



BACHELOR THESIS

# E-Learning Material for Computational Thinking in Secondary Education

Karlijn Kole

Creative Technology

EEMCS

Supervisor: Angelika Mader

Critical Observer: Ingrid Breymann

Client: GSG Guido

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## Abstract

Within a few years, digital literacy will be part of the compulsory curriculum for secondary education. One of the four domains is computational thinking, which is defined as reformulating problems into procedures and algorithms so that the problem can be solved by a computer. This research aims to design e-learning material for computational thinking for Guido, a school for general secondary education.

Current materials available often expect the teacher to have some background in programming while oftentimes this is not the case. Another issue is that the topic is often perceived to be difficult and boring. Via a literature review, research is done on how to make the material engaging. In close collaboration with the client, an educational escape room was built. The puzzles in the escape room cover the learning objectives of computational thinking.

The prototype was received positive in terms of engagement, quality and learning experience by 8 students of Guido. They evaluated the final prototype with a user test and questionnaire. Further research is needed to assess the prototype on improvements in computational thinking skills and the gameplay with a larger test group.

## Contents

Abstract.....	2
List of Figures .....	6
List of Tables .....	7
1. Introduction .....	8
2. Background Research.....	10
2.1. Current materials for CT .....	10
2.2. Comparison in Engagement of Learning Methods .....	13
Current Problems .....	13
Comparison of Learning Methods .....	14
Conclusion.....	15
2.3. Challenges of e-learning material .....	15
3. Methodology.....	17
3.1. Ideation .....	17
3.2. Specification.....	18
3.3. Realisation.....	18
3.4. Evaluation .....	18
4. Ideation .....	19
4.1. User/Expert Interview.....	19
4.1.1. Conclusion interview.....	19
4.2. Brainstorm integrating CT.....	20
4.2.1. Evaluation of the mind map.....	21
4.3. Stakeholder analysis .....	21
4.3.1. Direct Stakeholders.....	21
4.3.2. Indirect Stakeholders .....	21
4.3.3. Overview of stakeholder interest and influence .....	22
4.4. Preliminary requirements .....	23
4.5. Concept generation .....	24
4.5.1. Idea description .....	25
4.6. Co-Creation .....	26
4.7. Background on educational escape rooms.....	27
4.8. Storyline and Final Concept .....	28

5.	Specification.....	31
5.1.	MoSCoW analysis.....	31
5.2.	Requirement specification.....	32
5.2.1.	FR1 & NFR1 .....	32
5.2.2.	FR2.....	33
5.2.3.	FR3.....	34
5.2.4.	FR6 & NFR3 .....	34
5.2.5.	FR8.....	35
6.	Realisation.....	37
6.1.	The Vault .....	37
6.2.	Puzzles.....	40
6.2.1.	Nonogram .....	40
6.2.2.	Flowchart .....	41
6.2.3.	Spanning Tree .....	42
6.2.4.	Caesar Cipher .....	42
6.2.5.	Logic Puzzle .....	43
6.2.6.	Setup puzzles .....	44
6.3.	Email Client .....	45
6.4.	Debriefing.....	51
6.5.	Evaluation of requirements .....	51
7.	Evaluation .....	52
7.1.	Results Observation .....	53
7.2.	Results Questionnaire.....	54
7.3.	Conclusions .....	55
8.	Conclusion.....	57
9.	Further Research.....	59
	References .....	60
	Appendix A: Consent Form Interview .....	63
	Appendix B: Outline Interview 1 .....	65
	Appendix C: Existing Ideas in Matrix.....	67
	Appendix D: Computational Thinking Puzzles .....	68
	Appendix E: Vault Code.....	70

Appendix F: Nonograms.....	73
Appendix G: Employee List .....	75
Appendix I: Logic Grid filled out.....	82
Appendix J: Design Employee Card.....	83
Appendix K: Slides Debriefing .....	84
Appendix L: Information Parents and Consent Form .....	87
Appendix M: Information Students and Consent Form.....	89
Appendix N: Questionnaire.....	92

## List of Figures

Figure 1: Distribution of CT papers per year. Source: [9] .....	10
Figure 2: A Creative Technology Design Process. Source: [29] .....	17
Figure 3: Mind Map Integration of CT .....	20
Figure 4: Influence-Interest grid .....	23
Figure 5: Brainstorm Matrix .....	24
Figure 6: Value-Feasibility Grid .....	25
Figure 7 alignment puzzles. Source: [40] .....	28
Figure 8 Office Desk .....	29
Figure 9 Mood Board Office Supplies .....	30
Figure 10 Vault .....	30
Figure 11 Logic of Escape Room .....	35
Figure 12 Vault Schematic .....	37
Figure 13 5V Lock .....	38
Figure 14 Front Vault .....	38
Figure 15 Inside of Door .....	39
Figure 16 Side of Vault with Hole .....	39
Figure 17 Door Open .....	40
Figure 18 Solved Nonogram .....	41
Figure 19 Flowchart .....	41
Figure 20 Spanning Tree .....	42
Figure 21 Logic Puzzle Grid .....	43
Figure 22 Setup .....	45
Figure 23 Navigation Schematic .....	46
Figure 24 Start Screen .....	46
Figure 25 Use Cues .....	47
Figure 26 Email Menu .....	47
Figure 27 Spanning Tree Preview .....	48
Figure 28 Email Spanning Tree .....	48
Figure 29 Email Caesar Cipher .....	49
Figure 30 Explanation Logic Puzzle .....	49
Figure 31 Explanation Opening Vault .....	50
Figure 32 Lock Screen .....	50
Figure 33 Requirement Evaluation .....	51
Figure 34 Test Setup .....	52
Figure 35 Results of Questionnaire .....	54
Figure 36 Hover Over Event .....	55
Figure 37 Empty Logic Grid .....	55

