execution of the criteria are listed, it is important to note that the table itself does not yet attach any value such as good or bad to these levels, but that the evaluation of these levels will take place in Section 2.2.2.

Table 2: Levels of execution for each criteria

Name		Level of execution/inclusion
Immersive Storylines	Yes	Is implemented throughout the entire game, and game interactions take place with the story in mind
	Some	There is a story, but it serves no goal, no meaningful interactions in the game
	Themed	There is worldbuilding and a theme, but no inherent story
	None	There is no story, only practical game mechanics
Goals directed around target skills	Long	Game has a clear long term goal
	Medium	Game has a medium goal, e.g. just level based, but not throughout the entire game
	Short	The game has short targeted tasks and goals
Rewards and feedback about goal progress	Rewards	Inclusion of a system that rewards the user for immediate reinforcement
	Feedback	The game provides feedback that helps with achieving goals
	None	No rewards nor feedback system
Increasing levels of difficulty	Yes	Multiple different variables are used to variate difficulty
	Some	Limited use of increasing difficulty
	None	No increasing difficulty, just consistent
Individualization	Automatic	Based on players performance the game adjust
	Players choice	The player chooses a difficulty level themselves
	None	The game doesn't allow for individualization
Learner Control and Provision of choice	Yes	Player has own autonomy in determining their course through the game. (e.g. exploration, learning through experience)
	No	There is little to no autonomy for the player
Attention span	Yes	The game takes attention span of their target audience into account
	No	Game doesn't take attention span into account

2.2.2 Educational Games

Among serious games a subdivision can be made of games that target skill acquisition and games that target knowledge acquisition. These can not be seen completely separately since they inherently have a bit of overlap, but do tend to utilise different techniques. This section will mainly review games focussed on knowledge acquisition since that is the target of this thesis, but might include skill based learning games if they are deemed valuable.

These works will be evaluated at the hand of the criteria established in Table 1 and Table 2. This evaluation can be found in Appendix A, and will be expanded upon in the following sections. The games will be expanded upon in the sections below and will be ordered from adherence to the game attributes set in 2.2.1. Starting with the least adherence, going up to the most.

Duolingo and Similar applications

A possible source of inspiration comes from Duolingo [84]. It is a well known application for language acquisition. Duolingo can be considered on par with normal education of languages in the school system [48]. The nuance here being that Duolingo [84] users more often learn from intrinsic motivation and internal reasons than students at schools or colleges tend to [48].

A criteria to be given to this tool, however, is that in its definition it can not be considered as a game. Duolingo would rather be considered more as an e-learning or interactive tool than a game. Where an e-learning tool is meant just as a tool to deliver education in a digitised manner and a game involves mechanisms that try to optimise engagement and intrinsic motivation.

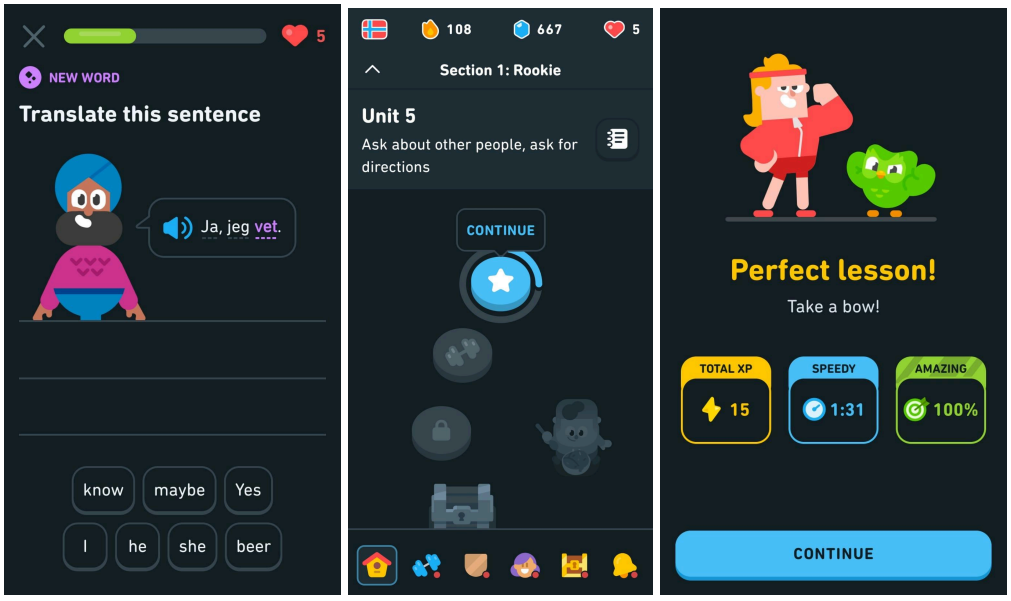


Figure 2: Screenshots from Duolingo app learning Norwegian

A counter argument to this is that Duolingo does contain a few of the game attributes described by Yussof [69] and Whyte *et al.* [66] as can be seen in Appendix A. However this inclusion is limited. The discussion whether duolingo is a game is not relevant so will be left alone, but it can be considered relevant to know the concerns behind it. Since it explains the concept behind intrinsic and extrinsic motivation. Duolingo itself does not provide much intrinsic motivation, but mainly extrinsic motivation.

Duolingo is not alone in taking approaches like this, with minute differences, applications such as Memrise [85], Babbel [86], Lingodeer [87], Mango languages [88], etc. (all can be found in Appendix A and have similar evaluations as duolingo) These applications differ in approach but often tend to utilise basic gamification principles, such as direct extrinsic rewards.

Gus on the go and Mindsnacks

The games of Mindsnacks [90] and Gus on the go [91] are quite similar and focus on extreme beginners (young children), they mention this on their website but are also visually confirmed by their applications. These games or rather learning tools consist of small minigames that teach small bits of information to the audience. They function similarly in structure to applications such as duolingo but the lessons are replaced by these minigames.

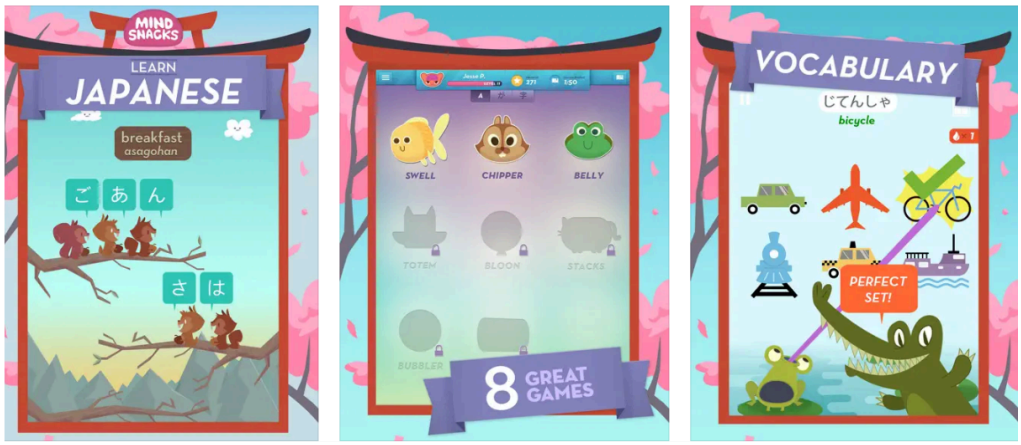


Figure 3: Screenshots of the mindsnacks application showing different minigames

Influent

Influent [92] is a language learning game which immerses the player in a 3D environment. With a 3D environment it models similarly to how native language is learned. The environment allows for every single object to be clicked and get the name from in the respective language. The game provides more information and pronunciation if needed. The environment is interactive allowing for drawers and doors to be opened to reveal more information.

Figure 4: Screenshots of the Influent game

This game is mainly aimed at building vocabulary, not grammar. The game has a few minor challenges included. For example by right clicking objects you add them to your *vocabulary list*, a challenge can then be done where the words appear on screen and you have to locate said objects. This product satisfies quite a few of the game attributes and criteria proposed by Yussof [69] and Whyte *et al.* [66]

Minecraft education edition

Minecraft education edition [89] might perhaps be one of the most well known educational games. Education edition provides multiple lesson plans on a variety of topics such as spaceflight, privacy, cities, coding and even AI. A few of these have been evaluated in Appendix A. Releases of education edition often revolve around solving puzzles and a bit of open world exploration leading to a bigger goal. All of these lesson plans are often targeted at absolute beginners.

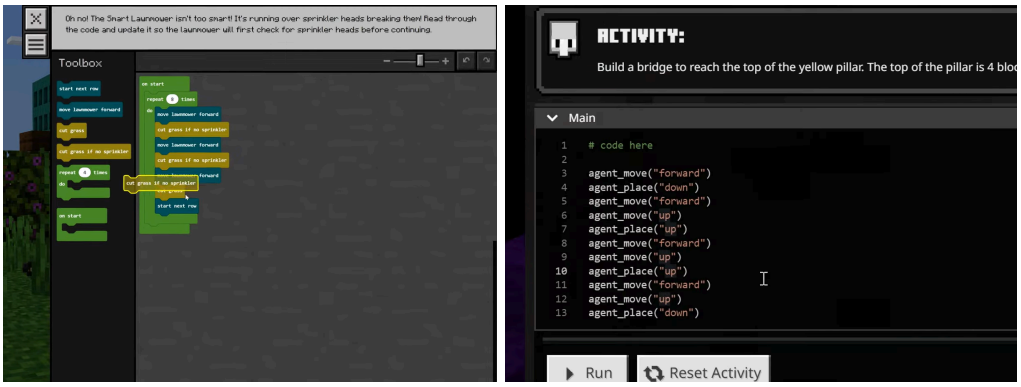


Figure 5: Screenshots of Generation AI lesson in minecraft education edition showing both python and block coding in minecraft

By framework standards of Yussof [69] and Whyte *et al*. [66] Minecraft education edition is a rather well made educational game, utilising many of the game attributes. This can be partly confirmed by the positive reviews of the game.

Hiragana Games

There are two games to be found in Appendix A that both focus on the learning of Hiragana (Japanese). Hiragana is the basic writing system used in japanese. These games [93], [94] take a similar style and approach in visuals and game design.

Figure 6: Screenshot of Hiragana Forbidden Speech, where the character interacts with the environment. The words on screen are voiced in addition to the written out pronunciation and translation.

These games satisfy many conditions set by Whyte *et al.* [66] and Yussof [69]. With the exception of individualization. As with many games, they are aimed at just beginners, and therefore do not include multiple difficulties.

Honourable mentions

Games such as scrabble or words with friends are not inherently targeted at language acquisition but might contribute much to vocabulary development among players or users. A relevant note to make in regards to language acquisition, is that the general exposure of children to video games and other forms of desirable entertainment greatly impact language acquisition (mainly vocabulary and pronunciation) due to mere exposure (for the English language) [78]. The engagement alone these mediums offer create a “positive and motivating atmosphere” [78] which is a good environment for children to adopt a foreign language. This is a conclusion drawn from multiple educational games around language acquisition.

2.2.3 Conclusion

There are an abundance of e-learning tools available, which all have shown to be of value, but that educational video games can perhaps have an even greater potential.

In summary, the evaluation criteria, outlined in Table 1 and Table 2, served as a lens through which these serious games are examined for their effectiveness in facilitating learning experiences. Influent [92] showcases the benefits of immersion in a 3D environment with interactive elements. Minecraft education edition [89] is a versatile and widely applicable educational game. The positive reception and its alignment with the established frameworks confirms its potential in using games in education. For all games it can be concluded that they might have been designed for a target audience but do not necessarily take the attention span of that target group into account.

2.3 Conclusion State of the Art and Literature Review

The design of an educational game is a well researched topic, and there are different approaches to doing so. Not all these approaches are similar in effectiveness and depending on the target group or setting differing approaches might fit better. An element that is rather important as well is the design of the educational game, this process needs to take many factors into consideration, such as stakeholder inclusion and the developer needs to be aware of their own biases and understanding of a topic. Extensive playtesting is technically also wishfull to make sure learning does not occur in ways which are not intended or wrong.

Activities before, during and after the gameplay activity (such as debriefing, discussing and reflecting) have a great impact on the knowledge retention of students, but also on making sure that the student can usefully translate the knowledge they learned in the game context into the real world. Many of these are physical activities and are separated from the gaming context, perhaps for good reason. This unfortunately also means that many of these activities also have to be facilitated and prepared by a supervisor or instructor.

It can be interesting to look into whether the game (environment) could facilitate or take over these activities and the positive impact remains, to reduce this added workload for the teacher or instructor. It is useful to once more repeat that this also suits the clients wishes, where their business model is based around providing lessons that require little teacher or instructor preparation or participance. An added benefit might be that the student could remain engaged during these activities, in a way that games tend to offer. To restate the research question introduced in Chapter 1 once more:

“Could the addition of a digital brief and debrief positively impact educational video games?”

From the state of the art it is to be concluded that not many games provide support for the aforementioned activities. Although repetition in a game can be seen as reflecting, it does not quite suit the definition it entails in the literature, where reflection signifies a separation from the gaming context to reflect. This is also where the literature can slightly come into conflict as to how effective the RQ might be. Since it could be that the added benefit of these activities comes entirely from the fact that they are detached from the gaming context. Whether the separation from the gaming context is the sole reason behind the positive impact, is something that could be looked into more extensively, and thus this RQ has been created.

2.4 Elaborative Literature Review

To gain a bit more insight into the conclusion of the state of art and literature review and the ensuing research question. A review of the exact activities is necessary, this elaborative review will look into what activities are named in literature and how they are currently implemented in or according to literature. We can separate the activities into three categories, with a bit of overlap; The activities before the game, during the game, and after the game. But we also see the activities themselves are rather similar and can thus also be subdivided into three encompassing terms.

These terms entail *contextualising* which can take place before and during the game, *briefing*, which can take place before the game, and *debriefing* which can take place during the game or after. To elaborate on the activities, all of them will be defined more broadly and how they are currently applied in or according to literature.

2.4.1 Contextualising

Contextualizing is seen as most important in the function of transfer (previously often referred to as "knowledge transfer into the real world"). An important point that has also been mentioned in Section 2.1.2 is the value of similarity between the game environment or context and the real world context in which the knowledge or skills are to be applied. In Section 2.1.2 an example was given by Frank [17] of 'gamer mode' where the gamer is more focussed on using the rules to win a game rather than learning from the learning objective. Contextualization of the game can be crucial for avoiding this behaviour. Where the game's representation of the real world is not similar to the player's expectation. Although here it is relevant to note that making the game environment similar to the real world is not necessarily the answer. This is because literature makes a difference between so-called near and far transfer. Where near transfer occurs when the context of the game and the real world are similar, but far transfer talks about transfer in dissimilar contexts. An example of far transfer would be a game where hand-eye coordination is trained, which can help surgeons improve their surgeries, by efficiency and fewer errors. Even though the game itself would not be about surgery, the skills and knowledge targeted in the game still aids in the development of skills of the surgeons that they use in their daily life.

It is consequently also stated that near transfer has the most functions where the user needs to perform specific behaviours, or with short term skill development that needs to be applied quickly. Alklind [30] states that far transfer can be defined as the overarching goal of education where higher cognitive abilities are trained that are associated with adaptive expertise (e.g. creative problem solving or other social skills).

With contextualization it is also aimed at how expectations influence learning. Honghøj [79] identified that teachers had to actively contextualise game based activities by

reminding students that learning, not gaming, is the main point of the activity. By actively framing the activity it may ensure that within a formal school context meaningful knowledge may be produced rather than manipulation of the game environment.

2.4.2 Briefing

Before users play an educational game they should be introduced to the concept of educational video games. They need to know what is expected from them (e.g. learning goal of the game). An introduction or briefing can be kept short if the idea of the game is inline with the learning-in-gameplay camp introduced in Section 2.1.1 [62]. In this case the game elicits the knowledge and not a lesson plan around the game. Here the game needs little pre-teaching, and does the teaching mostly itself. The briefing should thus focus on making the user comfortable and introducing the purpose of the game. Similarly to what is mentioned under *contextualising* by Honghøj [79], this framing of the activity can positively impact transfer of knowledge.

2.4.3 Debriefing and After Action Review (AAR)

As described by Alklindt [30] debriefing or AAR is an essential part of an experience based learning. Because it allows for reflection and generalisation of the learning experience itself. With generalisation she indicates that the knowledge be separated from the gaming context and placed in a real-world context. Where debriefing or AAR encourages the user “to make connections between game events and real world events” [30, p.91].

She also elaborates on using the term of AAR rather than debriefing for specific reasons, which are relevant reasons, but I still included the term of debriefing for an easier understanding for a larger audience.

In the literature there are thus also different interpretations of debriefing, but one that best suits this GP is the one of Crookall [80] where it is stated that debriefing would entail an activity where the participant is actively encouraged to make associations between their actions and knowledge in the game and the related settings or knowledge they already have.

Alklindt [30] makes two additional statements where she says that debriefing happens most often outside of the game (environment), either as intermediate debriefings (e.g. feedback in between rounds or levels) or as a final phase after the game. Secondly she states that debriefing is often more effective if it happens directly or soon after the gaming activity took place.

AAR or debriefing in its origins entails the action of discussing the learned material or reflecting on what was just learned. Although discussion might not be the most effective

form of debriefing. Kriz [81] suggests six phases through which an *ideal* debriefing would go (see Table 3)

Table 3: Kriz phases of ideal debriefing

Phases	**Description**
Phase 1:	Describe emotions (How do you feel?)
Phase 2:	Describe what happened (What has happened?)
Phase 3:	Relate game to reality (In what respects are events in the gaming simulation and reality connected?)
Phase 4:	Identify learning and challenge mental models (What did you learn?)
Phase 5:	Speculate on alternative scenarios (What would have happened if … ?)
Phase 6:	Plan goals for future actions (How do we go on now?)

The literature also states that, even though debriefing would benefit from a detaching of the game environment, debriefing could also take place in the game context where it would be automated. This however runs into much critique since self debriefing or automated debriefing do not really seem to function well, or at least as well as when an expert runs the debriefing.

3 Methods and Techniques

An iterative design process allows for changes to be made all throughout the design process, and improvements to take place. The creative technology design process [75] falls under such an iterative design approach (see Figure 7). This approach is suited for this project because it combines an approach of human-centric design and common engineering design principles (such as multiple prototypes). Besides this it uses a divergent and convergent design approach, where in the divergence phase the project is as open as possible to promote for example brainstorming. The convergence phase involves narrowing the design space until one specific solution is achieved.

For this purpose of this GP a creative approach will be taken to applying the creative technology design cycle. To elaborate on this, all parts of the design cycle will be laid out and written down how they will be executed in relation to this GP.