## List of Tables

Table 1: CT Materials .....	12
Table 2: Summary Interview .....	19
Table 3: Stakeholder Interest.....	22
Table 4: Preliminary Requirements .....	23
Table 5 Functional requirements.....	31
Table 6 Non-functional requirements.....	32
Table 7 Learning Objectives of Puzzles .....	33
Table 8 Hardware Components .....	34
Table 9 Puzzles in Context .....	36
Table 10 Encrypted message .....	42
Table 11 Translation words.....	44
Table 12 Time and Sequence of Found Solutions .....	53
Table 13 Requirement Evaluation.....	56

## 1. Introduction

Digital literacy is going to have a permanent place in the Dutch curriculum for primary and secondary education [1]. It includes all the basic principles regarding to technology that students need to function well in modern society. SLO divided digital literacy in four domains: ICT basic skills, media literacy, digital information and computational thinking [2]. SLO is the national expertise centre for the curriculum. While schools are not legally required yet to offer digital literacy, it is advised to do so already in two ways: integrated in other courses and/or as a standalone course [3]. Schools have thus the freedom in how they want to incorporate digital literacy. Secondary schools are struggling with finding good ways to implement this advice [4]. For both advices count that teachers and school planners have trouble finding time in the schedule for the subject [3]. Integrating the subject into other courses makes the quality dependent on the digital literacy level of the teacher, which can vary a lot across teachers [3]. Finding an expert teacher on the subject for making it a separate course might be even more difficult. There is already a shortage in ICT teachers, and this will only grow in the coming years [5].

E-learning material can support schools in providing digital literacy. There is already some material for digital literacy, but it mostly used as a support next to traditional classroom teaching [6]. Therefore, it does not overcome the problems which are mentioned above. Is there a way to implement e-learning for digital literacy so schools can integrate this new curriculum?

GSG Guido [7] is a Christian secondary school which has several location separated by the education level. The location for havo-vwo (general secondary education) is in the exploratory phase of how to implement digital literacy into their curriculum. GSG Guido is the client and therefore the research will focus on their needs with regards to providing e-learning material for digital literacy.

After the first interview with a teacher of Guido, the initial research topic was specified to one domain of digital literacy: computational thinking. This led to the following main research question:

**RQ:** *How to design e-learning material for computational thinking in lower secondary education?*

In order to answer this research question, it is necessary to decompose it into sub-questions. First, it is important to understand what computational thinking actually entails. Therefore, the following main sub-question must be answered:

**Sub-RQ 1:** *What does computational thinking entail for lower secondary education?*

Secondly, to design e-learning material, a good understanding of the problems that are currently faced in e-learning would be essential. Hence, the next sub-research question:

**Sub-RQ 2:** *What are the challenges of e-learning?*



To specify the needs of the client, it is crucial to know where their challenges lie in teaching digital literacy for them. The outcome of this RQ changed the direction of the other RQ's as mentioned above.

**Sub-RQ 3:** *What are the challenges teachers face in teaching digital literacy on Guido?*

Lastly, one of the requirements of the product is that it should be engaging for students. This resulted in the following sub-research question:

**Sub-RQ 4:** *How to design engaging materials for computation thinking?*

Together these sub-research questions can help formulate an answer to the main question.

The structure of this report is guided by 9 chapters. Chapters 1 and 2 provide necessary background information and some of the sub-research questions will be answered by reviewing literature. Chapter 3 describes shortly the methodology of the research. 4 will describe from start to end how the idea came to be. Chapters 5 and 6 realise that idea into a prototype and chapter 7 evaluates the prototype. 8 and 9 conclude the research and gives insight in what further research might be necessary.

## 2. Background Research

A turning point for computational thinking (CT) is in 2006 when Wing directs attention to it in [8] by stating that it is skill everyone should learn. After that there was a large increase in research into CT education [9]. The graph below shows the distribution of CT papers per year.

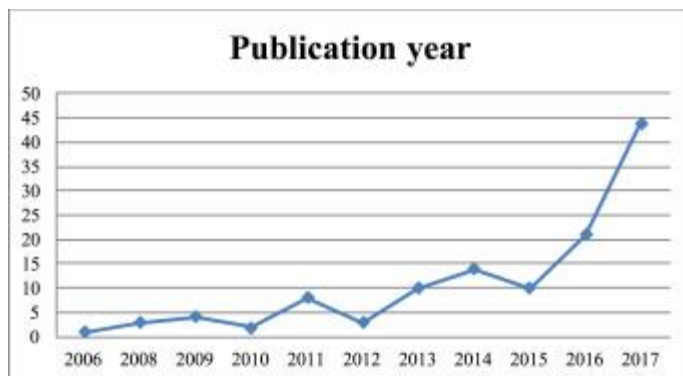


Figure 1: Distribution of CT papers per year. Source: [9]

It is seen as an essential 21<sup>st</sup> century skill, since many social problem cannot be solved without computer technology [2]. Therefore, Dutch curriculum makers also decided to add CT to the future curriculum. There is no unanimous definition yet for CT [10]. For this reason, this research will consider the definition that SLO gives as they also define the curriculum. SLO defines CT as: reformulating problems into procedures and algorithms so that the problem can be solved by a computer [2]. Additionally, SLO divided CT into three subcategories:

- **Problem-solving thinking** (directly translated). The English equivalent which is often used is: critical thinking and problem solving. This subcategory holds the concepts of reformulating, problem decomposition and problem abstraction.
- **Working with digital data**. Applications of this sub-category: analysing, concluding and finding patterns in graphs as well as gathering, visualising and modelling.
- **Procedures and algorithms**. Using and creating a series of ordered steps to find a solution or goal.