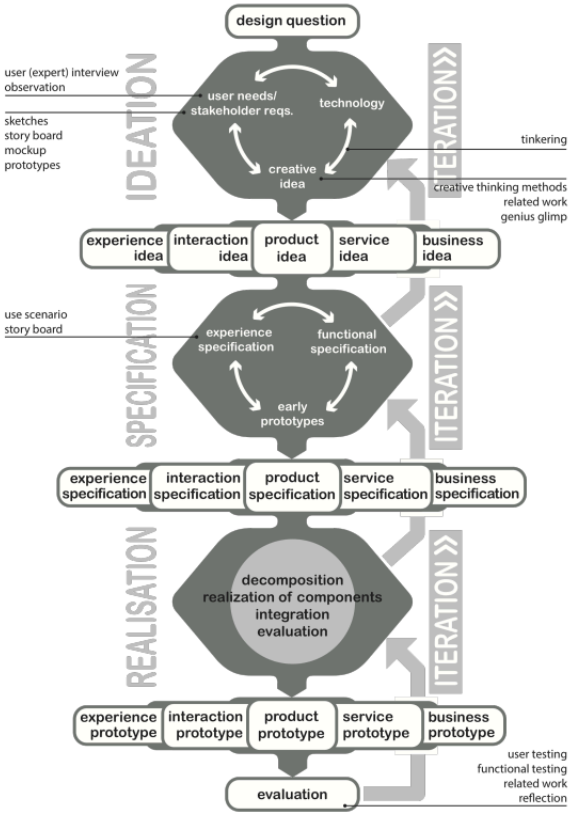


Figure 7: Creative Technology Design Process

3.1 Ideation

The first section of the create design cycle is the ideation phase, this phase contains a stakeholder analysis, user domain research, preliminary requirements and concept ideation.

3.1.1 Stakeholder Analysis

A stakeholder is anyone (a group or individual) that can influence or be influenced by the project [74]. A stakeholder analysis is performed to establish all stakeholders needs or preferences. They can be grouped according to their participation in the project/product, their impact on the project or the other way around the project's impact on them.

Newell's [74] approach to a stakeholder analysis is the one that will be used for this project, this approach allows for a clear oversight of stakeholders to be established and their influence on the project. Firstly the stakeholders will be identified and they will be assigned a value of 1-10 on the scale of interest in the project and influence in the project. An additional clarification to these values might be included to be able to trace where they come from. Secondly they will be placed in a matrix proposed by Newell to help establish their impact on the project and help establish what the correct course of action is regarding inclusion of these stakeholders (see Figure 8).

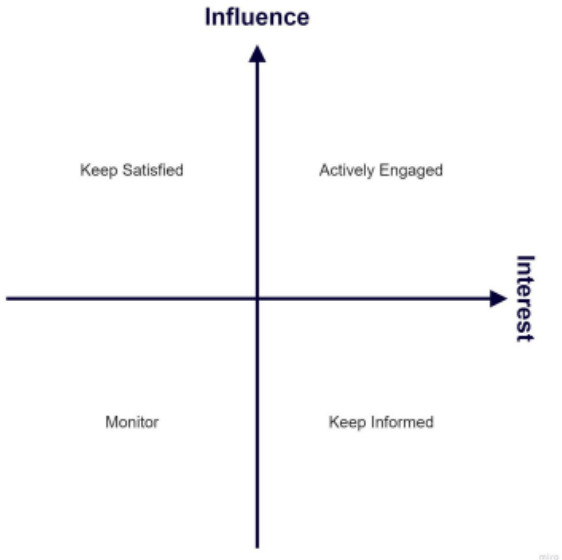


Figure 8: Stakeholder Influence-Interest Matrix

As can be seen in Figure 8 the stakeholders will be divided up into four categories according to their scores. Newell also mentions the different values each of the types of stakeholders have. Stakeholders with much influence and interest are the most important according to Newell and should be prioritised and included in the project. High influence

but low interest should be monitored. Low influence but high interest stakeholders need to be included in evaluating whether they are experiencing issues. And lastly low influence and low interest can be informed but are not that relevant. In relation to this GP it might be difficult to completely fall in line with Newell's recommendations because of the ethical concerns and bureaucracy around including children in one's project.

3.1.2 User Domain Research

In line with the client, the target group would be gifted children in primary school around the ages of 9-13 years old. But for the confines of this GP the target group will be generalised to be all types of children from 9-13 years old, and not specifically gifted children. This domain research will be executed with the help of interviews to establish a visual style and content wise style that is preferred by the target audience. This is inline with the previous literature that stressed the importance of user included designing. These interviews could be seen as a co-design session. The interviews will consist of a few previously prepared questions, but it will be open for the conversation flow to lead the interview. This creates the option for asking unprepared questions or investigating topics that the researcher might not have considered beforehand. Additionally, these interviews will familiarise the researcher a bit more with the target group that they are designing for. The user domain research will also include a testimonial or opinion of the client on what the children provided, since the client is well versed in designing lesson plans for this target group.

3.1.3 Preliminary Requirements

The requirements relevant for this project can be divided up into three categories: Firstly, requirements set by the cliënt, secondly, requirements taken from the literature review, and thirdly requirements taken from the related works section. These will be concretized using an adapted version of the moscow method. Only the *must have* and *should have* will be used. The preliminary requirements will be elaborated on in this way since the other categories are often redundant and looking for irrelevant problems. However the idea behind the MoSCoW method of prioritising important and less important requirements and thereby helping establish importance and priority in the project is valuable, since it allows for design choices and time commitment choices to be made based on this prioritisation. The requirements will be phrased as measurable as possible to eventually be able to evaluate how well all requirements were taken into account.

3.1.4 Concept Ideation

Based on all the knowledge from the background research and the other phases of the ideation a brainstorm session can take place. This brainstorm would lead to concepts on how the issue (research question and thus problem statement) might be solved. For this GP that will entail a plan on how to include activities such as discussing and reflecting in the gameplay environment.

3.2 Specification

In this phase exact requirements for the final concept are set. This is done with the help of the background research and stakeholder analysis, the knowledge from these are formulated into precise requirements. Since the final concept is more concrete the preliminary requirements will be narrowed down and made more measurable. This chapter will consist of a more concrete list of requirements, once more prioritised using the adapted moscow method described in Section 3.1.3.

3.3 Realisation

During this phase the knowledge from the ideation and specification will be realised into an actual prototype. This phase is utilised to describe how this process went (for example what tools were used). It elaborates on all the design choices and how they were made. It establishes used tools, assets and the eventual realised prototype.

3.4 Evaluation

In this phase the prototype is evaluated. With the goal being to discover the effectiveness, usability for all stakeholders or general experience of the product. The evaluation phase will optimally help answer the research questions. This phase contains a test to conclude whether the requirements from the specification phase are sufficiently incorporated and a user test to conclude on the effectiveness of the concept. Since the research question also entails the remaining effectiveness of the prototype in the variables of knowledge retention and transfer of knowledge into the real world, and the possible added engagement and enjoyment, the test will be measured under two cases.

In these cases it is important that both reflect a realistic view of the real world in evaluating whether the prototype brings forth actual improvements. This project is developed with the view in mind to reduce teacher workload and therefore minimise their involvement.

If no teacher could facilitate these activities they would still most likely be executed at the hand of paper debriefing or reflection forms. It would therefore be unrealistic to test one of the two cases with just the video game and none of the activities that improve the knowledge retention and transfer to the real world.

Therefore the two cases will test the factors of knowledge retention and knowledge transfer with case one being the game with its integrated activities and case two being the game with the current variant of how these activities are often done (so a paper debriefing form for example).
This will give us a realistic view if video games with the activities included are truly better. But in addition to this the other variables game included activities could bring

along should not be neglected. The game based activity could be much more engaging or enjoyable then a paper based activity and therefore also work better. These two variables of engagement and enjoyment will also be evaluated.

An analysis between the two cases on knowledge retention and knowledge transfer into the real world will most likely be measured with a test in the form of an interview or questionnaire. Possible engagement and enjoyment increase will be detected with the use of personal interviews.

4 Ideation

The first section of the ideation entails a stakeholder analysis, user domain research and preliminary requirements (Section 4.1 to 4.3). In the second section preliminary concepts will be formulated (Section 4.4), to help give a more concrete image of a final concept. And lastly a ideation concept is presented (Section 4.5)

4.1 Stakeholder Analysis

The stakeholder analysis consists of an identification and an analysis of stakeholders, the first part containing all stakeholders and elaborating on them and the second part analysing how they impact the project. This analysis will help in establishing requirements for the concept, and possible actions that need to be taken in the design process. Such as inclusion of a specific stakeholder.

4.1.1 Identification

The stakeholders were identified, given a score on influence and interest and an elaboration on the score was given. The score ranges from 0-10, with 0 being least interest or influence and 10 being the most. Interest is graded based on the eventual product this project produces and not on interest in the process, the same goes for influence.

Table 4: Stakeholder identification and clarification table

Stakeholder name	**interest**	**influence**	**clarification**
Wilna van den Broek	8	5	Wilna is the client of this project. She impacts the course of the thesis quite a bit, but since the thesis is not just about producing a game for the client but also about scientific research, she impacts the base idea but not the minor details or the smaller components of the game. Her interest in the end result is however rather large since it could be a useful product.
Children 9-13 years old	3	7	They are the target group. They influence the project to the extent the designer lets them. Since user-centred design and inclusion is important in this thesis their influence can (perhaps unknowingly to them) be rather large. Their interest could be large, but it is unlikely.

Teachers	7	7	They are the teachers that need to use or prepare the product for their students. Teachers are the ones that eventually need to bring the end result into use, so their influence is already rather large in that regard. In addition to this the designer does try to minimise the necessary contribution of the teacher. As is the point of this thesis and in line with the client's wishes. Their interest might also be rather large since they (presumably) want the children to get the necessary learning, but they do not always have the time. A tool that aids them with this can be quite valuable.
Thérèse and Maro	4	8	Thérèse and Maro are supervisors of this project. Since they influence the process they also influence the end result. The end result is of interest to them but not because of the products and its intended purpose itself but because of the grading.

4.1.2 Analysis

The stakeholders will be analysed at the hand of the matrix proposed by Newell, and thus the consequences this analysis brings along for each stakeholder. Refer to Figure 9 once more to clarify this matrix.

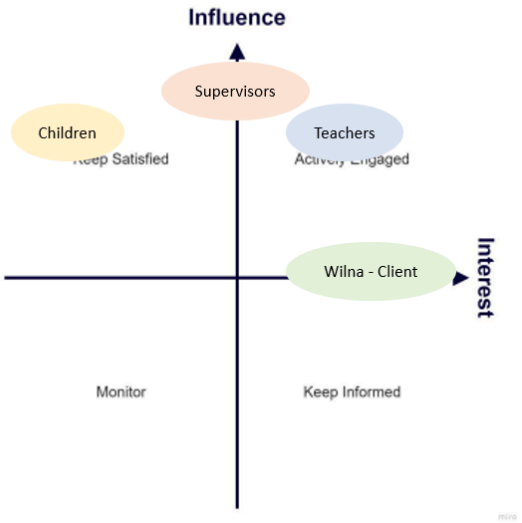


Figure 9: Stakeholder Influence-Interest Matrix

Wilna, the client, can be found on the right side of the matrix balancing between the two quadrants. She will be kept informed of the process along the way, but her feedback will be welcome through each step of the process. The children are in the upper left quadrant, they need to be kept satisfied in the way that the product needs to be successful to them in their ways. Their preferences should be taken into account when designing the prototype. The teachers should be actively engaged in the development process to make sure the product is indeed easy to use and does not require much effort from them. This is also done to increase user acceptance as is recommended in Section 2.1.2 of the literature review. The teachers can thus be found in the upper right corner. Lastly the supervisors, similar to the target group, will be kept informed, and their knowledge and opinions will be taken into account when designing the prototype.

4.2 User Domain Research

The domain research is about finding what is relevant to the target audience and what preferences they have, and to familiarise the designer with the target group, to make designing with the target group in mind easier. Since the client is well versed for designing for this target group an informal conversation was held. Knowledge from this conversation will be included in the client side requirements, because, since the client has experience designing for this target group, they feel it is imperative that these be included.

The client's previous occupation was being a teacher for the respective target group, therefore the testimonial from this person could give valuable insight. The conversation took place in an informal context and setting. The following two paragraphs will recapitulate a few of the takeaways from this conversation.

One of the main points the client brought up was the simplicity of designing something engaging for this target group, at least in the short term. As soon as, during a schooling activity, an interaction with a screen can take place children seem to be enthusiastic about or engaged with it. She also commended the value of avatars and mentioned the minimalistic style they use.

To also take into account the other stakeholders, the client offered valuable insight as to why their product worked so well with teachers. Since extra lessons for gifted children are often time consuming for teachers to prepare, where the teacher needs to understand the topic themselves completely and needs to prepare education and prepare testing in some form. It is also mentally draining. Their product eliminates all of these actions and just requires the teacher to guide the child through the lesson, more so in the role of a supervisor. This still gives the child more tailored education fitting their gifted needs and does not require a big time investment from the teacher.

To conclude this brief user domain research, it is valued that the product stands on its own and does not require much preparation and is thus easily accessible. Regarding the wishes of the children it can be concluded that they will be engaged nonetheless. To nuance this with literature we can conclude that long term engagement is more wishful and can utilise intrinsic motivation more.

4.3 Preliminary Requirements

The requirements will consist of three different categories. Firstly being the requirements set by the cliënt, secondly the requirements taken from the literature review, and thirdly requirements taken from the related works section. These categories will be prioritised by an adapted version of the MoSCoW method.

4.3.1 Requirements from Related Works

Educational games should adhere to certain game design principles and criteria to achieve an engaging and effective educational game. The Table (Table 1) introduced in Section 2.2.1 is used as a guideline for the requirements. To summarise the game should take into account or must contain:

- Immersive storylines
- Goals directed around target skills
- Rewards and feedback about goal progress
- Increasing levels of difficulty
- Individualization
- Learner control or provision of choice
- Attention span

An extensive explanation of these criteria and game attributes can be found in Table 1.

4.3.2 Requirements from Literature

Besides the state of the art, in the literature review five points of attention were established which will be used for preliminary requirements. To summarise, the five points of attention that were identified in Section 2.1.2 that educational games should or must take into account the risks and values behind the following points:

- Technical limitations
- User-centred design
- Intrinsic and extrinsic motivation
- Superficial understanding
- Faulty understanding or unintended learning
- Translation into the real world

Similarly to the state of the art requirements a more extensive explanation of these points can be found in Section 2.1.2.

4.3.3 Requirements from Client

Lastly, the client also has requirements regarding the more practical aspects of the design. The fact that learning could occur seemed almost axiomatic to them. The client main wishes included:

- The game be aimed at vocabulary acquisition
- Playable from a website page
- Also be fitting for gifted children
- Should be easily convertible to more languages
- Duration of game/level from 5 to 15 minutes (or make it choosable)
- Printable tests
- Built with a free platform
- Simplistic visual style
    - No screaming and overwhelming colours
    - Clear font
    - Simplistic imagery
- The game should be able to export a list of learned knowledge

To elaborate on the third requirement, that the game should also be *fitting for gifted children,* it is not a main priority for this GP. However, as games have a few inherent qualities that can be valuable for the education of this target group, it will be assumed that the final concept can also be used by gifted children.

Some of the game attributes set by Yussof [69] and Whyte *et al.* [66] such as autonomy [72] and individualization [73] are important parts in teaching gifted children. In addition the engagement educational games can offer is an important factor for vocabulary acquisition among gifted children [70], [71]. This is an oversimplification of how gifted children learn, but to limit the scope of this GP it is assumed that the game will not actively dissuade gifted children, and that the game might even have qualities that are fitting for education of gifted children.

4.3.4 MoSCoW Prioritisation of Preliminary Requirements

For the prioritisation of the requirements with the adapted MoSCoW method it is relevant to once more clearly state that the aim of the client is not the same as the aim of this GP. The client wants an educational video game and the GP looks into increasing learning effectiveness in the gaming environment. In addition to this, a few of the points raised by the literature or the state of the art are important but can, for the scope of this thesis, not be optimally implemented, even though they can add much value. An example of this would be the extensive inclusion of users in the design process. These differing aims give somewhat of a clarification given for the priorities given in Table 5.

Table 5: Preliminary requirements prioritised with adapted MoSCoW method

Priority	**Preliminary Requirements**
Must Have	- Must be easily accessible (e.g. playable from website) - Must be playable on a large variety of devices in regard of specs of the devices - Achievable in short development time - Must be aimed at vocabulary acquisition

Should Have	- Should be made with a platform that is free
	- Should be transferable to test in a non-digital fashion
	- Should be 5 to 15 minutes
	- Should be easily convertible to other languages
	- Should be fitting for gifted children
	- Should have a simplistic visual style
	  - No overwhelming colours
	  - Clear and accessible font
	  - Simplistic imagery
	- Should include users (teachers and children) in the design and implementation process
	- Should make sure no faulty and superficial understandings are created
	- Should optimally use intrinsic and extrinsic motivation (rewards and feedback)
	- Should have an immersive storyline
	- Should have increasing levels of difficulty
	- Should make sure the user has autonomy
	- Should take attention span of target group into account
	- Should take individualization into account

4.4 Concept Ideation

The concept ideation contains different preliminary concepts and how they adhere to current requirements. To recapitulate once more what has thus far been discussed and what kind of concepts will be generated a short description is provided:

Quick Oversight

Based on the preliminary requirements set in Section 4.3 and the aim of this thesis which is to develop an effective educational video game, the concept comes down to including an activity that increases knowledge retention or transfer of knowledge into the real world, this activity should be included in a digitised manner in either the game itself or the game environment (see Figure 10 for visual clarification). With the term game is being referred to the section where a player interacts with a world and mechanics typically related to game, and with gameplay environment it is being referred to the platform the game takes place on, such as the website, but also the menu screen of the game for example.

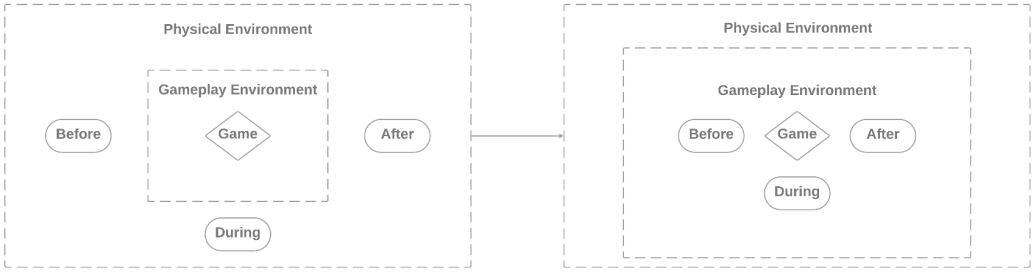


Figure 10: Aim of thesis visualised, the activities move into the gameplay environment.

Based on the information from the literature it is known that activities before, during and after the gameplay activity can have a large impact on knowledge retention and knowledge transfer into the real world. This GP wants to utilise this in combination with the clients wishes of decreased teacher workload by looking into taking the activities and digitising them in a form into the gameplay environment or the game itself.

To achieve this within the scope of the GP, the concept generation phase will take an existing game concept from Section 2.2.2 that adheres to the requirements as best as possible. The game mechanics of this game will be recreated to be fitted for a website and the client's wishes, and the modifications (of activities during, before and after) will be added on top. The concept generation will thus pick an existing game, and work out multiple concepts on how these activities can be included in the game. The concepts can be separated into two parts, either for the game and the briefing and debriefing part.

4.4.1 Game Concept 1: Likeness

Based on: Influent [92]
Included Activity: Contextualization
Description: The activity described, *contextualization*, entails an activity during the gameplay activity, where the user connects knowledge learned in the real world to the game to better help translate the knowledge from the real world into the game and vice versa. The game could perhaps inherently facilitate this if the game is much like the real world. So not a fantasy game, but a general school layout or a bedroom. This links the learned knowledge more strongly to the actual environment, which is the benefit of using real world knowledge. This also ties into *situated learning* and *near transfer*. A specific concept here is the learning of words would proceed in themes where if the user learns about a zoo, the virtual environment reflects a zoo, when the user learns about traffic or rooms the context in the game reflects this. Within this concept not so much an activity is added, but the game is designed in such a way that it facilitates knowledge transfer. This can be defined as *near transfer* that is described in Section 2.4.1.

4.4.2 Game Concept 2: Indirect Likeness

Based on: Hiragana Forbidden Speech [94]
Included Activity: Contextualization
Description: This concept would be based more on *far transfer*. Here the game takes skills that are inherent parts of vocabulary acquisition, and applies them in the game, focussing more on a good educational game as described in Section 2.2.1. This means the game is going to be based on one of the Hiragana games [93], [94], which both scored high on adherence to the framework in Section 2.2.1. Here the activity would be included by having the game not necessarily match with the real life context in which words are used, but just where it makes sense within the game. The vocabulary acquisition techniques would match that of the base game being repetition and testing (auditory, and writing). By putting the same word in different contexts the user could experience far transfer where the user learns to transcend specific contexts in which the words are used.

4.4.3 Game Concept 3: Combination

Based on the two previous concepts a few strong suits of each come forward, these concepts also need to adhere to the requirements set in Section 4.3. Hereby, stating that the game should be no more than 15 minutes and preferable between 5 and 10 minutes, more and more of Hiragana Forbidden Speech's [94] attributes become unattainable, such as long term goals and a full storyline, this puts it on par with Influents [92] score regarding the framework in 2.2.1. Since Influent's mechanics could also utilise situated learning and thus near transfer, it is what this concept will mostly be based around.
Concretely this entails a player in a setting, where the player can collect objects where it learns the translation, and can testrun their ability to recognize these objects by a timed collection, where a translated word is proposed and the user has to find it. This will be

recreated in a style suitable for a short development time, and one that is suitable for the requirements. This indicates that the game style that Hiragana has is quite optimal for it. Since 2D graphics and environments are generally faster and easier in development.

4.4.4 Requirements Check

Table 6 shows the preliminary requirements set in Section 4.3 from the *must have* section and the *should have* section compared to the concepts. From this table the conclusion can be drawn that all the concepts are all suitable for the ideation concept, but concept 2 (C2) would be hard to complete without scrapping a large part of the game mechanics, regarding long term goals and strong storyline. Leaving concept 1 and 3. Where concept 1 (C1) is also rather extensive and would most quickly be developed in an engine such as unity, which makes it not a free platform, other platforms are of course also possible but put a strain on the development time. So concept 3 (C3) adheres to most of the requirements.

Table 6: Oversight of criteria and what concepts adhere to them

Must Have		
No.	Requirement	Concepts
1	Must be easily accessible (e.g. playable from website)	C1, C2, C3
2	Must be playable on a large variety of devices in regard of specs of the devices	C1, C2, C3
3	Achievable in short development time	C1-ish, C3
4	Must be aimed at vocabulary acquisition	C1, C2, C3
Should Have		
6	Should be made with a platform that is free	C1, C2, C3
7	Should be transferable to test in a non-digital fashion	C1, C2, C3
8	Should be 5 to 15 minutes	C1, C3
9	Should be easily convertible to other languages	C1, C3
10	Should be fitting for gifted children	-
11	Should have a simplistic visual style	C1, C2, C3

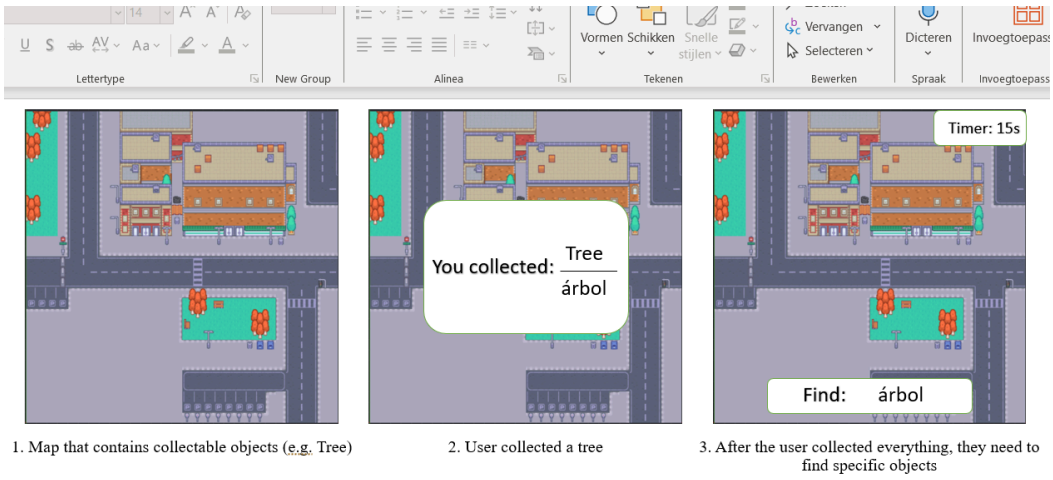
12	Should include users (teachers and children) in the design and implementation process	-
13	Should make sure no faulty and superficial understandings are created	C1, C2, C3
14	Should optimally use intrinsic and extrinsic motivation (rewards and feedback)	C2
15	Should have an immersive storyline	C2
16	Should have increasing levels of difficulty	C1, C2, C3
17	Should make sure the user has autonomy	C1, C3
18	Should take attention span of target group into account	C1, C2, C3
19	Should take individualization into account	-
20	Utilise smart colour use from colour psychology	C1, C2, C3
21	Utilise an accessible font	C1, C2, C3
22	Simplistic Imagery	C1, C2, C3

4.5 Ideation Concept

The concept went through a significant alteration during the realisation of the concept, therefore the original concept will first be presented, and consequently, what changed and why.

Concept 3 was the concept that adhered to the most requirements and was the concept that was continued. The concept was presented to the client, and they agreed with the concept being a suitable pursuit for the aim of this thesis. This concept granted most of their requirements and the requirements that emerged from the literature.

The concept entailed the collection of objects in an environment in the style of Hiragana Final Battle [93]. After all objects are collected the player is able to test their knowledge by re entering the map and with a timer being able to find the objects again by recognizing the translation. As is shown in Figure 11.



1. Map that contains collectable objects (e.g. Tree) 2. User collected a tree 3. After the user collected everything, they need to find specific objects

Figure 11: First concept drawn up in powerpoint.

The alteration the concept went through was mainly reflected in the visual style of the video game, since this style was mainly chosen because of the time limitations to make something more extensive and not because it was a better suited visual style. One might argue that a 2D environment would be worse at near transfer through situated learning, than a 3D environment could be. The technical limitation of a 3D game being harder to develop in the time limitation is what caused this choice.

Originally the game was to be designed in the game engine: Defold [95]. This engine has options for website based game development and is made for 2D game development. This engine appeared to be unsuitable for this project due to the learning of a completely new and different engine and coding language being more time consuming then expected, and the engine being somewhat limiting in documentation and options for development.

This prompted the switch of the development environment to P5.js. While developing in P5.js and when starting out in P5.js it was shown that in this case the switch to 3D would be viable, if not, more viable, due to the experience of the developer. Therefore the switch to a 3D environment was made.

5. Specification

In the specification we expand upon Chapter 4, the ideation. The ideation concept presented in Section 4.5 is specified in this chapter through the use of identifying important elements for the game and briefing and debriefing, such as visual elements, and design specifications. In addition, a persona, scenarios and more specified requirements.

5.1 Persona's

Persona's are often used in design to understand the user's goal in a better, more clear way. These persona's are based on the user domain research and stakeholder analysis that can be found in Section 4.1 and 4.2. Persona's can deliver an oversight of goals and behaviours.

From the stakeholder analysis it can be concluded that there are two important stakeholders that can be translated into persona's. I) The teachers, handing out the learning materials and software, II) the student learning the language.

5.1.1 Persona 1: The student

The persona that can be identified is the student, learning a new language, and specifically vocabulary of a new language. In their curriculum they could use something that is more interesting and motivating than a piece of paper with words on it. Bart is a student who is in 7th grade of primary school and can fast track to learn one additional language. Bart decides he wants to learn Spanish, since he saw a cool movie about it. Bart, however, is also quickly distracted, and needs a bit of teacher supervision to make sure he keeps on track. Sadly the fast track needs to be cut short often since the teacher is called back to the class to deal with the other children. Bart does not really like working since he finds it a bit boring.

5.1.2 Persona 2: The teacher

The second personna that can be identified is the teacher. This teacher teaches a primary school, with certain children that need additional attention, either in the form of help or more challenging material. Rianne is a teacher that teaches seventh grade, she is passionate about teaching but realises she is unable to offer every child the specific education they might need. She started a fast track for a few of the students that could use a bit more of a challenge in the classroom, but is often unable to make and guide all the material for these children. Rianne's schedule makes it rather difficult to offer all the children what they need. She needs the ability to give the children more advanced teaching materials that they can autonomously do or with as little guidance as possible, and are interested in. For this she needs learning content that is engaging but also more challenging. And should not take much effort to set up.

5.2 Scenarios

Scenarios describe how the prototype made from this thesis could possibly be used after completion. The scenario can help in establishing what is important to include in the prototype. Below is a bullet pointed, chronologically ordered list of events in a scenario that can take place when people use the prototype.

1. A child wants to learn a new language or more challenging content
2. This often starts at vocabulary acquisition
3. The teacher does not have the option to prepare the lesson material in addition to their usual workload
4. Even if the content was there already, the teacher is also unable to dedicate a segment of their time to extensively guide the student.
5. The teacher is looking for alternatives
6. Briljant onderwijs offers complete lesson materials that require limited participation and no preparation. Also offer interactive activities on their website.
7. The teacher is happy to have found such an easily accessible learning material that has the option to also provide engaging learning content.
8. The teacher can choose to watch the video and do the worksheets with the child if there is time or…
9. Alternatively/additionally the child can play the game designed to teach them the material
10. The child is more engaged and requires less supervision, allowing the teacher to do other activities, the teacher also does not need to prepare the materials.
11. Teacher is happy because the child can be equipped with a more suitable education while it doesn't cost the teacher extra time.

5.3 Summary Scenarios and Personas

The scenario and persona’s shows that there can be different reasons stakeholders like the prototype, e.g. enjoyment and motivation or workload reduction and educational quality. The persona’s provide a description of what the goals or needs are of the stakeholders. The scenario shows how the stakeholders might interact with the prototype. For the teacher it is important that the content is easily accessible and does not require much supervision or guidance, and that the child actually learns something. For the child the content just needs to be interesting and engaging.

5.4 Design Specifications

For the prototype a few specifications can be set based on the background research. These are in addition to the requirements and mostly entail aesthetic guidelines and choices, but also why these were taken into consideration.

5.4.1 Design Guidelines

Based on the findings of the background research and an additional interview with an expert, certain design guidelines can be set for the briefing and debriefing part of the prototype, and a few minor specifications for the game.

The expert that was interviewed teaches children in special education both with one-on-one tutoring and in front of larger classes. The interview conducted was taken in an informal manner and informal setting. General takeaways from the interview was a model that is often used in Dutch primary school education to help teachers establish lesson plans, a model called E.D.I, *Explicit Direct Instruction* [82]. Furthermore, additional tips on elements that can be useful in a lesson in addition to the actual learning activity, such as how different types of reflections can work best for different students. She emphasised the value of the learning goal being visible at all times throughout the learning, since it gives students the ability to be aware of what they are doing and not lose interest or motivation if they fail to understand a minor piece. Specific parts of the E.D.I were also discussed and how they could be implemented into the prototype currently proposed.

One of the first guidelines to keep in mind was the order of operations when engaging in a learning activity. This order is established by the model E.D.I, *Explicit Direct Instruction* [82]. The guiding principle of this model entails that in certain moments during the learning process, certain activities are best suited to effectively teach.

This also includes the actions commonly associated with briefing and debriefing. The model can be divided into three main sections, starting off with the *start* of a lesson, then the *core* and lastly the *independent processing*. In Table 7 these three sections will be discussed more extensively and what they specifically entail.

Figure 12: Model Expliciete Directe Instructie giving a common order of operations for a lesson

Table 7: Entailing order of operation for a lesson/the prototype

Order of Operations		
Start	- Lesson Goal	It is important that the learner is aware of what it is exactly they are trying to learn. It is aiding to have this goal clear during the entire learning experience. According to the model it helps make a lesson goal oriented instead of activity oriented, it allows every learner to participate successfully, it makes it measurable if the intended learning was achieved, it provides clarity
	- Activating prior knowledge	The model emphasises the value of activating the prior knowledge, this can be useful for both the learning of that knowledge (by repetition) and for the ensuing lesson. Since it could get the learner into the right learning space. Although according to the expert interview, this element is of lesser importance for vocabulary acquisition since prior knowledge is not as relevant. For a sequence of lessons, it might be because thereby it includes repetition. For a first lesson, and thus our prototype, this is irrelevant.
Core	- Learning Activity	The model expands on this core quite significantly. This core entails the actual learning, since the actual learning is already set by the final concept of the game we will not modify the game with this model in mind. In addition it is safe to say that the game already satisfies the criteria of the model. In the expert interview one relevant take away was mentioned, is that the goal should be clear(ly visible) during the learning activity as well. Useful to note: Lesson conclusion: For the lesson conclusion the children will make assignments or answer questions to show they correctly master the lesson goal. Only after this succeeds are they to move on to the independent processing part.
Independent Processing	- Extended instruction	The model states that a lesson should add an extended instruction if it appears that the learner has not yet achieved the learning/lesson goal
	- Independent processing in class	In this phase, the learners will do assignments that suit the lesson goal. The goal here is to help remember, not to learn

Independent Processing	- Task work	More work based on the lesson goal
	- Periodic retrospect	In this part a retrospective look will be taken at what has been learned in the lesson. This helps with better retention and understanding of the information
	- Test	Testing of the learned knowledge

5.4.2 Graphic Design Elements

In accordance with the clients requirements a few graphic design specifications have to be set. One of the client's wishes or requirements was a simple design, or so to say, not too busy on the screen. There are multiple aspects where this has to be taken into consideration graphically speaking. Two relevant ones are colour scheme and font choice.

For the colour scheme, the reason behind no bright or busy elements is the potential psychological effects. These can be evaded by looking at colour psychology. Lighter and less saturated colours are often associated with calmness [96]. But brighter and more saturated colours, besides being considered overwhelming, can also be used to improve engagement and cause stronger emotions (positively and negatively) [96]. The colour scheme for the briefing and debriefing sections will mainly consist of a few darker colours, or pastel colours, since they elicit more calmness [96]. Pastel colours can be defined as colours with a bit of white added to it. Examples of these colours can be seen in Figure 13. This is not the exact palette for the whole game, since there are many different objects which will require different textures, but they will try to follow a pastel palette. In addition to this, every device and screen renders these colours in a different manner. Figure 14 shows the eventually chosen colours for textures in game.

Figure 13: Example of pastel colours

Figure 14: Actual colours used for textures

For fonts the game and (de)briefing sections have to be easily readable and not too distracting. When deciding on font size, a font size of at least 16px will be applied [97]. The font that will be used is called BEBAS NEUE:

THIS IS A SAMPLE TEXT OF THIS FONT

This is a simple and easily readable font considering its letter spacing and neutral format [98]. Letter spacing meaning the space between letters and neutral format meaning the style of the font. Furthermore header differentiability and paragraphs will be used to make text more readable.

5.4.3 Environment Design

For the specification the environment also needs to be specified, this section includes what vocabulary will be taught in the game. The game visualises an environment with objects in the scene that represent the words to be taught. This list of words is provided by the client as it is part of their lesson plan. The game will be developed for one specific lesson of vocabulary.

Therefore the chosen list of words/chosen lesson is one that is easy to visualise for the development process. This list contains words of objects that are part of a home interior. For the evaluation the target group will largely consist of Dutch participants, based on the languages the client offers, Italian is generally the most unknown of them, since languages such as German, French and English are offered in high school education. Thus the language chosen for the specification is Italian.

Table 8: List of words related to home interior

Dutch	**Italian**	**English**
de tafel	la tavola	The table
de stoel	la sedia	The chair
de kast	l'armadio	The closet
de bank	il divano	The couch
de lamp	la lampada	The lamp
het schilderij	il dipinto	The painting
de kapstok	l'attaccapanni	The coat rack
het bed	il letto	The bed
het gordijn	la tenda	The curtain
de plant	la pianta	The plant
de spiegel	lo specchio	The mirror
de kruk	lo sgabello	The stool

5.4.4 Content Organization

A flow of the prototype will be visualised, this will provide an overview of what the prototype specifically contains and in what order. This flow is constructed and visualised in Figure 15. This flow was established at the hand of the literature, meetings with the client and the design guidelines.