Each one of these subcategories lead to different learning goals, described in [11]. Learning goals are defined for CT from primary education to the end of secondary education. These goals serve as a guide for now, but will be formally established in the near future [1].

### 2.1. Current materials for CT

Investigating the current learning materials for computational thinking will help creating new materials and finding the limitations. SLO made a list of the materials Dutch schools can use for secondary education. To get an overview of materials, learning methods, subcategories they teach and limitations of them, the table below is made. The learning methods are divided into three frequently used categories in CT: unplugged activities, robotics and programming languages. Unplugged activities refer to methods where no computers are used. The programming languages are

divided into two subcategories: visual programming languages (VPL) and text-based programming languages (TPL).

Material	Learning method	Sub-categories	Limitations
<b>Bouw je BEP</b> <a href="http://www.bouwjebep.nl">www.bouwjebep.nl</a>	Robotics with Micro:bit and programming in VPL	Problem-solving thinking & procedures and algorithms	-The visual appearance is more targeted towards younger users. -Costs: €395 per three weeks -Only for rent -Knowledge of programming by teacher
<b>BYOR (Build Your Own Robot)</b> <a href="http://www.byor.nl/educatie/">www.byor.nl/educatie/</a>	Robotics with Micro:bit and programming in VPL	Problem-solving thinking & procedures and algorithms	-Costs: €300 per set for a maximum of 8 students. -Knowledge of programming by teacher
<b>Code Avengers</b> <a href="http://www.codeavengers.com">www.codeavengers.com</a>	Programming with VPL, TPL and cognitive games	All	-Not translated to Dutch -Free trial version had bugs -Limited courses
<b>Code Studio</b> <a href="https://studio.code.org/projects">https://studio.code.org/projects</a>	Programming with VPL, TPL and cognitive games	Problem-solving thinking & procedures and algorithms	-Educational material is not translated to Dutch. - Not plug in and go. Teachers would need to select projects since it provides an overview for all ages and interest
<b>CodeCombat</b> <a href="http://www.codecombat.com">www.codecombat.com</a>	Programming with TPL in games	Problem-solving thinking & procedures and algorithms	-Only in English -All games have a fighter style gameplay and look which might not be interesting for all students.

<b>CodeKinderen</b> <a href="http://www.codekinderen.nl">www.codekinderen.nl</a>	All	All	-Provides an overview of materials and not an own lesson plan
<b>Digi-doener</b> <a href="http://www.lessonup.com">www.lessonup.com</a>	All	All	-Only supportive material for teachers.
<b>GoTo leerlijn</b> <a href="http://www.studiotast.com/goto">www.studiotast.com/goto</a>	Combination of all	Problem-solving thinking & procedures and algorithms	-One application: creating drawings with a robot
<b>Informatica unplugged</b> <a href="http://www.informaticaunplugged.nl">www.informaticaunplugged.nl</a>	Unplugged Activities	All	-Provides an overview of materials teachers can choose to use
<b>LEGO Mindstorms</b> <a href="http://www.heutink.nl">www.heutink.nl</a>	Robotics with VPL or TPL	Problem-solving thinking & procedures and algorithms	-Costs: €700 per set. Appr. 8 students per set. -Prior knowledge of teacher about programming
<b>STEAMvidz</b> <a href="https://steamvidz.nl/">https://steamvidz.nl/</a>	Robotics with VPL and TPL and stand-alone programming	Problem-solving thinking & procedures and algorithms	-Costs: €2000 per year -Only consist of tutorial videos. The material needs to be purchased separately.
<b>De Creatieve Code</b> <a href="https://decreatievecode.nl/platform">https://decreatievecode.nl/platform</a>	All	Problem-solving thinking & procedures and algorithms	-Not plug in and go. Teachers would need to select projects since it provides an overview for all ages and interest -Prior knowledge of teacher about programming

Table 1: CT Materials

Some of the limitations that are mentioned might not be a limitation depending on the purpose. When making this table and trying out the different materials, it stood out that free materials either only supported teachers in the way of giving slides or they were very limited with their options if there was a student environment. Oftentimes, free materials were not (correctly) translated to Dutch. To make good use of the free materials, one would need a teacher with background knowledge in programming.

Another finding is that very few combine the three different learning methods in one assignment. The more complete programs do use all different learning methods, but in separate lessons/assignments.

## 2.2. Comparison in Engagement of Learning Methods

Teaching CT is a difficult task since students find learning algorithms boring and complex due to their abstract nature [12]. Teachers therefore struggle with finding engaging ways to teach computational thinking. Extensive research is done on how to engage students in learning but there is still a lot to be explored in relation to CT. This is mainly because it is still a relatively new concept in contrast with other more established courses [9].

To find out how to engage students in CT a literature review is conducted and split into two parts. The first part will review the current problems with student engagement in CT. The second compares research where engagement is measured in different learning tools for CT. By combining these two parts, suggestions can be made on how to improve the engagement for CT.

### Current Problems

The lack of engagement by students when learning CT has multiple reasons. Two of those are already mentioned in the introduction: students find learning about algorithms difficult and boring. The former is also supported in [13], where students were asked to perform a certain algorithmic task to assess their computational thinking skills. Students stopped trying to find a solution once they found that the task was too difficult. The participants in this study did not have computational thinking in their curriculum. These findings relate to the work of Doukakis et al. [14] where they found that the confidence level of students in algorithmic problem-solving without prior courses related to computer science is lower than those with some prior experience. However, this was only to be found true for questions that have a direct connection with programming. There was no significant difference for confidence in problem-solving itself. Since the tasks in [13] require some understanding of pseudo-code or syntax, the difficulty in understanding algorithms might occur because the subject is often connected to programming. Whether algorithms should be inherently taught with programming is still an ongoing debate [12, pp. 2-3].