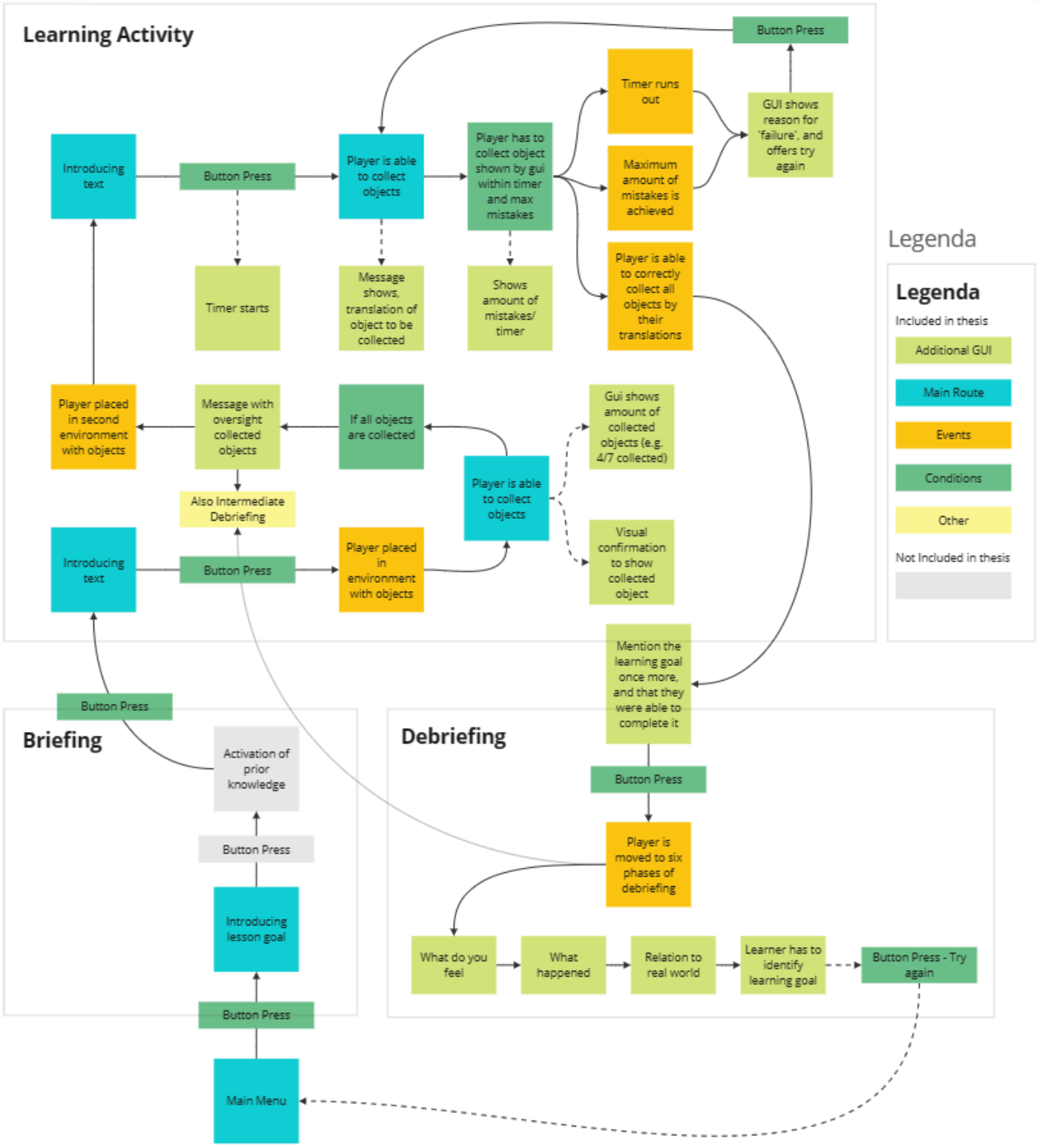


Figure 15: Flow of prototype, including, events conditions and GUI

The player will start off at a starting screen, and is moved into the briefing section, this section entails clarifying the learning goal, and possibly activating prior knowledge. After this the user can proceed to the game, where they will be greeted by an introduction screen clarifying the goal of the game and how it works. Then, as can be seen in the Figure 15, depending on certain conditions, certain events will happen. The game consists of two states, where state 1 is the collection and familiarising with the objects, words and translations. And the second stage being recognition of the just learned words. Where the player is asked to collect *árbol*, and has to find a tree. Each section of the prototype is separated by a light grey border, indicating the briefing, learning activity and debriefing.

Separately from the main track, light green cards can also be found that inform the user of information through the GUI, depending on events, or actions in the game. And the player is always able to redo the game.

5.5 Requirements

With help of the stakeholder analysis and the personas and scenario the preliminary requirements can be narrowed down and made more measurable. This chapter will consist of a more concrete list of requirements, once more prioritised using the adapted MoSCoW method described in Section 3.1.3. These requirements now also entail specified requirements into the briefing and debriefing. In addition a separation of functional and non-functional will be applied. Functional indicating specifics of what the prototype should do to achieve its goal, and non-functional indicating how it should do it.

Table 9: Functional requirements, requirements that are necessary to achieve the goal

No.	**Requirement**	**Must**	**Should**
1	Duration: be 5 to 15 minutes		x
2	Include users (teachers and children) in the design and implementation process		x
3	Is playable from a website	x	
4	Utilise accessible font		x
5	Made with a free platform		x
6	Simplistic visual style		x
7	Is Achievable to be built in short development time	x	
8	Smart colour use from colour psychology		x
9	Playable from wide range of devices	x	

10	Transferable to test in a non-digital fashion		x
11	Should be easily convertible to other languages		x
12	The briefing clearly shows the learning goal	x	
13	The briefing activates the prior knowledge		x
14	The debriefing includes the six phases of debriefing	x	

Table 10: Non-functional requirements, requirements useful for the prototype but not a must for the goal

No.	**Requirement**	**Must**	**Should**
1	Should optimally use intrinsic and extrinsic motivation (rewards and feedback)		x
2	Should have an immersive storyline		x
3	Should have increasing levels of difficulty		x
4	Should make sure the user has autonomy		x
5	Should take attention span of target group into account		x
6	Should take individualization into account		x
7	Learns the user vocabulary of a strange language		x
8	Fitting for gifted children		x
9	Should make sure no faulty and superficial understandings are created		x
10	The prototype with digital briefing and debriefing should improve knowledge retention		x
11	The prototype with digital briefing and debriefing should improve enjoyment and engagement		x

6. Realisation

The realisation describes how a prototype was realised, it consists of three parts. Firstly an oversight is given of the used tools, and the workflow that followed from those tools. The second part shows the used assets and how they were created, and the third part concludes with showing the interactions and interface of the prototype. In addition to these three parts, a functional requirement evaluation is performed.

6.1 Tools and Workflow

To actually make the project a few tools were used. These tools can be separated into game development tools and asset tools, where game development tools entail the tools made for the game itself and asset tools the tools used for making assets. It will also be mentioned how these tools are used in workflow and what potential drawbacks where.

6.1.1 Game Development Tools

As explained in the ideation concept in Section 4.5, originally the prototype had a differing style, this was due to the use of a specific engine in which the developer was not fluent. In Table 11 is an oversight of the options for the development of such a prototype, and the requirements they had to suffice to, this will also explain the initial choice and consequent switch.

Table 11: Oversight of tools and adherence to main requirements/specifications

Tools	**Able to run on website**	**Free platform**	**Game engine or mainly code**
Unity [104]	Half - often has issues	Pay-per-download / vague as of lately	Game engine
Unreal Engine [105]	Half - not latest version	Half - after 1 million dollar royalties kick in	Game engine
Defold [95]	Yes	Yes	Game engine
Godot [106]	Half - not latest version	Yes	Game engine
Phaser [107]	Yes	Yes	Game engine
P5.js [108]	Yes	Yes	Code
Three.js and webGL [109]	Yes	Yes	Code
HTML/CSS/JS	Yes	Yes	Code

Initially Defold was the chosen engine for the development, this choice originated from the fact that, however Unity was the engine where the developer had most experience in, it did not satisfy a few important requirements, such as being a free platform and website based. The drawback of using Defold is that it utilises an original concept within these tools, with the use of lua as its scripting language. In addition to this scripting language stylistic choices are limited to top down or side view 2D games.

This eventually prompted the switch to another tool, here the choice was made for P5.js, this choice was made to not issue the developer with another learning curve, since there was already present experience, and learning just code is an easier code than orientating in a new engine. This also opened up more freedom in regard to stylistic choices. P5.js also had its drawbacks however. One thing is that P5.js is not optimised to be used as a game engine, as opposed to other game engines, large amounts of triangles or polygons from 3D models provide lag when updating the screen. In addition to this, the library is still a work in progress in the WEBGL front, meaning that certain functions are not able to be used or modified at all when they would be useful.

P5.js is a library for javascript that can be ran on a website, it allows for code to draw things on a canvas, the library includes a few basic objects such as rectangles and other primitives, and if the user enables the webGL option, simple 3D primitives are also an option. All the other elements have to be done through scripting. P5.js has an active and elaborate community, and it being based on javascript makes it easy to troubleshoot code issues as well.

To be more specific, P5.js is not actually the tool used for game development but Visual Studio Code [99] is. But since Visual Studio Code can be seen as a general text editor, P5.js was named the tool for Table 11 to keep it understandable. Visual Studio Code [99] was used in combination with a few extensions to make the workflow easier. The first extension being Live Preview [102], when developing for the web, this tool gives a live preview of the website you are currently making, this saves the hassle of opening a local webpage in the browser and manually refreshing the page to see updates. The second extension being P5.vscode [103], this extension allows for autocompletion and the easy creation of a P5 project.

6.1.2 Asset Tools

Since these tools were also impacted by the switch, but are of lesser relevance a quick oversight is given. With the use of Defold [95], a 2D tilemap tool was needed, one to make tiles and entire maps. For this Tiled [100] was the chosen tool.

The switch to P5.js [108], issued the choice to switch to 3D, this meant that the assets also had to be 3D. For this Blender [101] was chosen as a tool. Blender also offers an oversight of the amount of vertices and quads in a modelled object, this allows it to create

assets that are light for P5.js to run. The objects are then exported as an UV-unwrapped obj file. The materials and textures are baked into one image. This allows for P5.js to correctly render the material.

The textures for the objects are also made in blender, either by applying simple materials or using the texture paint tool, for more detailed visuals. Textures of the models do not exceed a 1024x1024 pixel size.

6.2 Assets and Media

A couple of assets were required to design the needed environment and objects for the prototype. This can be divided into two types of assets, where one are textures and the other are 3D objects.

6.2.1 3D objects

The words are home interior objects. In Figure 16 an oversight of the modelled objects and an image is provided.

All objects are under 8000 triangles, with the lowest being 362 triangles for the lamp. To allow for further expansion and keeping in mind the unoptimized nature of p5.js the poly count was kept as low as possible, without making major aesthetic sacrifices. As a side effect of this, this means the objects are simple in nature, this also nicely ties into the style preference of the client.

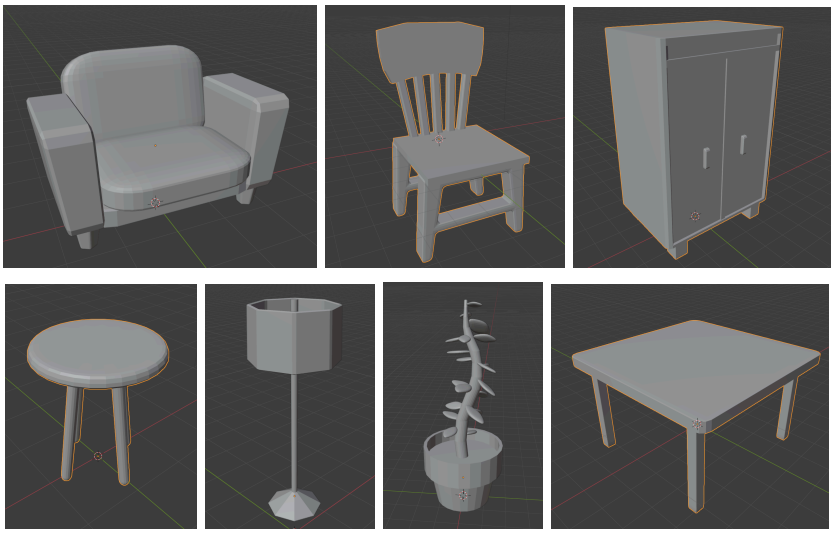


Figure 16: Models made for the prototype, couch, chair, closet, stool, lamp, plant, table

6.2.2 Textures

The textures were made at the hand of the established colour palette in Section 5.4. These textures were then baked into the UV map of the object and exported as an image texture. Figure 17a till Figure 17c show examples of these baked image textures.

Figure 17a,b,c: From left to right. a: baked image texture of couch, b: baked image texture of chair, c: baked image texture of the lamp

6.3 User interface

The user interface describes the actual visual interface of the prototype. Consisting of the three main parts: briefing, learning activity, debriefing. When realising the game, the conclusion was drawn that perhaps the briefing and debriefing should be included more into the game than just a separate screen. To allow for this a few interactions were changed. When pressing the start button the user would first see the game environment and a loading logo on top of it, thus placing the user in the game environment already. After a few seconds of loading, the game would prompt a briefing screen with an avatar presenting the text. After completing the game, an avatar would also as a layover present the debriefing questions. This was done to create a more clear inclusion of the briefing and debriefing into the game.

The first screen the user lands is the landing page of the game, on a website emulating the design of the client's website (see Figure 18).

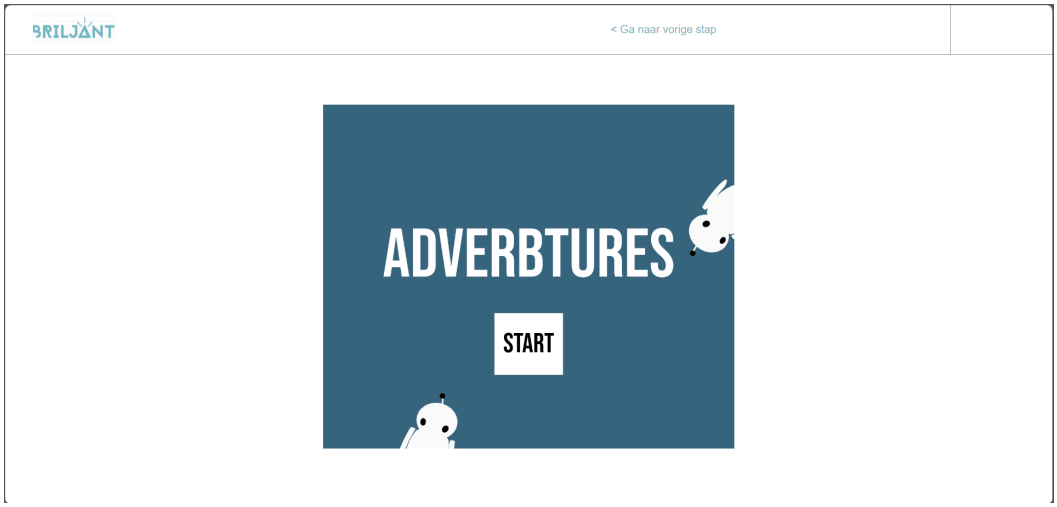


Figure 18: Screenshot of the landing page

To provide a bit higher quality and clearer screenshots the images from now on will be zoomed in on just the video game, and not the website surrounding as in Figure 19.

Figure 19: Zoomed in screenshot of game on website

6.3.1 Briefing

After clicking the start button the game will load for a few seconds to give the users time to become aware of the game environment (see Figure 20), and a briefing overlay will pop up. Here the user is made aware of the learning goal, and presented with how it will be taught (Figure 21). They are shown a simple and clear overlay over the game environment.

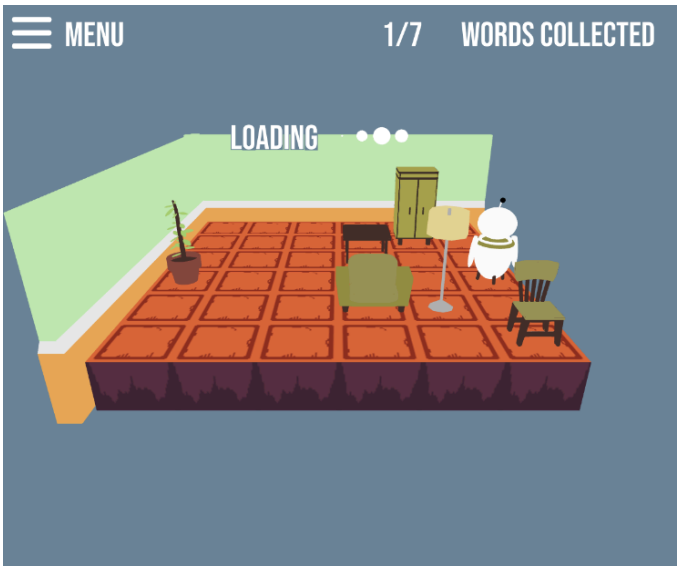


Figure 20: Loading logo that is shown for 3 seconds

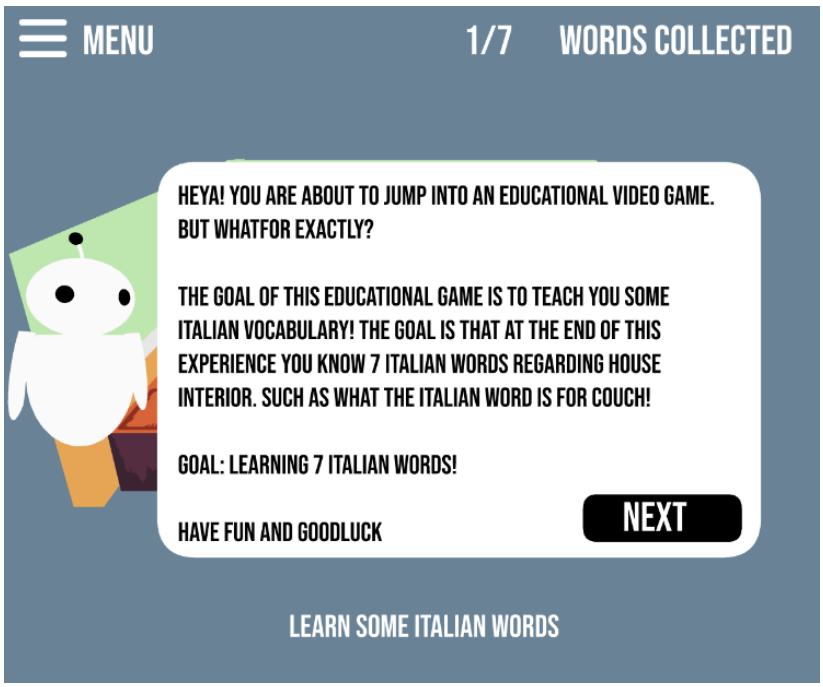


Figure 21: Screenshot of Briefing overlay in prototype

6.3.2 Learning Activity

After clearing the briefing page, an introduction popup is presented to the user. It explains to the user what kind of game they can expect and what the controls are. Figure 22: shows a screenshot of this introduction screen.

Figure 22: Screenshot of Introduction section

The user is then presented with the game environment, where they are free to move around in and collect objects. Figure 23 shows a screenshot of the game environment.