Another reason for the lack of engagement is the context and the materials being used for teaching CT. In [12] Nijenhuis-Voogt points out that teachers not always use context which are engaging for students. The contexts do not relate to their day-to-day life or have a gender-bias. The latter tends to be a problem across all disciplines within computer science [15]. Both context and materials used in teaching CT have a bias to the male interest. Additionally, the way computer science classrooms are furnished and decorated, like the posters on the wall, make female students less

connected to the subject [16]. Together with the learning material, they reinforce the stereotype that computer science is for nerdy males [15], [16]. Since computational thinking will be mandatory for all students in secondary education, it fails to engage a large target group. Fortunately, there is much more awareness of this problem and teachers are willing to change this [12].

### Comparison of Learning Methods

The rate of student engagement varies between different CT learning methods. To compare engagement, the tools to be compared are divided into three frequently used learning methods in CT, namely: unplugged activities, robotics and visual programming languages (VPL). Unplugged activities refer to methods where no computers are used. The increase of CT skills per method will also be considered, since that makes determines largely the quality of the product. An adequate comparison between methods can only be made if other differences are minimised. Therefore, all tools considered have the same learning objective: getting familiar with algorithms or constructing them. They also all have gamification elements in them, although they differ from competition to levels and rewards. Additionally, the student sets in all experiments had no prior formal education in CT beforehand.

Starting with a comparison between VPL and robotics to teach CT, it is important to have a minimal difference in learning objectives and tasks like mentioned above. Smith et al. [17] do exactly this in their research when comparing Scratch, a VPL, to Cozmo the robot. Two sets of students follow a similar eight-week course in Scratch (n=21) or Cozmo (n=22), where Cosmo was programmed with a VPL. They found that there was no difference in learning results between the sets. However, students were significantly more engaged in Cozmo than Scratch. Merkouris and Chorianopoulos did similar research with Scratch and LEGO Mindstorms (robotics) and had the same outcome [18]. Again, no significant learning difference between the two methods, but students found LEGO Mindstorms more engaging. These two studies show that programming a robotic agent is more engaging for learning CT than with a VPL. In [19] Madariaga et al. point out that the having a physical robot agent to program is more engaging than an online robot agent. Therefore, it can be concluded that the physical aspect of the robot has a positive influence on student engagement when learning CT.

The second comparison is made between engagement in unplugged activities and VPL for teaching CT. Contrary to the comparison above, a difference was measured in learning results in CT between the methods. Kirçali and Özdener [20] and Looi et al. [21] both found that unplugged activities have significantly more contribution to CT than VPL. On the other hand, Kirçali and Özdener also observed that students engaged more with the plugged activities in their research, especially Scratch. Their research consisted of 6 lessons where the last lessons had a design assignment. They believe that creative component of designing is responsible for the increased engagement. However, both studies fail to take into account that the teacher's openness to CT unplugged activities play an important role in student engagement, which Catete et al. point out in [22]. It is common sense that teachers have a role in student engagement but since most unplugged activities are in a classical classroom setting instead of a computer lab, it has a bigger influence. The last similarity is that both suggest that unplugged activities would be most helpful with introducing CT to engage students in the topic, which is in line with [12].

## Conclusion

Multiple factors play a role in student engagement in CT. Current problems lie in the context of the material and the surroundings as well as the level of difficulty. Changes must be made to make the material more appealing to a broader set of students. Since students experience the topic to be difficult, it is also crucial that the material has a good build up from concrete and simpler meanings to abstract and complex meanings [23]. Additionally, no programming languages or only the use of VPLs to teach CT takes away some difficulty because students do not have deal with a programming syntax.

Cognitive results did not differ between learning methods. However, students showed different results in engagement between learning methods. Robotics was found to be most engaging, on the condition that the robot was physical. The creational side of programming with VPL was also found to be engaging. For unplugged activities, teacher's engagement and openness proves to be the most important factor for student engagement.

### 2.3. Challenges of e-learning material

There is not one set definition for e-learning because it is under constant influence of change [24]. Since the design range of this research is broad, the broadest definition is chosen: the delivery of education and training through or with support of computer technology. A lot of researchers consider e-learning to only have an online environment, like experienced with the COVID lockdowns. However, the definition chosen also allows for mix between face-to-face teaching and online learning, better known as blended learning [25].

To assess the challenges that should be kept in mind for designing fitting material, multiple search terms were used that fall under the umbrella definition given. This resulted in the following list of challenges [26],[27],[28]:

- Motivation and engagement
  - Little variation in material
  - Lack of interactivity in material
  - If there is no physical teacher around, students lose motivation more easily
- Digital literacy
  - The digital literacy of a student has impact on learning performance
- Technical issues
  - Issues in the infrastructure
  - Issues on the student's side
- Inflexibility of material
- Credibility and plagiarism
  - Internet sources are not always reliable
  - Easier to copy another's work
  - Students might skip thinking steps because they can google questions
- Less student-to-student and teacher student contact

Many of these challenges can be overcome with a good design. On some, the design has little influence, such as the technical issues a student might have. If their device is not working properly, the design cannot resolve it for example. The challenges will help form requirements for the design in chapter 5.



### 3. Methodology

The Creative Technology Design Process [29] is chosen to be the design guide for this research. It is a human centred approach consisting of divergence and convergence models combined with spiral models (see figure 2). Divergence refers to opening up the design space and generating ideas. Convergence is limiting down these ideas based on knowledge, which might be incomplete. The spiral model makes sure the designer can go back to previous steps for evaluation and reconsideration.

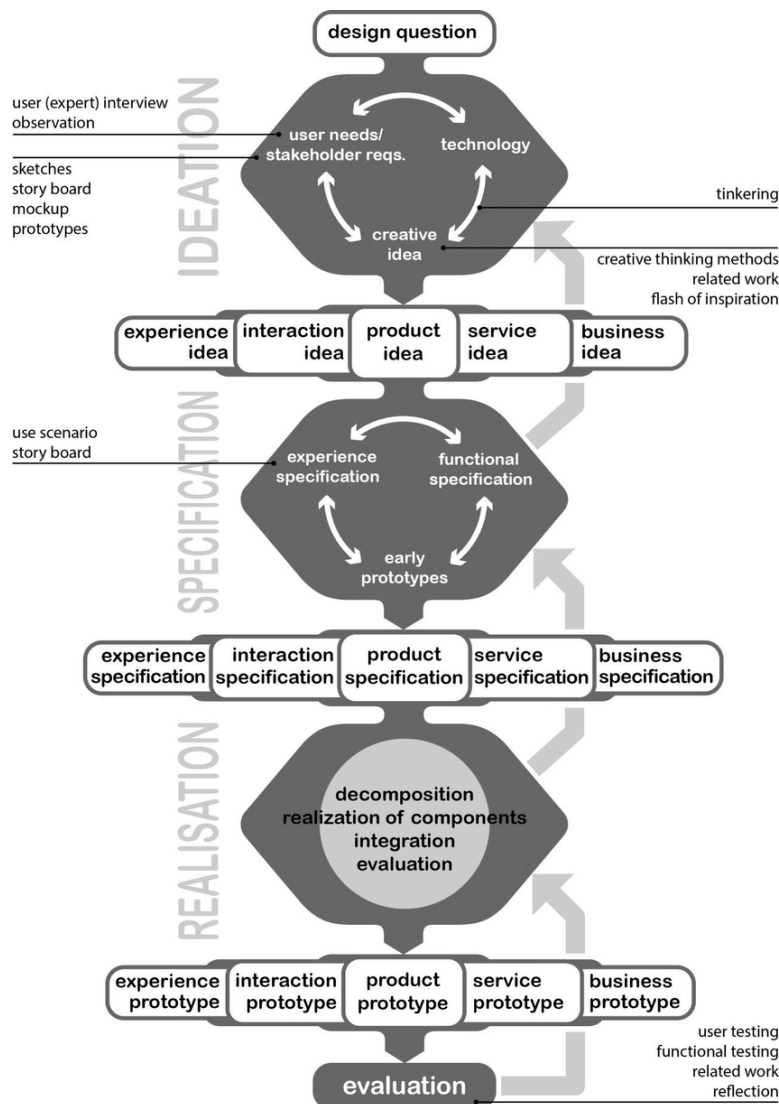


Figure 2: A Creative Technology Design Process. Source: [29]

#### 3.1. Ideation

The starting point of this research is a creative idea or rather problem which was identified in earlier studies during the educational minor of this bachelor. After that, the client was found who related to the problem. During this ideation phase, the preliminary requirements and stakeholders were identified with a user interview, whom is also expert in the field (teacher). The preliminary requirements were set as boundary constraints for a brainstorm which resulted in a mind map. This mind map was then evaluated again with the stakeholder which converged the design space by choosing one course to integrate CT in. Then another brainstorm was performed to generate concept ideas with the new set of requirements and diverged the design space again. These requirements were

also derived from literature research and related work. The possible ideas were discussed with the user and converged the possibilities again. The ideation phase is now completed, and preliminary requirements are set for the specification phase.

### 3.2. Specification

The preliminary requirements of the ideation phase will be translated to functional and non-functional requirements. These will be analysed with the MoSCoW method. MoSCoW stands for: Must have, Should have, Could have and Won't have. This will help focus first on the most important things to implement in the realisation phase. There will be a specification on how the requirements will be achieved. A list of components is made, and different CT puzzles will be linked to learning objectives. Lastly, the puzzles will be linked to the context of the escape room.

### 3.3. Realisation

With the set requirements after the specification phase, the high-fidelity prototype can be made. The implementation of all the requirements has a more linear approach so the spiral is typically not seen in this phase. After the implementation there will be an evaluation whether the functional requirements are met.

### 3.4. Evaluation

Finally, the (non)-functional requirements can be tested with user testing. Then it can be evaluated whether the prototype met all the requirements set in the specification phase. This evaluation will be done with 8 students of Guido who are in age and education level of the target group.

## 4. Ideation

This research started without the client and therefore the problem description was very broad. When GSG Hugo fulfilled the client role, it was crucial to place the problem to their context and needs. Therefore, a semi-structured interview, appendix B, was conducted with a teacher who has the role of expert on the topic as teacher, but also the role as possible end-user. Both roles were questioned during the interview.

### 4.1. User/Expert Interview

A semi structured interview was conducted with a lower secondary teacher of GSG Guido. The interview had as a main goal to limit the problem statement into a feasible design direction. To reach that goal, multiple questions had to be answered. These questions and summary answers are showed below:

Question	Summary answer
Does the school already teach digital literacy?	Partially. Parts of each domain are already integrated but there is no regulation and some only exist in extracurricular courses.
Which domains are integrated?	Parts of: ICT basic skills, media literacy, digital information. Computational thinking is only in a extracurricular course.
Is this split between courses or teachers?	Teachers take on parts that they think are important or have an interest in. There is no regulation yet.
Is there a learning method used?	No. Teachers make own material or combine free materials.
Which digital devices are used on the school?	All the learning material is available online and Its Learning is used for handing in assignments
What are the plans of the school regarding digital literacy?	Providing it in a more regulated way, so all the material will be covered. A group of teachers will take this task and make a digital learning line.
Which subdomain of digital literacy should the thesis focus on?	Computational thinking as that is the most difficult one to integrate.
What could be need(s) of teachers using the material to be designed	Easy to use and not a lot of background knowledge required.