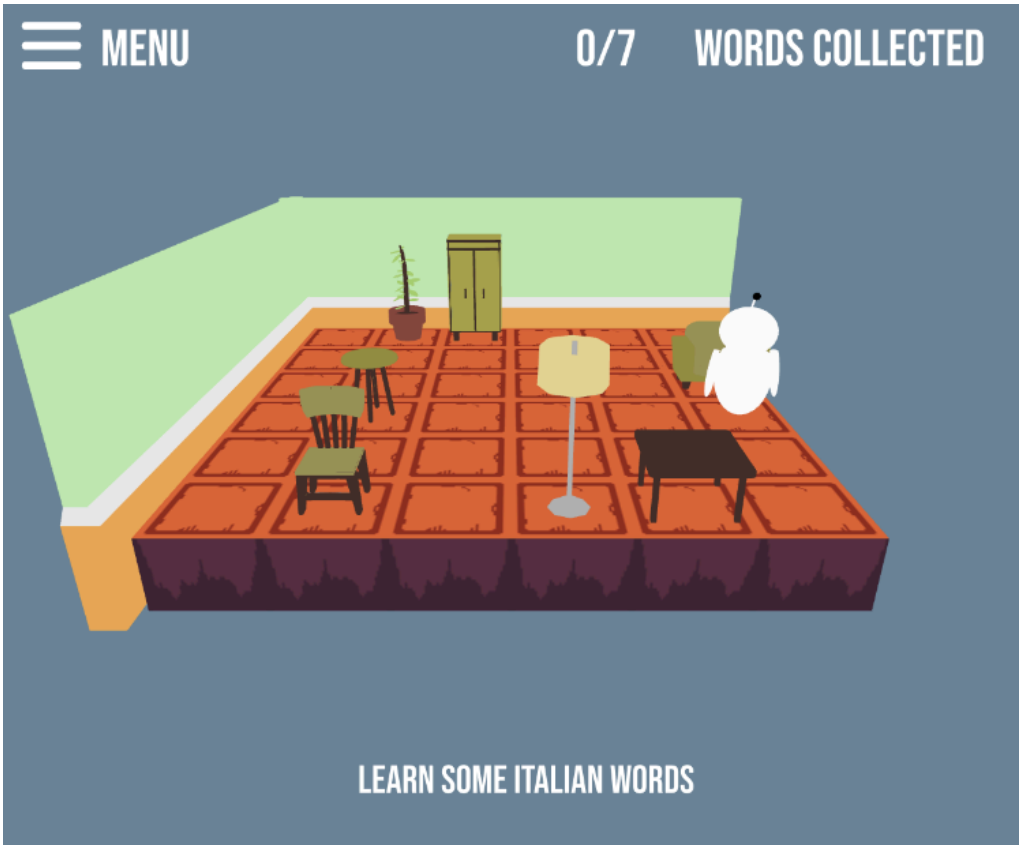


Figure 23: Screenshot of game environment

After collecting all the objects the user is prompted with an oversight of the collected and learned words. And a statement regarding the repetition of the just learned words, testing the memory of the user. (See Figure 24a) And thereafter a short explanation of what they are to do now (See Figure 24b)

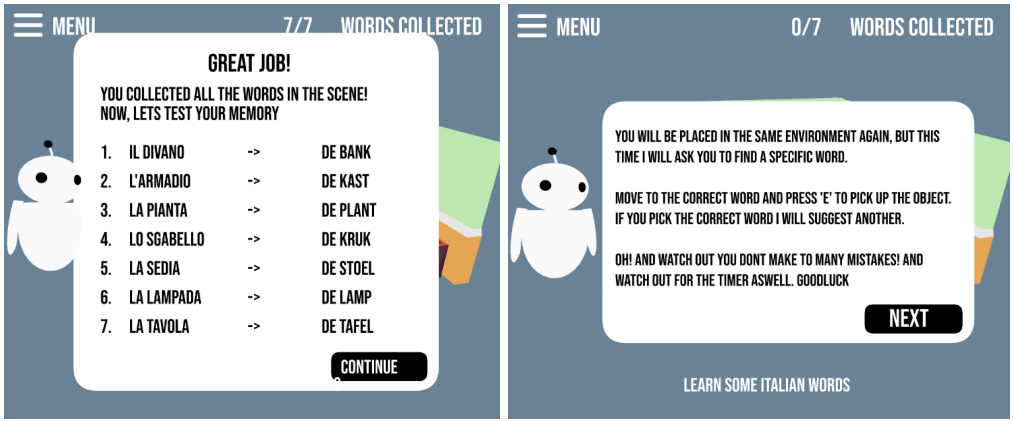


Figure 24a,b: Screenshot when all the objects are collected

The user then moves on to the same game environment, but has to find an object by its translation shown at the bottom of the screen (see Figure 25a,c). This part of the game involves a timer (Figure 25d), and a counter of mistakes (Figure 25b). These signify two losing conditions.

Figure 25a,b,c,d: Left: a, top to bottom: b,c,d. a: Screenshot of game environment where user has to find prompted object. b,c,d: GUI elements

The game environment has a couple of GUI elements to help inform the user of progress and give an overview of the learned words and collected objects. The GUI differs through the first section of the learning activity and the second section. The elements that can be found in the GUI are shown in Figure 26 until Figure 30. The description of the figure also states whether it is included in the first or second section of the learning activity.

Figure 26a,b: Section 1 and 2: a: The menu closed, b: the menu opened showing the currently collected words and their translation

Figure 27: Section 1 and 2: GUI component showing amount of collected words

Figure 28: Section 1: Popup GUI showing the currently collected object/word.

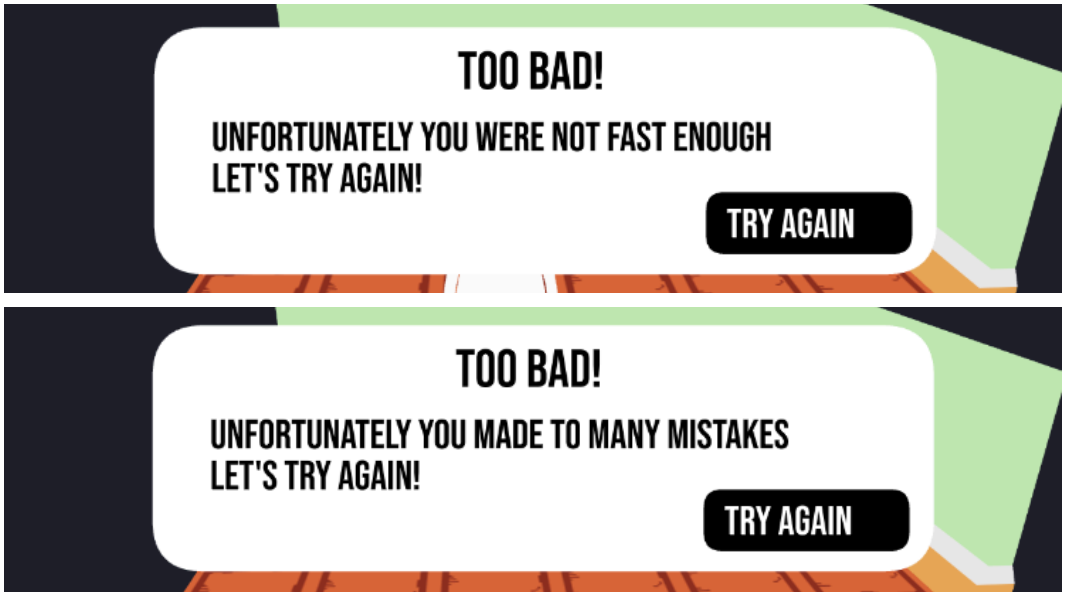


Figure 29a,b: Top: a, Bottom: b, a: Losing condition when losing if the timer is up. b: Losing condition if the user made too many mistakes

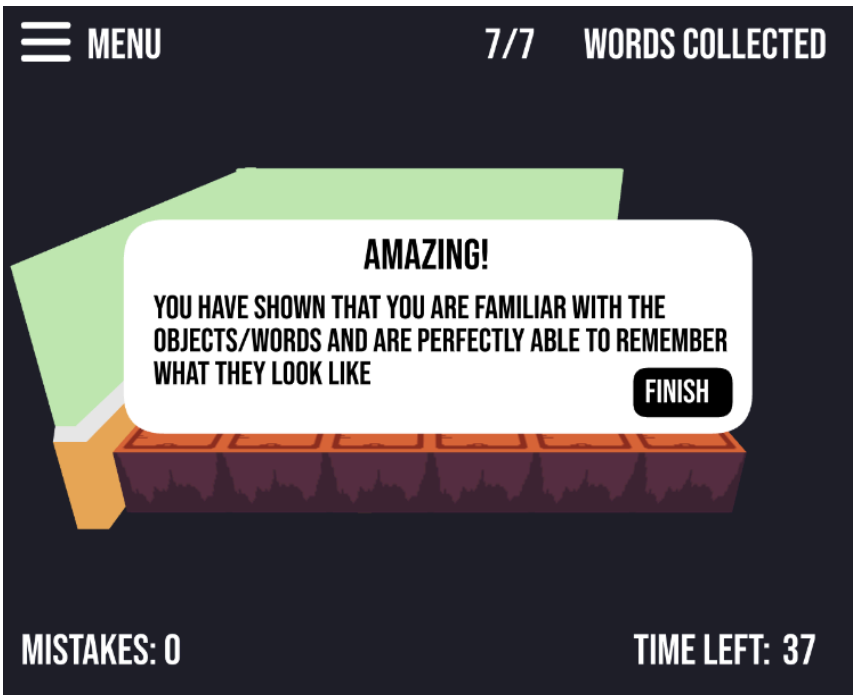


Figure 30: When all the objects are correctly collected winning screen

6.3.3 Debriefing

After the user clears the win condition of the game an overlay is shown where the character presents the debriefing questions to the user. Which looks the following (Figure 31):

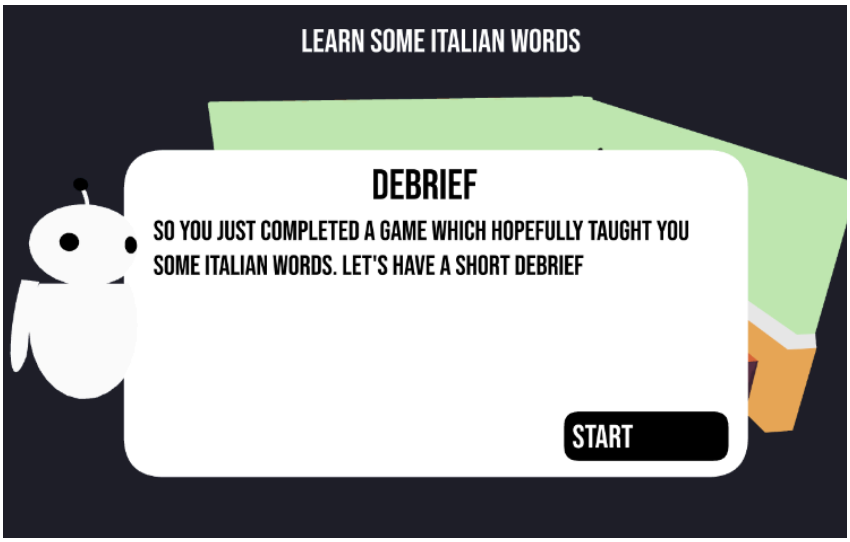


Figure 31: First overlay page of debrief, showing short introduction to debrief

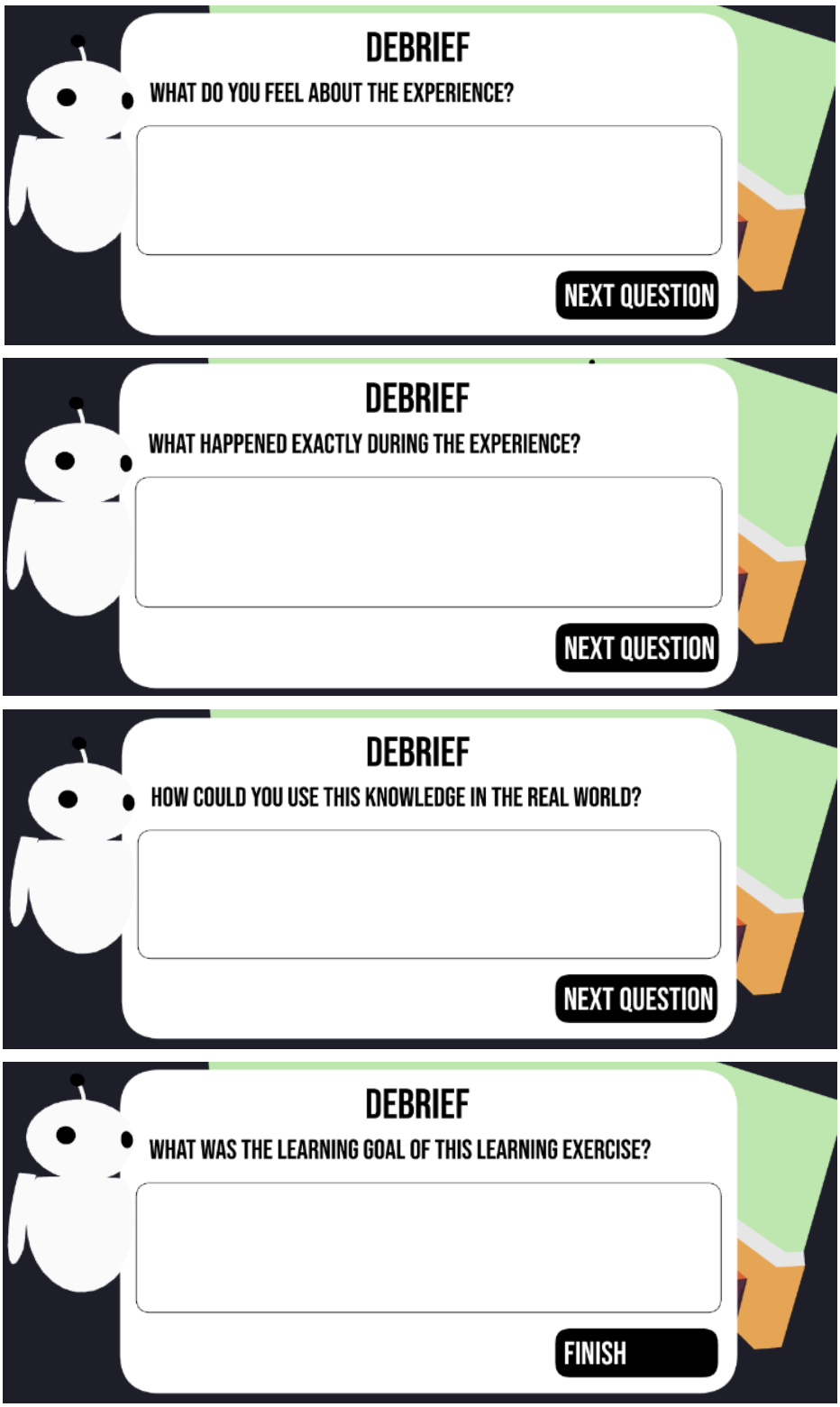


Figure 32a,b,c,d: Top to bottom, a: Question one of the debrief, b:Question two of the debrief, c: Question three of the debrief, d: Question one of the debrief

And lastly the user has the option to try again (Figure 33).

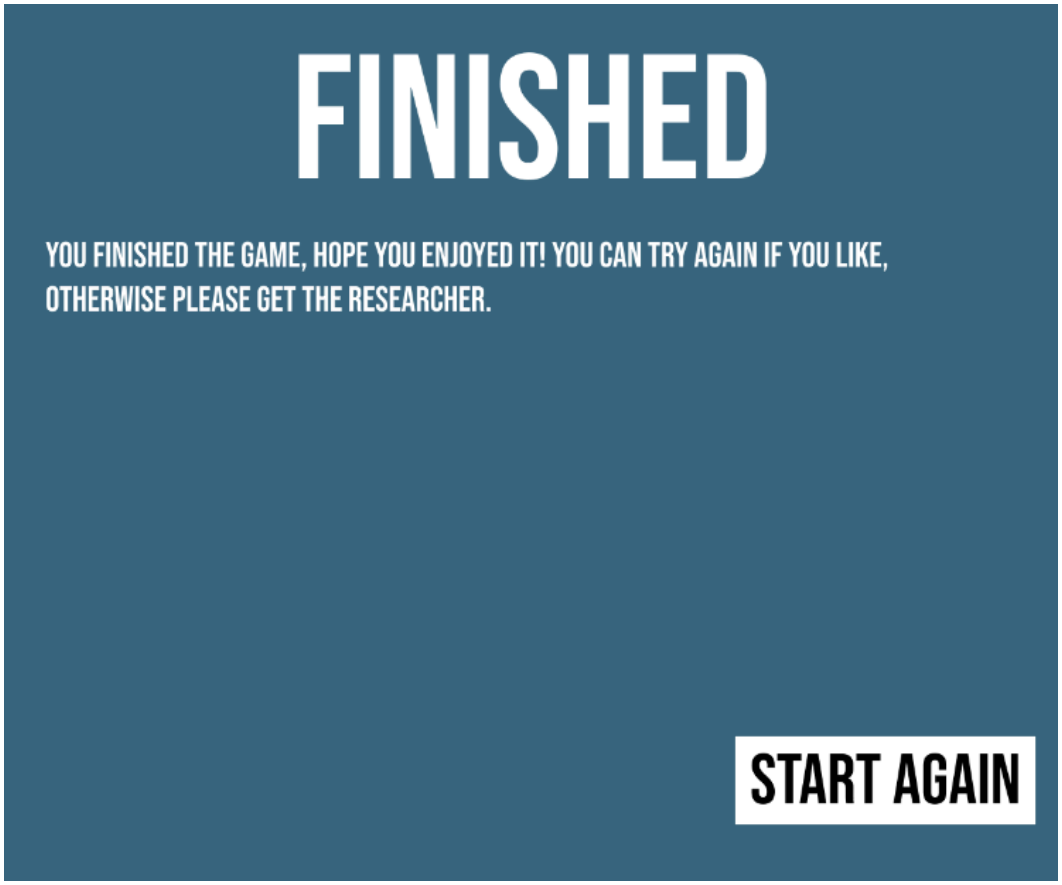


Figure 33: Final Screen of game allowing for retries

6.4 Functional Requirement Evaluation

After the prototype was completed, the functional requirements set in Section 5.5 were evaluated by the researcher. Table 12 shows which requirements are completed, and to what extent, and under what prioritisation they belong under the MoSCoW method.

Table 12: Evaluation of functional requirements.