Table 2: Summary Interview

#### 4.1.1. Conclusion interview

The school is in the beginning stage of making plans to provide digital literacy in a regulated way. Teachers who are interested take on task of making a plan and integrating it into their courses. Computational thinking seems to be the most difficult one to integrate and therefore the thesis focused on this subdomain. There will be no separate teacher for the course, and it is not decided yet in which course CT will be integrated in. However, LAT (learning atelier), which is an interdisciplinary course with project-based learning, is mentioned as a solution because it has the freedom to fill in its

own content. Parts of computational thinking are already incorporated in this course, but it is optional for students to follow.

#### 4.2. Brainstorm integrating CT

The interview resulted in a convergence of the problem statement, where the main focus lies now on CT. A brainstorm was performed and visualised in a mind map (Figure 3) on how CT can be integrated into the existing curriculum. There were some topics which had to be kept in mind during the brainstorm. As discussed in chapter 2, CT had 3 sub-categories: problem-solving thinking, working with digital data and procedures and algorithms. These are displayed in blue under topics. There were also some challenges identified, which are translated to goals for the brainstorm and displayed in yellow. In green, there are some of the most common teaching methods which can be used. The bottom of the mind map displays the actual brainstorm where in red the separate courses are mentioned with possible integration ideas. On the bottom right, some ideas are displayed which would be possible with the interdisciplinary course LAT.

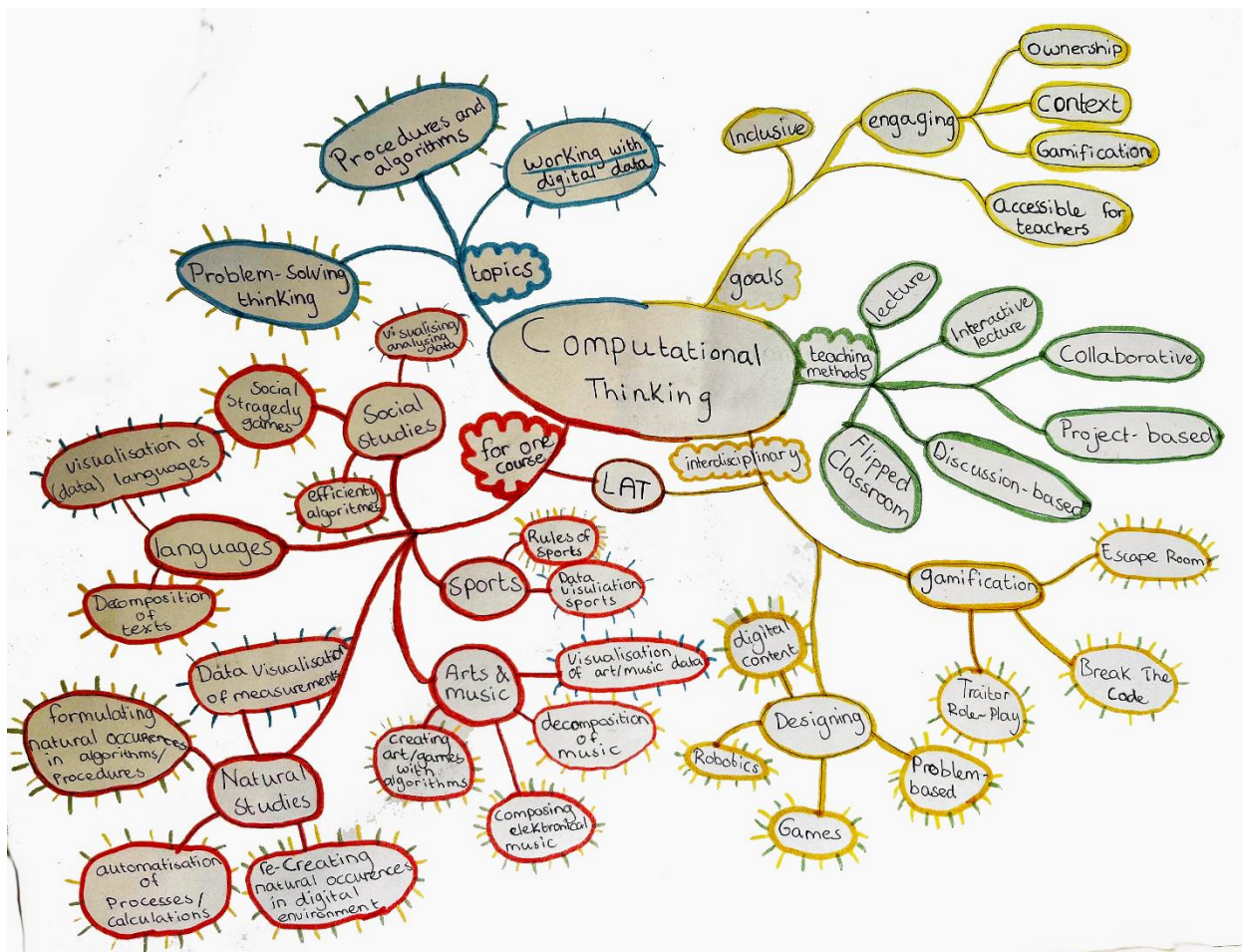


Figure 3: Mind Map Integration of CT

#### 4.2.1. Evaluation of the mind map

After finishing the mind map, a pattern became visible where the possible integration ideas were could be connected to the three subcategories of CT. The relation is visualised with the rays in colour around the solutions. Most solutions either refer to subcategory of working with data or to both procedures and algorithms and problem-solving thinking.

The mind map was also evaluated with the teacher of the interview. This evaluation resulted in some outcomes where we both agreed upon. The first one is that the design should focus the two subcategories: procedures and algorithms and problem-solving thinking. Finding a way to integrate working with data is easier and is in some courses already inherently done. The second conclusion is that there is more freedom in choosing LAT as the course for integration and allows for more interesting design options.