No.	Requirement	MoSCoW	Passed
1	Duration: be 5 to 15 minutes	Should	Yes
2	Include users (teachers and children) in the design and implementation process	Should	Yes-half
3	Is playable from a website	Must	Yes

4	Utilise accessible font	Should	Yes
5	Made with a free platform	Should	Yes
6	Simplistic visual style	Should	Yes
7	Is Achievable to be built in short development time	Must	Yes
8	Smart colour use from colour psychology	Should	Yes
9	Playable from wide range of devices	Must	Yes
10	Transferable to test in a non-digital fashion	Should	No
11	Should be easily convertible to other languages	Should	Yes
12	The briefing clearly shows the learning goal	Must	Yes
13	The briefing activates the prior knowledge	Should	No
14	The debriefing includes the six phases of debriefing	Must	Yes

The table shows all of the requirements set as a *Must* under the MoSCoW prioritisation have been fully implemented in the prototype. The requirements with a *Should* prioritisation have nearly all been implemented, with the exception of requirement 10 and 13. As shown in the design specifications, for the scope of the thesis requirement 13 was excluded, and requirement 10 in combination with time pressure was deemed not as important to include for the evaluation of the prototype, since it was a client's requirement for inclusion of a finished product.

As a concluding statement, regarding all the requirements set as *Must* have been implemented, and a large part of the *Should* as well, indicating that the system is functioning on its basic systems, and it can be said the realisation was successful.

7. Evaluation

The evaluation chapter discusses the methods of the evaluation phase, and its results. It consists of a user evaluation and a non-functional requirements test. The evaluation provide insight into the operation of the prototype and might provide an answer to the research question:

"Could the addition of a digital brief and debrief positively impact educational video games?"

7.1 User Evaluation

The user evaluations are relevant for answering the research question. Since they will allow for evaluation of the effectiveness of the prototype against other cases and measure the engagement and enjoyment of the participants.

7.1.1 Setup

The setup of the evaluation entails all the steps that were made in preparation of the actual evaluation. Such as the recruitment process, the elaboration of the procedure, interview and test.

7.1.1.1 Recruitment Process

The recruitment process of participants took place with the use of personal contacts and snowballing. They were approached via whatsapp or in person, where the goal of the evaluation was briefly mentioned. If the participant showed interest, the information letter was shared with them. The information letter can be found in Appendix B. In this information letter, the purpose, procedure, benefits of participation, procedures for withdrawal and other general information is provided. If the participant understands all this information and wants to continue they are to sign an informed consent form.

The research population is everyone that is allowed to give informed consent, meaning people of 16 years of age and older. There is no discrimination(exclusion) on any characteristic for participation.

For answering the first part of the research question regarding the impact on effectiveness this evaluation should be mostly a quantitative evaluation, but for answering the second part of the research question regarding enjoyment and engagement the qualitative data is also important. Therefore the list of participants was kept manageable and was aimed for 20 participants.

7.1.1.2 Location

The location of the evaluation was a neutral location, since the location will most likely minimally impact the results when quantitative enough, a location preference could be expressed by the participant, but otherwise the location was suggested where the researcher and participant most commonly meet. This could either be at home or at the university.

Allowing participants to be evaluated from their own preferred location brings certain advantages a set location might not. It lowers the entry level for participation which makes the gathering of participants and thus data more accessible. It is also less time consuming and effort for the participant regarding travel time. In addition the participant will be in a familiar setting, with usual environmental stimuli, which will make them more comfortable in a familiar location.

7.1.1.3 Procedure

The procedure of the evaluation went as follows:
Two groups were devised from the participants. To keep the groups balanced, the participants were assigned to either group in an alternating pattern. The evaluation happened one person at a time. Both groups of participants will have read the information letter beforehand, and after getting a debrief of the experiment. They are free to retreat from the research during any point and ask questions about the research. The content they learn from the game will be vocabulary words in Italian.

Group 1: They will read a paper briefing about the content they are about to learn through a video game (approximately 5 minutes) They will play an educational video game (approximately 5-10 minutes) They will read a paper debrief about what they just learned, and might need to answer a few debriefing questions on the paper (approximately 10 minutes) They will perform a paper test where they are asked to translate words, based on the knowledge learned in the game (approximately 5 minutes). They will answer a few questions in a semi structured interview about enjoyment and engagement (approximately 5 minutes).

Group 2: They will play an educational video game with the briefing and debriefing included in the game environment (approximately 10-15 minutes). They will perform a paper test where they are also asked to translate words, similar to group 1 (5 minutes) They will answer a few questions in a semi structured interview about enjoyment and engagement (approximately 5 minutes)

The user evaluation was then concluded by giving the participants a debrief of the evaluation, not to be confused with the debrief of the learning activity. If interested, the researcher will concretely explain the difference between the two groups the participants were part of. They will also be provided with a textual debrief including this information,

as can be found in Appendix D. The researcher will conclude the evaluation by thanking the participant for being part of the evaluation.

In bullet points, this is the itinerary of the evaluation:

1. Read information letter
2. Read and sign consent form
3. Read briefing (group 1: digital | group 2: paper)
4. Do learning activity (game)
5. Read and answer debrief (group 1: digital | group 2: paper)
6. Make test
7. Answer interview questions
8. Debrief of evaluation

7.1.1.4 Collected Data

The collected data will be the test results, the answers to the questions about enjoyment and engagement and possibly notes by the researcher about perceived enjoyment and engagement, an additional measure is the time spent in the learning environment, since the evaluation will put no hard cap on the allowed amount of time spent in there, it can be a useful variable to correct for when looking at the knowledge retention during the test, if someone spent way longer learning their knowledge retention might be better, regardless of the briefing and debriefing. The reason why both questions and observations are used is that observations can provide valuable additional insight (body language) that might not become apparent during the answering of questions. The interview questions can be found in Section 7.1.1.5 since it is relevant to understand them for interpretation of the results. The test the participants took place in can be found in Appendix E.

7.1.1.5 Interview Questions

The interview questions were devised with the intention to provide the researcher with insight into the more subjective side of a participant's experience. The specific interview sheet can be found in Appendix F.

Since it is a semi structured interview the interview will start off with a main question regarding the experience of the prototype, this will allow for continued questions and conversations, giving more context to the coming questions. The specific question is:

- “Can you share your overall thoughts and feelings about your experience with the prototype?”

Secondly since it is interesting to evaluate whether the prototype was more enjoyable to users in group 2 than group 1 (the difference between game based briefing and debriefing over paper based), the following questions were asked:

- "Were there any specific features or elements of the prototype that you particularly enjoyed?"
    - If so which and why

Thirdly, it is of value to know if the prototype invokes a type of engagement for the user, therefore the following questions were asked. The first question is also there to aid in establishing the value of the digital (de)briefing. Engagement might be better measured with the use of observation, but a question that could aid in this, would be about their feelings during sections.

- "Were there specific features of the prototype that particularly engaged you?"
    - If so which and why

To get more specific data besides textual data, the following questions are asked with a likert scale gradation afterward on enjoyment.

For the briefing:
- “What is your opinion on the briefing?”
- Please grade the briefing according to the following scale: (in between is allowed)
  Liked it a lot - liked it - neutral - disliked it - disliked it a lot

For the learning activity
- “What is your opinion on the learning activity?”
- Please grade the learning activity according to the following scale: (in between is allowed)
  Liked it a lot - liked it - neutral - disliked it - disliked it a lot

For the debriefing:
- “What is your opinion on the debriefing?”
- Please grade the debriefing according to the following scale: (in between is allowed)
  Liked it a lot - liked it - neutral - disliked it - disliked it a lot

Lastly a general reflection of the usability of the system is of value:

- “Do you have any major issues with the system or remarks?”

7.1.2 Pilot

To ensure that the evaluations proceed as smoothly as possible a pilot test was conducted to weed out any major issues and problems that could occur during the evaluation. The pilot was the procedure conducted as a normal evaluation and all problems and issues were written down, and the participant was asked for more extensive feedback on the prototype. The main attributes that were changed after this pilot test are listed in Table 13.

Table 13: Pilot test changes implemented

What was changed	Elaboration
- Rework information letter	After the pilot test, two minor spelling errors and the general timings suggested in the information letter were altered. Initially the estimate was that the whole evaluation would take around 45-50 minutes, this could be lowered to 15-20 after the initial test.
- Improve control explanation	In the game, the explanation of the controls was elaborated on, and the functionality of using the arrow keys beside the WASD keys was added.
- Improved digital debrief	When making the debrief digitally the typing function had a few bugs, such as the backspace key not functioning, this was fixed after the pilot test

7.1.3 Results

The results of the user evaluation are two-part. Firstly the results of the test on effectiveness of the prototype regarding knowledge retention. Secondly the results of the semi structured interview and the notes taken by the researcher regarding enjoyment and engagement.

The transcribed and translated and collected data can be found in Appendix J. This data is still the raw data that is collected, merely presented in a clearer manner and translated into english.

Eventually 16 people partook in the evaluation. Of these 16, 8 were assigned to the digital variant and 8 were assigned to the paper variant. Out of these 16 no major outliers were found, and all data points were included.

7.1.2.1 Knowledge Retention

As explained in 7.1.1 *Setup*, the knowledge retention was measured at the hand of a test. In this test (found in Appendix E) the participants were asked to translate five words from

Italian to English and two words from English to Italian. The amount of correct answers the participants were able to give, is how the retention was measured.

On average the participants over both groups got 4.81 answers correct out of the 7. When looking at the groups separately, we can see that the group presented with the digital variant got 5.12 answers correct, and that the group with the paper variant got 4.62 answers correct. So on average, the group who got the digital variant did perform better.

7.1.2.2 Enjoyment and Engagement

To establish the enjoyment and engagement of the participants for the briefing,debriefing and the learning experience, a semi-structured interview was conducted with three likert-scale questions in it. To interpret the data it was converted to a numerical scale from 1-5, where 3 means neutral, lower than 3 is negative, and above 3 is positive. In addition to this numerical data there is of course also information to be taken from the textual answers of the participants. Therefore this section will be divided into two subsections called Numerical Data and Textual Data.

Numerical Data

When looking at the group who got the digital variant the average grade of the briefing came to 3.56 out of 5. For the group with the paper variant the grade averaged 3 out of 5. On average the digital group seemed to like the briefing more than the paper group.

For the debriefing the digital variant group gave it a 2.81 and the paper variant group a 2.62. Both groups seemed to have a slight dislike against the debriefing, albeit the paper group seemed to have a slightly bigger dislike.

When looking at the engagement and enjoyment numerical data for the learning activity however, we can observe something interesting. On average the digital group graded the learning activity with a 3.75, while the paper group gave a 4.37 on average. So the paper group graded the learning activity higher on average than the digital group.

Textual Data

To keep this section clear the data here will be presented at the hand of frequent keywords and synonyms used by the participants.

Words that were frequently used over both groups were for example “fun”, “clear”,“satisfying”, “fine” and “vague”. In Table 14 you can find an oversight of words or related synonyms that were used more than two times in either group and a count of how often.

Table 14: Oversight of common words and their count for either group for the Briefing, learning activity and debriefing combined. Words are graded from positive to neutral and negative by order of green, yellow, orange and red.

Word	**Digital count**	**Non-Digital count**
Fun	4	3
Nice	4	3
Useful	1	1
Clear	3	2
Fine	1	3
Useless	3	3
Vague	3	4
Annoying	2	1

It is however relevant that this table does not get taken out of its context, this table is merely here to provide substantial data points for the textual data. As such it is useful to note that many of the negative words were related to the debrief for both groups, and many of the more positively affiliated words were in regard to the learning activity. And the neutral terms, linked to the briefing.

At the hand of this data one could perhaps show that generally the engagement and enjoyment would be higher for one of the groups. But as can be seen from Table 14 the data is relatively balanced and does not provide any significant additional insight. There is a slight difference in that the digital group has a few more positive responses and the paper group is more neutral.

In addition to this, much of the interview feedback that was given was about the learning activity itself, such as small improvements they recommended, or things they enjoyed. This data is not relevant for establishing a conclusion for the research question, but a few perhaps useful takeaways for educational video games can be taken from it.

- Clarity
  Many participants had an opinion on the clarity, they were generally opposed with a few participants stating it was extremely clear, and that they liked how clear it was, and others stating many improvements they would do to improve clarity. One example of this was the explanation of the controls of the video game. For future accessibility, images beside text explaining the controls would be appreciated.

- Visuals
  Much positive feedback was given on the visuals, saying the simplicity was appealing and helpful in understanding the environment. Certain people gave feedback on how to improve the environment to make it more homely, (since the words they were learning were house interior objects). A few participants liked the low stimulating nature of the game with the pastel colours and clear font, while one participant expressed the preference for brighter colours.

- Concept
  The concept of the game itself received feedback as well. People generally stated they liked the concept behind the game and that it was a lower threshold for them to start learning and learn vocab. The nuance that a few participants gave was however the question of how this concept could be expanded beyond words that represent objects. The difficulty with colours or adjectives.

7.1.4 Statistical Analysis

To establish whether this data is actually statistically significant, a statistical analysis was performed. A statistical analysis was performed for the test results (i.e. the effectiveness), the grades linked to the briefing, learning activity and debriefing (i.e. the engagement and enjoyment).

The performed analysis is done with a student T-test. Because of the small sample size a T-test is more in place than a Z-test and since the analysis is about the comparison of two groups a student test is more in place rather than an ANOVA which requires three or more groups.

The following abbreviations are used in the analysis to communicate more compact and effectively:
M = mean
SD = standard deviation

To establish whether data is statistically significant a p-value has to be chosen. A p-value refers to the probability that results from a sample happened by chance. An example of this is, if a p-value is 0.01, it means there is a 1% chance the data happened by chance. The p-value that is used to determine statistical significance for this evaluation is p=0.01 and 0.05. Meaning there is still a 1-5% chance that the data occurred by chance. Generally the lower the p-value the better it indicates that the data did not occur by chance.

Test Results (effectiveness)

The 8 participants (M = 5.12, SD = 2.7) who received the digital variant of the brief and debrief, compared to the 8 participants who received the paper variant (M = 4.62, SD = 1.41), did not perform significantly better t= -0.7, p = 0.248 on the test, despite the average for the test results being higher in the digital version. So since 0.248 > 0.01 or 0.05 we can say it is not significant.

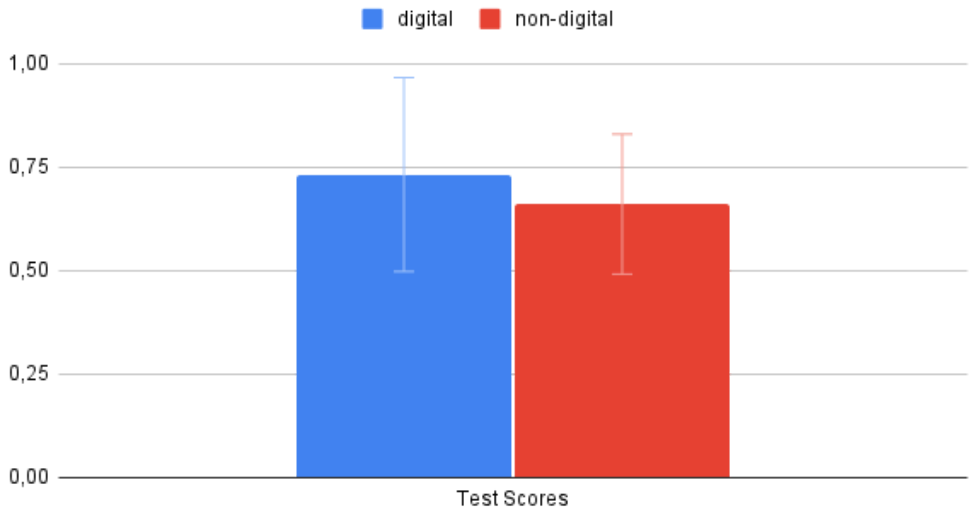


Figure 34: Average Test scores bar graph, with standard deviation

Briefing (engagement/enjoyment)

The 8 participants (M = 3.56, SD = 0.39) who received the digital variant of the brief and debrief, compared to the 8 participants who received the paper variant (M = 3, SD = 0.21), the digital group did significantly grade the briefing better t= -2.05, p = 0.029. Since 0.029 > 0.01 we can say it is not significant at p=1% but at p=5% 0.029<0.05 it can be said as significant.

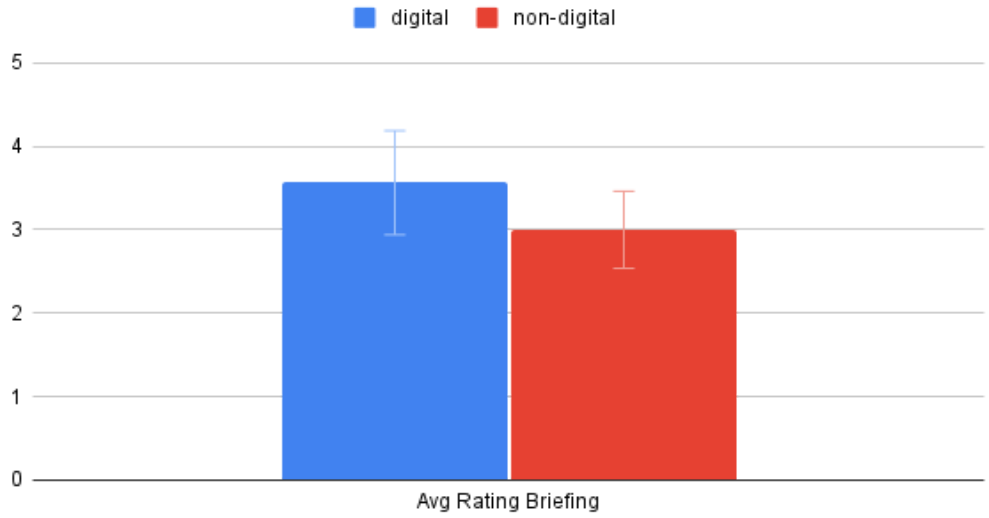


Figure 35: Average Rating on briefing bar graph, with standard deviation

Learning activity

Even though this analysis is not part of the results we originally wanted to evaluate, it is interesting to check whether the difference between the groups is statistically significant. Since the difference in averages is relatively big.

The 8 participants (M = 3.75, SD = 0.21) who received the digital variant of the brief and debrief, compared to the 8 participants who received the paper variant (M = 4.38, SD = 0.2), the digital group did significantly grade the learning activity different t= 2.76, p = 0.007. Since 0.007 < 0.01 and < 0.05 we can say it is significant. But the paper variant group graded the learning activity significantly better than the digital group. Both groups are positive about it, but the paper group was significantly more positive.