#### 4.3. Stakeholder analysis

Now that the design scope is more narrowed down, a stakeholder analysis can be performed. The analysis will be done according to the steps explained in [30]. A stakeholder analysis helps determining the interest and influence of the stakeholders on the product. The first step is to identify who the direct and indirect stakeholders are. Direct stakeholders interact with the product while indirect stakeholder does not directly interact but might be influenced by the product or influence the product. First, an explanation will be given on why they are stakeholder and whether their influence and interest are high or low. Influence refers to the power over whether the user makes use of the product. Interest is how they will be affected by the product. Second, an overview will be given in a table and lastly an influence-interest analysis will be performed.

##### 4.3.1. Direct Stakeholders

###### Students

Students will directly interact with the product. Therefore, their interest in the product is high. The influence could be considered low as they do not determine whether the product will be used or not within the school. However, since this is user centred research and they are the end user their influence in designing the product will be high.

###### LAT Teachers

LAT Teachers will also directly interact with the product, but they have different interests than students. Their interest and influence are high as well because they decide the learning methods and tools that are used.

##### 4.3.2. Indirect Stakeholders

###### Teachers

Teachers of other courses than LAT, might be indirectly influenced by the product due to the reaction of students. For example, if the product causes a lot of stress or workload, it might influence the performance of students on their course. However, their interest and influence are probably both low.

### Parents

Parents of the students might have interest if personal data of students is gathered or an online platform is made. They want their children to have a safe environment. Looking at other materials discussed in chapter 2, they will most likely have low interest and low influence.

### School Board

The school board has a final say in which material will be used, especially if money is involved. They have also interest in good performance of the students. As a consequence, their influence will be high, but their interest will be low.

#### 4.3.3. Overview of stakeholder interest and influence

Stakeholder	Interest	Influence	Estimated priority
Student	-Engaging product -Learning CT -Security of data	High	1
LAT Teacher	-Performance of student -Not a lot of background knowledge needed -Overview of students -Keeping workload low -Security of data -Wellbeing of student -Costs	High	2
School Board	-Costs -Performance of students -Wellbeing of students	High	3
Teacher (other courses)	-No interference with their course -Wellbeing of student	Low	4
Parents	-Wellbeing of students -Security of data	Low	5

Table 3: Stakeholder Interest

Now that the overview is made, the stakeholders can be placed on the influence-interest grid. This will help set the requirements in importance as well as keeping an overview of who should be considered with designing.

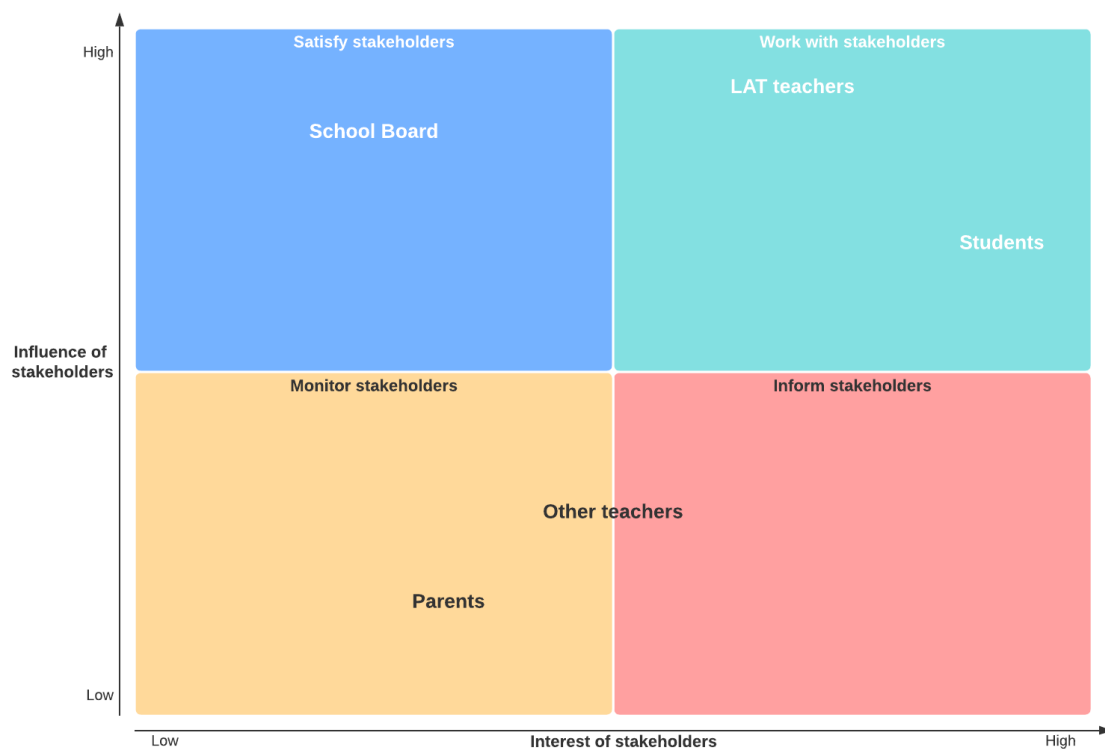


Figure 4: Influence-Interest grid

#### 4.4. Preliminary requirements

After the background research, the interviews and the stakeholder analysis, some preliminary requirements can be set. The requirements from the stakeholder analysis are made by looking from their perspective to the product. The requirements on top have a higher priority than those on the bottom. Later when the MoSCoW analysis is conducted they will be given further estimation of priority. The requirements will help later in evaluating the brainstorm session on whether the ideas are viable.