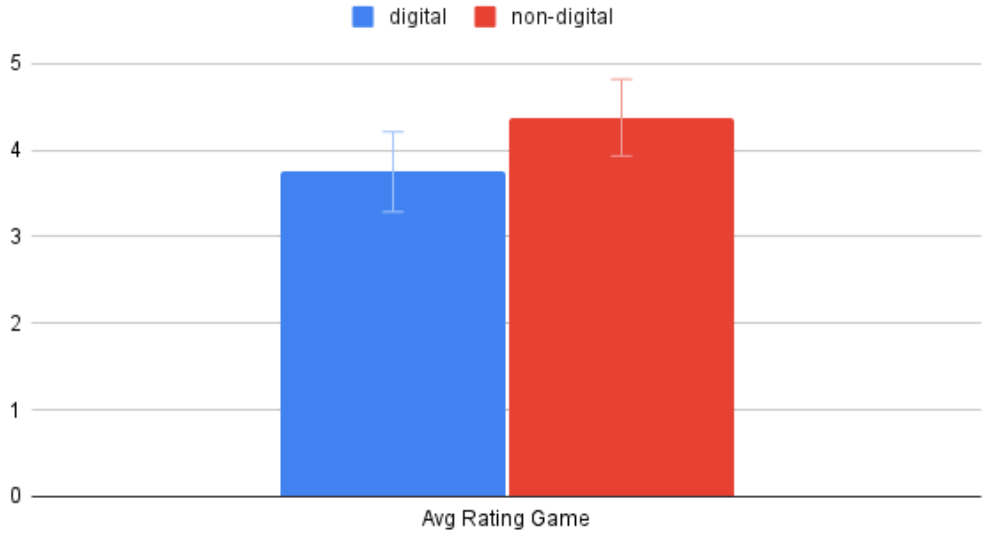


Figure 36: Average Rating of Game bar graph, with standard deviation

Debriefing (engagement/enjoyment)

The 8 participants (M = 2.81, SD = 0.14) who received the digital variant of the brief and debrief, compared to the 8 participants who received the paper variant (M = 2.62, SD = 0.55), the digital group did not significantly grade the debriefing better t= -0.64, p = 0.267. Since 0.267 > 0.01 and > 0.05 we can say it is not significant.

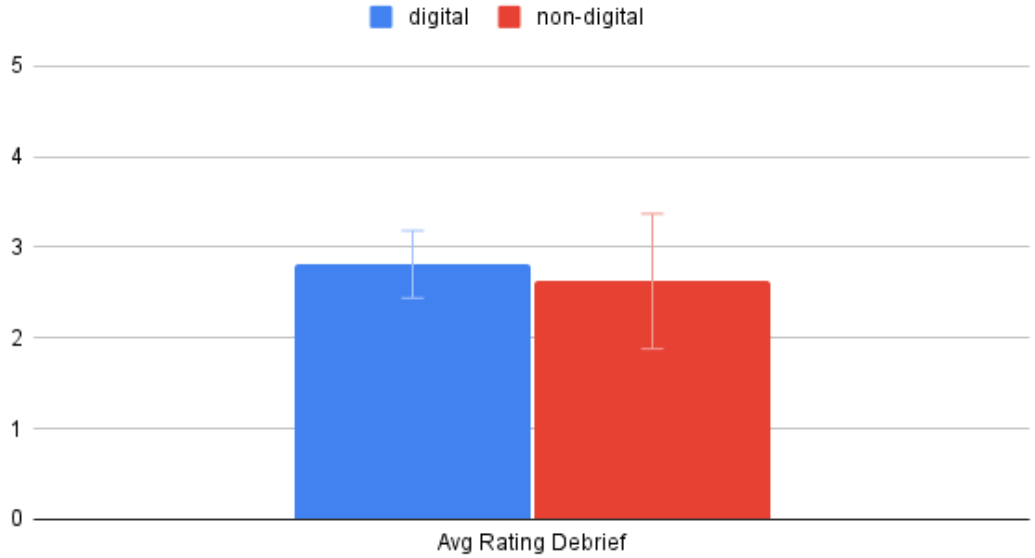


Figure 37: Average Rating on Debrief bar graph, with standard deviation

7.1.5 Data and Statistical Summary

To summarise, in Table 15 a more clear oversight is provided of the data.

Table 15: Oversight of processed data

Type	**Mean Digital**	**Mean Paper**	**Statistically significant p=0.01**	**Statistically significant p=0.05**
Test (out of 7)	5.12	4.62	No	No
Briefing (out of 5)	3.56	3	No	Yes
Debriefing (out of 5)	2.81	2.62	No	No
Learning Activity (out of 5)	3.75	4.38	Yes	Yes

None of the data is statistically significant except for the grading of the learning activity. This can have a multitude of reasons, but one example could be the contrast caused by the paper variant of brief and debrief as opposed to the digital brief and debrief.

Since the grading of the brief and debrief is not significant at p=0.01. They are both graded relatively neutral, with the briefing slightly more positive and the debriefing slightly more negatively. If the participants established the scale of neutrality at the hand of the brief or debrief, the learning activity has the possibility to be perceived as a larger contrast toward the brief and debrief, which might explain the significant difference in grading between the two groups. I.E. the contrast of the paper brief to the learning activity caused the learning activity to be perceived as more enjoyable, than the contrast a digital brief might have given. Their interpretation of the scale was influenced.

In general the averages of the data and the textual data presented in 7.1.2.2 slightly tend to the conclusion that the digital variant was indeed more enjoyable and engaging, but the statistical analysis leads to the conclusion that it is not statistically significant at p=0.01. But the briefing can be seen as statistically significant at p=0.05. To conclude the statistics with a statement, for the effectiveness, and engagement and enjoyment of the debrief, we can not reject that the paper variant might have been just as good as the digital version. But for the briefing we can reject that the paper version is just as good as the digital version. In addition to this we can also reject that the digital version is just as good as the paper version when looking at the enjoyment of the game itself.

7.2 Non-functional Requirement Evaluation

With the results from the interview and the notes from the researcher, an assessment can be made at to what extent the non-functional requirements have been completed. This completion is graded with five categories, being: not/half/almost/completely and unclear. Table 16 includes all the non-functional requirements and their degree of completion.

Table 16: Evaluation of non-functional requirements

No.	**Requirement**	**MoSCoW**	**Fulfilment**
1	Should optimally use intrinsic and extrinsic motivation (rewards and feedback)	Should	unclear
2	Should have an immersive storyline	Should	not
3	Should have increasing levels of difficulty	Should	half
4	Should make sure the user has autonomy	Should	completely
5	Should take attention span of target group into account	Should	half
6	Should take individualization into account	Should	not
7	Learns the user vocabulary of a strange language	Should	half/almost

8	Fitting for gifted children	Should	unclear
9	Should make sure no faulty and superficial understandings are created	Should	half
10	The prototype with digital briefing and debriefing should improve knowledge retention	Should	not
11	The prototype with digital briefing and debriefing should improve enjoyment and engagement	Should	not/half

Many of the non-functional requirements were established at the concept of developing an effective educational game. The tool developed for the evaluation, was a tool that had to teach the user about a foreign language vocabulary, and was purely a tool to measure the effect of the digital vs paper variants of the briefing and debriefing. Therefore the first six non-functional requirements, which were extracted from the literature frameworks on developing effective educational games, are somewhat included in the prototype, but not at all relevant to this thesis.

When looking at requirement 7, it can be established at the hand of the test data, that the participants were able to, on average, learn about five words out of the seven. With this data in mind, this requirement is fulfilled as its purpose was to teach people a bit of vocabulary.

When looking at requirement 8, it is not possible to determine whether this is the case. This was a requirement from the client, but not relevant for the purpose of this thesis in answering the RQ. Therefore this point has not been evaluated. It does adhere to a few of the requirements set for education of gifted children, such as autonomy. But to concretely declare this a more extensive research should take place.

For requirement nine it can not be established that this did not happen during the evaluations. Because of two points. Point one entails the fact that this is also a non-functional requirement for the prototype, which is not the focus of the thesis. Point two is interesting in that this requirement was unintentionally measured during the evaluations. With a few of the participants, objects were incorrectly translated on the test, not in the manner of spelling errors, but by writing down the incorrect name of an object, but the name of an object that looked like the object. An example of this is the fact that four participants wrote down "side table" for the stool object in the scene, pasted in Figure 38 for your convenience. This allows the establishment that a few incorrect and faulty understandings were created during the learning process. All the other objects did not have this occurrence however.

Figure 38: Stool in game

Looking at requirement 10 and 11, it can be established that they were not or only in a half manner achieved. As stated in the results and statistical analysis section, all of the data's averages point to digital variants being more effective, enjoyable and engaging, but at p=0.01 none of the data was significant, and at p=0.05 only the briefing was considered more enjoyable and engaging.

7.3 Discussion

In the discussion, the test procedures, results and factors that could have impacted the evaluation in a certain manner are discussed.

In general it can be assumed that the prototype is a functioning application that was useful in attaining the goal of this evaluation. It was able to teach the participants a bit of vocabulary in a foreign language, which was all it was required to do for the researcher to evaluate the briefing and debriefing. Additionally, mostly all functional requirements and the important non-functional requirements have been completed. The ones that have not been completed included aspects that were setup for optimization of the learning activity, and therefore not the main focus for the research.

The user evaluations were helpful in providing feedback, opinions and insight into the participants, and gave generally positive responses to the evaluation activity. However, it is relevant to acknowledge the large amount of limitations that have come with this evaluation. The sample size of the evaluation is relatively small with only 16 participants, leading to not being able to draw concrete conclusions as to the general population. And for future work, with the help of a bayesian statistical analysis it can be determined whether there is any value in expanding the experiment with a larger sample size. In addition to the size of the amount of participants, the recruitment of the participants could have allowed for a bias to exist. The participants being recruited through mainly personal connections and a bit of snowballing could lead to large similarity, or for the participants to be more lenient to the researcher by giving less direct and more sugar coated feedback and opinions.

Besides politeness to the researcher, the presence of the researcher during the evaluation can strongly have impacted people's attitude and behaviour toward the prototype. The researcher could also have allowed for a bit of bias to occur in the note taking of the participants. Incomplete information or general observations of emotion can be biassed by how the researcher interprets certain people and information.

The environment during the evaluation could also have been of influence more than originally thought. Other interactions, sounds and general environmental sounds impacted a few of the participants' attention, and could have thus impacted their engagement. These distractions have led a few of the participants to miss information which in turn

impacted their engagement and enjoyment even more. An example of this is two participants missing the popups with translations or the explanation of the controls.

This impact of engagement and enjoyment can possibly also be attributed to another factor. This factor being the fact that the evaluation was executed with an incomplete tool (the programmed game, i.e. the learning activity). The fact that the tool was programmed by the researcher in a short development time leads to the consequence that it is not a full fledged educational game, that it lacks responsiveness, accessibility, includes minor bugs and perhaps incomplete aesthetical design of the game. An elaboration of how these aspects could have impacted engagement and enjoyment can be found in a clear oversight in Table 17.

Table 17: Oversight of impacting factors an incomplete game could have on the evaluation

Factors	**How it impacts engagement and enjoyment**
Not a full fledged game	This point speaks for itself pretty much, but the fact that a game is incomplete, has no storyline or interesting goal, besides the learning activity goal that was provided, can impact the engagement and enjoyment a participant might gather from the game
Responsiveness	This refers to the fact that if a user made a mistake, or collected the correct word, the game did not extensively give that much feedback, currently only a counter was increased in the bottom of the screen, but this unclarity or lack of response of the system led a few participants to miss this aspect impacting the engagement. Two participants suggested popups or animations to occur during these things happening.
Accessibility	This point speaks for itself as well, but for a few of the anecdotally observed older participants or not familiar with gaming participants, the controls only being mentioned textually and no images or trial of learning controls given caused a bit of trouble among certain participants. This led to frustration amongst a few participants not being able to navigate the game as well. This issue could have been avoided with a more complete game or longer development period.
Minor bugs	Minor bugs, such as the character being able to move off grid or the tile selection for moving the character around not working perfectly impacted a bit of engagement and enjoyment as well. The dysfunctional controls frustrated a few of the anecdotally observed older participants since they opted for using this control over the key based movement control (since clicking on where you want to go is easier than using arrows).

	This frustration and breaking of immersiveness impacted engagement and enjoyment further.
Aesthetics	This point kind of ties into the first, not a full fledged game point. A few of the participants remarked that the incompleteness of the environment design also impacted their engagement, the lack of animations, and a more homelike environment.

To elaborate more on aesthetics, the concept of *near transfer* should be mentioned once more. Near transfer is based around a simulationary nature, since the game's graphics do not necessarily provide this, and are limited, the effect of this concept can be limited, thus perhaps limiting the engagement and effectiveness of the game. Now, not for all participants are the points mentioned in Table 17 as much of an influencing factor, and they impacted certain participants more than others. It is nonetheless relevant to elaborate on how these points could have impacted the evaluation process.

Another point of relevance that could have impacted the evaluation is the interest of participants. Even though all participants were receptive toward being part of the evaluation a few had more interest in partaking than others. This could have impacted how well participants performed on the test or how engaged they were to the prototype, similarly for enjoyment. With a more quantitative sample size this point might be negligible, but with the current sample size this data strongly impacts the end result.

This level of interest is also reflected in the data where the amount of retries and amount of time spent was noted. Initially the time spent was to be used as a control variable for effectiveness on the test, but the great variance of times, and the fact that the measured time for the digital group included the time spent on the brief and debrief led to inaccuracy for the control variant of time. The amount of retries provide a bit of insight, but only two participants did the game/learning activity more than once. While they did perform well on the test, many other participants who did not do the learning activity more than once, also performed well. The lesser time spent and amount of retries show, amongst other factors, a difference of interest. Another factor could be that a few participants were fluent at movement in the game, and understood everything quickly and therefore got fast times as well, not indicating low interest in this manner.

Lastly, but certainly not unimportant is the fact that the way of measuring the variables and what they signify. To measure effectiveness, engagement and enjoyment the current measure methods chosen are a test, behavioural notes and an interview. The accuracy and thus legitimacy of these methods cannot be said with 100% certainty to be the best. While tests, behavioural notes and an interview introduce a couple of strengths, they can be questioned on their ability of controlling variables, their reliability and context. The subjectivity of these variables also impact the validity of their measures. Other

measurement methods, such as, for example, more invasive systems observing emotions on participants' faces or body language might give a less biassed and more consistent dataset on the enjoyment of participants. In addition to this the fact that the briefing and debriefing eventually included an avatar in the design might have impacted the validity of the results regarding how related the outcomes are to the brief and debrief and not caused by the avatar. The background research shortly elaborated on the fact that an avatar also has a positive impact on engagement. Thus it is not possible to conclude that the caused and observed changes are necessarily because of the brief or debrief.

Despite all the aforementioned limitations and factors that could have influenced the accuracy of the evaluation, the evaluation provided useful information about the prototype. A small sample size allowed for more qualitative data and more in depth responses. The participants' extensive feedback was easier to process and delivered valuable suggestions and recommendations.

Summarising, future research should aim to improve the sample size, and to make the sample pool more diverse. Researcher influence in data collection and evaluation influence should be minimised. The influence the environment can have on participants should be minimised, and future research should use a complete tool in its evaluation.

8. Conclusion

The goal of this thesis was creation and improvement of an educational video game for children in primary school levels of education. A review of literature exposing criticisms and recommendations for educational games and related works revealed that activities outside of the learning activity and educational game can strongly impact the effectiveness of such a tool. The addition of a briefing and debriefing to an educational game should allow for a more effective learning environment. In light of the client providing lesson materials to children without requiring much preparation or guidance from the teacher, provided the question if this briefing and debriefing could be digitally incorporated into the video game and how it would impact the effectiveness. So at the hand of the client a research question was defined:

"*Could the addition of a digital brief and debrief positively impact educational video games?*"

The variables that were measured in order to establish this impact were the effectiveness of the learning activity but also whether the briefing and debriefing incorporated in the game would influence the engagement and enjoyment. In order to establish whether the approach of a digital (de)brief was an improvement, an alternative scenario involving a paper-based version of the brief and debrief was tested as well. As this is a common approach in current education, when the teacher is unable to guide or prepare an in person brief and debrief.

To help answer this research question, three sub questions were answered.

- How can one devise an effective briefing?
- How to make an educational video game?
- How can one devise an effective debriefing?

At the hand of the E.D.I model [82] and Honghøj's [79] contextualization, a briefing was established. In addition, with Kriz [81] six phases of debriefing a debrief was created. To aid in evaluating these briefs and debriefs an educational video game was created in the likeness of the game Influent [92]. The base concept of *Influent* was modified in a manner replicable for the researcher in a short development period, but tried to adhere as much as possible to the combined framework criteria provided by Whyte *et al.* [66] and Yussof [69]. The prototype was unable to follow a few of the criteria, such as long term goals and a present storyline. For answering the aim of this thesis, that is, to measure the impact of the brief and debrief, these criteria fortunately were not a main priority. If the tool is able to teach the participants a bit of vocabulary, and suffices the definition of a video game, the tool succeeded in its purpose to aid in the evaluation of the briefing and debriefing.

Whether the prototype manages to have a positive impact on educational video games can not be said for certain, and would require a more extensive future research. The experience with the digital brief and debrief was positively received by participants and the digital briefing included in the game showed significant increase in enjoyment. The effectiveness seemed to be unaffected by the addition of a digital briefing and debriefing. Similarly the digital debriefing did not show any significant increase in enjoyment. The paper control group did however rate the game itself significantly higher than the digital group. This shows that digital briefs and debriefs can positively affect educational video games, but also bring along other, perhaps unwanted effects.

Regardless of this outcome, this project managed to successfully address the research question to the researchers contentment, while also successfully managing to satisfy the client. The client, paraphrasing, said the following in a closing meeting, that they are excited about the product and what it opens up in the future, they were eager to incorporate it into their curriculums and that thanks to this project they got a good insight into how achievable educational games on websites can be.

Even though there is much to be improved about the evaluation process and prototype, it has provided the client with a useful look into the use of video games in their curriculum, showed them the technical side is cleary achievable with easy integration in their structure and LMS, and provided an interesting basis in establishing the value of digital briefings and debriefings. Hopefully this research can provide future researchers with a basis to start with, and perhaps useful data to be used in future research.

Concluding, one additional point is important to remark. Even though this research was proposed in researching a good replacement method for decreasing the teacher workload, it is relevant to mention that these methods will most likely never outperform a teacher themselves guiding the briefing and debriefing. Also in factors such as social development. As a personal remark I feel that improvements of digital systems in efficiency for education should not go to the detriment of current teachers, since their influence in current education cannot and should not be understated.

9. Future Work

The insights already made in this thesis deliver useful information that can be used in future research or implementation of educational video games. There are, however, always points to be improved upon or extended into. The Future Work delves into those points.

Firstly, performing the research with a larger and more diverse sample size can already improve the accuracy of the results. Beside this standard measure future research should also aim to execute the evaluation with a more complete educational game, since the incompleteness of the educational game can also have impacted the results in a certain manner. A few aspects that influenced the engagement and enjoyment were already mentioned, but one principle from the framework provided in Table 1, based on Whyte *et al.* [66] and Yussof [69] criteria, the *individualisation* is something that is not implemented at all. The game does not provide the player with any sort of alternate starting point or harder challenge, it also does not take the player's current level into account. This aspect can strongly influence engagement and consequently enjoyment amongst participants and could provide an interesting future research perspective. Exploring in more detail how this criteria influences players engagement is an interesting direction for future research, especially since current level and skill can vary greatly amongst participants.

Successive research can also be executed. It would be interesting to measure other variables a digital briefing and debriefing could influence in the learning activity. Since briefings and debriefings help actively remember and process the information, it could be interesting to measure how they impact problem solving skills, as perhaps opposed to a paper variant or a teacher guided variant.

Another successive research that could be valuable to this project could be the exploration of implementing the digital brief and debrief with a video game into an actual formal school environment. Hereby looking at user acceptance of the teachers, and their consequent opinions. It is known that user acceptance is crucial for the functionality of a product, thus evaluating the user acceptance of the project could be a valuable piece of information. When implementing the prototype in a formal school setting the game could once more be evaluated. Because, unfortunately, research that looks into the effectiveness of educational games, specifically in a formal educational environment, is quite limited [15].

The project already tried to limit technical complications of educational video games by optimising game aspects such as poly counts, and by programming the game for a website to allow for easier access, but the technical aspect of educational video games is also an aspect where further exploration might be necessary. A few papers from the background research also mentioned the lack of technical infrastructure for their tests, or

in general. Hence future work could focus on devising strategies that enhance the availability and accessibility of educational video games.

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Appendix A - Table framework evaluation existing games

Name	Immersive storylines	Goals directed around target skills	Rewards and feedback about goal progress	Increasing levels of difficulty	Individualization	Learner Control/ Provision of choice	Attention span	Amount of Attributes included/taken into account
Duolingo	None	Medium to short	Rewards and feedback about goal progress	Some	Players choice	No	x	2.5/7
Memrise	None	Medium to short	Rewards and feedback about goal progress	Some	Players choice	No	x	2.5/7
Babbel	None	Medium to short	Rewards and feedback about goal progress	Some	Players choice	No	x	2.5/7
Lingodeer	None	Medium to short	Rewards and feedback about goal progress	Some	Players choice	No	x	2.5/7
Mango Languages	None	Medium to short	Rewards and feedback about goal progress	Some	Players choice	No	x	2.5/7
Influent	Some	Medium	Rewards	No	None	Yes	x	2.5/7
M.e.e: privacy	Some	Long	Rewards and feedback about goal progress	Yes	None	No	Yes	4.5/7
M.e.e: coding	Some	Long	Rewards and feedback about goal progress	Yes	None	No	Yes	4.5/7
M.e.e: A.I.	Yes	Long	Rewards and feedback about goal progress	Yes	None	No	Yes	4.5/7
Words With friends	None	Medium	Rewards	No	None	No	x	1.0/7
Muzzy	Some	Short	Rewards	x	x	No	Yes	2.0/7
Mindsnacks	None	Medium	Rewards	Some	None	No	x	1.5/7

Gus on the go	Some	Short	Rewards	No	None	No	Yes	2.0/7
Hiragana Battle	Yes	Long	Rewards and feedback about goal progress	Yes	None	Yes	x	5.0/7
Hiragana Forbidden Speech	Yes	Long	Rewards and feedback about goal progress	Yes	None	Yes	x	5.0/7

X refers to unknown

Appendix B - Information letter user evaluation

Purpose of research:
This user evaluation aims to test a prototype made for a graduation project by a student of the bachelor Creative Technology. This project consists of creating an educational game for a client that provides lesson plans for gifted children. This game is aimed at learning the basic vocabulary of a new language. The project is aimed at testing whether certain modifications of the game have an impact on how well the learning occurs and the knowledge transfers from the game to the real world.

A prototype of this game has been made, and this research aims to test its functionality and evaluate what to improve. When reading this information letter this research has been reviewed and approved by the CIS ethics committee of the University of Twente.

Procedure:
You are currently reading the information letter, if you approve you will sign a consent form for participating in this research. If you participate you will belong to one of 2 case groups, in this group you will be playing an educational game where you should learn some vocabulary in a foreign language. This game should take from 5-10 minutes, this also depends on what group you are part of. The gameplay activity will have very little interference from the researcher, and should be self explanatory. Afterward a short test will take place that should take no longer than 5 minutes. After this you are asked to fill in a few questions on a questionnaire, this should take up to 5 minutes. The total activity(excluding the reading of the information letter and consent form) should take approximately from 15 to 20 minutes. After these 20 minutes there is room for giving some more extensive feedback if the participant is willing.

Benefits of participating:
The benefits of participating involve supporting a project that possibly helps children in primary education get fitting and effective education without requiring a large amount of extra effort from teachers to provide these children with education that suits them. Additionally you will be supporting a student with their graduation project. And you might learn some vocabulary of a foreign language.

Procedures for withdrawal from the study:
- Writing an informal email to the researcher - or contacting them on any platform the participant might have the contact information of additionally (whatsapp, sms, phone call).
- Ending the interview at any point in time by leaving the meeting
- Orally informing the researcher about your wish to withdraw

Personal data collection:

No personal data will be collected. Throughout the session, the researcher will possibly take notes from how the session is going. These notes will be about the activity or the game itself and perhaps some perceived engagement or enjoyment of the user, no personal information about the user.

Retention period for the research data:
The findings based on the collected information during the interview will be published online indefinitely in the thesis repository of the University of Twente.

Contact details of the researcher:
Jesse Strijker
j.j.strijker@student.utwente.nl

Contact details of the CIS Ethics Committee to file a complaint:
ethicscommittee-cis@utwente.nl

Appendix C - Consent form user Evaluation

Consent form developing an educational video game for primary school children

You will receive a copy of this form

Please tick the appropriate boxes	**Yes**	**No**
I have read and understood the information letter, or it has been read to me.	□	□
I have been able to ask questions about the study, which have been answered to my satisfaction	□	□
I consent voluntarily to being a participant in this study and understand that I can refuse to answer questions and withdrawn from the study at any time, without needing to give a reason	□	□
I understand that taking part in this study involves testing a video game prototype and participating in a test afterward that tests the knowledge I could have learned during the game. I understand that the whole process should take approximately 30 minutes	□	□
I understand that the information I provide will be used for a published graduation project, available in the thesis repository of the University of Twente.	□	□
I understand that the results of my test will be used to evaluate the effectiveness of the prototype	□	□
I understand that none of my personal information will be collected, including my identity, unless specifically requested or granted permission.	□	□
I give permission for the transcripted notes of the session to be archived in the thesis repository of the University of Twente so it can be used for future research and learning.	□	□

Signatures:

Name of participant:	Signature:	Date:

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands what they are freely consenting to.

Name of researcher:	Signature:	Date:
Jesse Strijker		

Study contact details for further information:
Jesse Strijker
j.j.strijker@student.utwente.nl

Contact Information for Questions about Your Rights as a Research Participant
If you have questions about your rights as a research participant or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science:
ethicscommittee-CIS@utwente.nl

Appendix D - Textual Debrief

You just took part in an evaluation where 2 different groups are evaluated against each other.

The purpose of this evaluation is to establish to what extent the difference between a paper and digital brief and debrief influence the effectiveness of the learning activity, and if they bring more or less engagement and enjoyment.

If you have more questions or are interested in more extensively hearing about this experiment you can contact me at j.j.strijker@student.utwente.nl

Appendix E - Test

Participant Number: _____ Date:_____

Please translate the following words to their counterparts

Italian -> English

Word	Translation
l'armadio	
il divano	
la lampada	
lo sgabello	
la tavola	

English -> Italian

Word	Translation
The chair	
The plant	

Appendix F - Interview

Participant Number: _____ Date:_____

Researcher should say: So you just did a briefing, a learning activity in the form of a video game, a debriefing, and a test.

Can you share your overall thoughts and feelings about your experience with the prototype?

Were there any specific features or elements of the prototype that you particularly enjoyed? If so which and why

Were there specific features of the prototype that particularly engaged you? If so which and why

What is your opinion on the briefing?

Please grade the briefing according to the following scale: (in between is allowed)

Liked it a lot - liked it - neutral - disliked it - disliked it a lot

What is your opinion on the learning activity?

Please grade the learning activity according to the following scale: (in between is allowed)

Liked it a lot - liked it - neutral - disliked it - disliked it a lot

What is your opinion on the debriefing?

Please grade the debriefing according to the following scale: (in between is allowed)

Liked it a lot - liked it - neutral - disliked it - disliked it a lot

Do you have any major issues with the system or remarks?

Appendix G - Learning Activity Briefing

Heya! You are about to jump into an educational video game. But what for exactly?

The goal of this educational game is to teach you some Italian vocabulary! The goal is that at the end of this experience you know 7 Italian words regarding house interior. Such as what the Italian word for couch is!

Goal: Learning 7 Italian words!

Have fun and goodluck

Appendix H - Learning Activity deBriefing

So you just completed a game which hopefully taught you some Italian words. Let's have a short debrief

What do you feel about the experience?

What happened exactly during the experience? Can you give an example.

How could you use this knowledge in the real world?

What was the learning goal of this learning exercise?

For the researcher:
Participant Number: _____ Date:_____

Appendix I - Researcher Notes

Participant Number:_____ Type of Briefing:_____ Date:_____

Time in game:_____ Amount of retries:_____

Appendix J - Processed Data

This is a clear oversight of all the collected data, this is all raw data but it is translated into english where necessary. The first image is all the non-digital data, the second all the digital data

Person	Type	Date	Time (s)	Mistakes (if applicable)	Amount of Tries		Result Test	Specifics test section 1	Specifics test section 2	Rate brief	Notes Brief	Rate learn	Notes learn	Rate debrief	Notes debrief	core terms	Other info (noted by researcher)	Reccomendations	Opinions
3	Non-Digital	21/01/20	149	1	1		0,5714285714	4/5	0/2	3	Clear	4	"gaaf", design of game: "gezellig". Learned some words	3	x		Uses inbetween menu for gaining oversight, not learning		Clear controls explanation, nice design aesthetic, objects were very clear
5	Non-Digital	21/01/20	493	0	2	First attempt 5 min, second 3 min	0,8571428571	5/5	1/2	3	Clear, but forgot about it, goal wording was weird because it is in there twice but worded differently	4,5	Fun, new, italian is fun, competative, not to hard, therefore not discouraging	3	Fine		Competative spirit, wants to perform well, very engaged		Fun, clear controls, objects easily recognizable, moving character around is a fun form of learning vocab, Liked the random object spawns each time, time limit vs controls is a dilemma, really like the avatar
7	Non-Digital	22/01/20	211	x	1	Started after 1 min	0,7142857143	5/5	0/2	3,5	Fine, preps your brain	4	Satisfying, recall (section 2) was nice, section 1 was annoying, used menu for learning mostly, character not rotating annoying, collection of items was fun, section 2 finding objects was engaging, learned words without resistance which is nice.	1	Sucks, unclear questions and unclear what the goal was		Seemed a bit bored	Change controls with camera rotation combination, and remove popup section 1 after user confirmation (movement or distinct key)	
8	Non-Digital	22/01/20	396	1	5	Finished attempt 1 2.45. Attempt 2 at 3.20	0,8571428571	5/5	1/2	3	Short, double goal is bit vague, misses explanation why a game is the chosen teaching tool	4,5	fine, could be better, learning happens mostly by coupling of italian word to object not to the translation, popup of collection should be longer or based on user confirmation to move on	3	Fine, okay-ish questions. 2nd question vague. Questions feel as if they are for research not for participant themselves(except Q3)		Enthousiastic and competative, tried speedrunning game 2 to 4th attempt (got 5 sec highscore section 2). Used last attempt for actual learning. 1st attempt was dissatisfied with mistake, took extensive time for debrief.	Change controls in combination with camera rotation, section 2 popup for collection key, make order for section 2 random each time. Make sure character can't spawn in item. Game interactions, give popups for mistakes, when timer is low or when correct item collected, impacts engagement negatively otherwise. Make popup longer, or user confirmation based	Liked timer/speedrun aspect, freedom of exploration is fun
10	Non-Digital	22/01/20	149	5	1	Section 1: 56 sec, section 2 2.29 sec	0,4285714286	3/5	0/2	3,5	Usefull, otherwise no clue what you are doing	5	Concept nice, repetition nice, luck is part of gameplay now tho	2	Not really fun		Said: "Yup this is not gonna end well" after section 1. Had bijzettafel as wrong answer for stool	fix controls with camera rotation	game looks nice, nice mechanics, controls in combination with camera rotation vague, walking around and seeing what words meant was fun. Section 2 was more teaching and usefull. Wonder how would expand with certain words in future however
12	Non-Digital	23/01/20	145	11	1	section 1: 58 sec	0,4285714286	3/5	0/2	3	nice, clear that scope was 7 words, category was also nice, had the idea it was usefull	4	Quick	3	Q3 less relevant, is usefull because prompts you to think about the experience		Had armchair as wrong answer, so remembered object, not translation. Understands controls immediately. Really took his time and tried during test	Popup once more, or until user confirmation would be nice. Improve controls with camera rotation	Fun, but taught mainly translation to object not text translation. ccollection of words was fun
14	Non-Digital	26/01/20	185	5	1	Section one: 1 min	0,7142857143	5/5	0/2	2	Very short, introduction ingame overlaps	4	Good game, maybe bit unclear font	3	Unneccesary		Troubled with section 2		Liked memory aspect of game, didnt understand why briefing and debrief not ingame
15	Non-Digital	26/01/20	270	1	1		0,7142857143	5/5	0/2	3	Usefull and clear, short but nice	5	Fun game, subconscious learning	3	Usefull for researcher, has some effect for participant themselves		Enthousiastic, but notes the difficulty of remembering words, pretty quick	Add pronounciation to game, learn it the other way around aswell. Make the game larger, collection animation (move object up). Make text shorter	Liked models, avatar is nice, fun idea, efficient, not a lot of colors tho, fun experience, liked conversation with avatar. Simple design was nice

Person	Type	Date	Time (s)	Mistakes (if applicable)	Amount of Tries		Result Test	Specifics test section 1	Specifics test section 2	Rate brief	Notes Brief	Rate learn	Notes learn	Rate debrief	Notes debrief	core terms	Other info (noted by researcher)	Reccomendations	Opinions
1	Digital	20/01/2(	120	2	1		0,2857142857	2/5	0/2	4	As expected	3	Seeing objects is nice	3	x	x			
2	Digital	21/01/2(	926	Run 1: a lot, Run 2: 3, Run 3: flawless	3	6 min first attempt, 1.48 2nd 1.03 3th	1	5/5	2/2	4,5	Clear, enthousiastic, example is nice, character is cute and encouraging	4	Walls would be nice, cute, control(rotation) avatar would be nice	3	Usefull for creating clarity for yourself. Usefull -> not neccesarily fun. Clear	x	Took time during every section extensively, doesnt use inbetween menu for learning. Used section 2 mostly for learning words	- Improve Controls - Size text blocks better (smaller) - setting more homely - section 1 game, see words only once = bad - improve typing controls	Nice vocab(clear and not forcing, nice tone). Mood of game catered engagement
4	Digital	21/01/2(	622	A lot	1	Game Finished after 8 min, started game at 48 sec	0,8571428571	4/5	2/2	3	Usefull for oversight, bullet points would be nicer, image for controls would be clearer	3	Hard, mainly because of controls, section 1 annoying, section 2 nice learning loop	3	Fine, not interesting, no value in it for participant		Has a lot of trouble with the controls, takes way longer for section 1 than other candidates(around 2.5 min). Lot of frustration with controls, annoyed with duration and made mistakes NOTE: one mistake in test was wrong word, but gave description of object: bijzettafel)	Improve Controls, bullet points in large bits of text, add image introducing controls	Nice order of learning, if making mistake not start from 0, but same order, learning loop was nice. Controls really unclear
6	Digital	22/01/2(	240	0	1	section 1 only 30 sec, game completion 2 min	1	5/5	2/2	4	Didnt remember very well except for goal, word use was nice, in one end out the other	4	Objects are clearly distinctive, helped in remembering, controls clear, gave idea of moving in a space	3	Unclear what the point of it was		Is very fast, and agitile		Liked style of game, would like to see the object to be able to be collected more often. very short experience
9	Digital	22/01/2(	183	1	1	section 1 in 49 sec, section 2 in 72 sec	0,7142857143	4/5	1/2	3	Lot of text, good that its there. How text was presented was nice. Helped with mindset and correct frame of reference for learning	4	Fun, wasnt hard	2	Vague, could be usefull		Uses oversight for quick lookover, very fast and agile in controls		Likes this more than duolingo, wont be able to learn grammar however, interesting concept. Liked the game controls of grid based design, and different control options
11	Digital	23/01/2(	355	0	1	Finished game at 2.30, rest of time was debrief	0,5714285714	4/5	0/2	3	Just clicked through it	4	Nice concept, wonder how you'd expand on it though, but works for objects	3	Cant go back to previous answer, really had to think about answers		Had bijzettafel as wrong answer for stool. Was very focussed, uses menu for learning words, not popup, answered debrief extensively	Have an animation between briefing screen and introduction screen. Make it so can switch back to previous answer	Liked idea behind it. Idea behind the learning more interesting than conventional methods, less braindead
13	Digital	26/01/2(	416	0	1	Section one: 2:43, section 2:330	0,7142857143	5/5	0/2	3	Didnt remember very well	4	Fun, 2 sections of learning are nice, visuals are nice	2,5	Felt like for researcher, not that usefull for themselves, learning goal could be usefull		Interested, takes time section 1, first person that took longer for section 1 than section 2. Takes time for debrief	Popup too short, big amount of text, maybe teach playing, add sounds!, more visual info.	Liked the walking around, environment exploration, free choice in order and learning, was engaged by this freedom
16	Digital	26/01/2(	794	10+	1	Started scene one after 2 min, finished after 4, took to 12 minutes for scene 2	0,7142857143	5/5	0/2	4	Clear goal, enthousiastic	4	Nice, controls for scene 1 without stress nice, popup was too quick	3	Fine, quick after learning activity is good, but felt usefull for researcher, not themselves		Takes time, controls are hard, uses double click, not arrows, has some frustration section 2, bit of stress. Lot of mistakes and timer run outs. Would have liked to see the words once more	Popup too short, controls could be clearer. Maybe word above object in scene?	Frustrated with controls and timer gave stress, looks nice, learning words with image is nice, but controls were really hard