Requirements	Source
Should contain both procedures and algorithms and problem-solving thinking	Interview
Should be engaging for students	Background research
Should be easy to implement for teachers	Interview, background research
Accessible for students with medium level digital literacy	Background research
No prior knowledge of CT skills is needed for use	Interview
Make use of collaboration between students	Interview, background research
Gives an overview of progress of students	Stakeholder analysis
Should have a physical aspect to it	Background research

Table 4: Preliminary Requirements



#### 4.5. Concept generation

Another brainstorm will be needed to generate ideas about the concept. A brainstorm matrix is used to help guide the brainstorm. The earlier discussed three learning methods are put against teaching methods, which are also used in the mind map. To ensure that these do not limit the creativity, 'other' is added on both axes. The requirement that all ideas must contain is that they can address the learning objectives that apply to procedures and algorithms and problem-solving thinking, since this is the most important one. To guarantee that the ideas are new and kick-start the brainstorm, the CT materials from Table 1 were placed first in the matrix. These are coloured blue in Figure 5 and can be found without the ideas in Appendix C: Existing Ideas in MatrixC. After identifying where the current materials belong in the matrix, it is easier to see what does not exist yet for CT. The blue arrows in the matrix show that there is overlap between some of the cells. For example, the BYOR (Built Your Own Robot) is design based and collaborative. However, it was placed at design based because one person could do it by themselves. Collaboration in robotics for education is also done to reduce costs as it cheaper to buy a set for multiple students than let each student have their own.

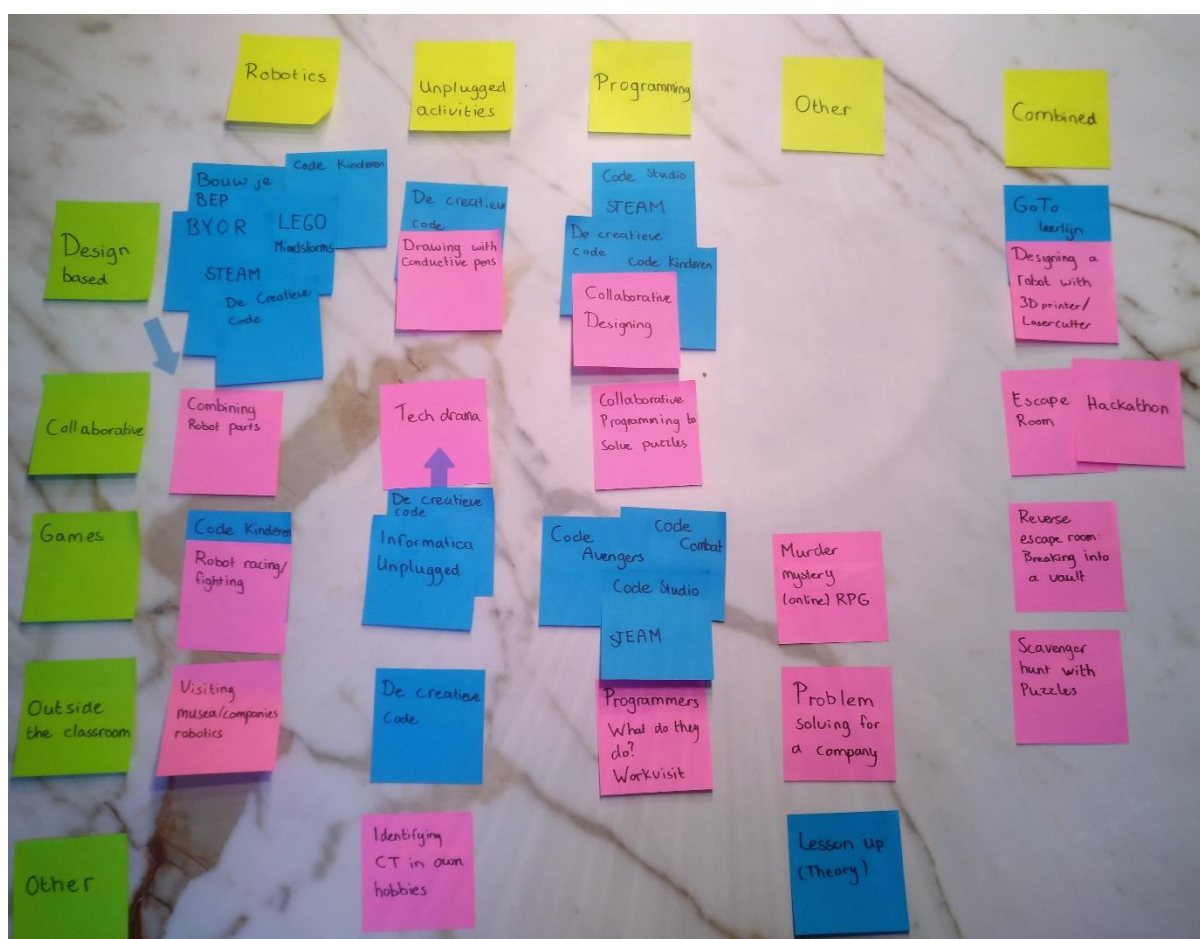


Figure 5: Brainstorm Matrix

The image below is the result of the brainstorm session and the new ideas are presented in pink. After the brainstorm session, the ideas were analysed by placing them on a value-feasibility grid. Feasibility is determined by how easy it would be to implement for this thesis, where timeframe and resources are the most limiting factors. Value is determined by how many of the preliminary



requirements of Table 4 could be implemented and originality. The grid is divided in 4 areas: A, B, C and D. The yellow notes are critical thoughts.

A: Feasible but low in value. Could more value be added to these ideas?

B: Feasible and high in value. Further conceptualise.

C: Low feasibility and low in value. Discarded for this project.

D: High in value and low in feasibility. Can changes be made to make it more feasible?

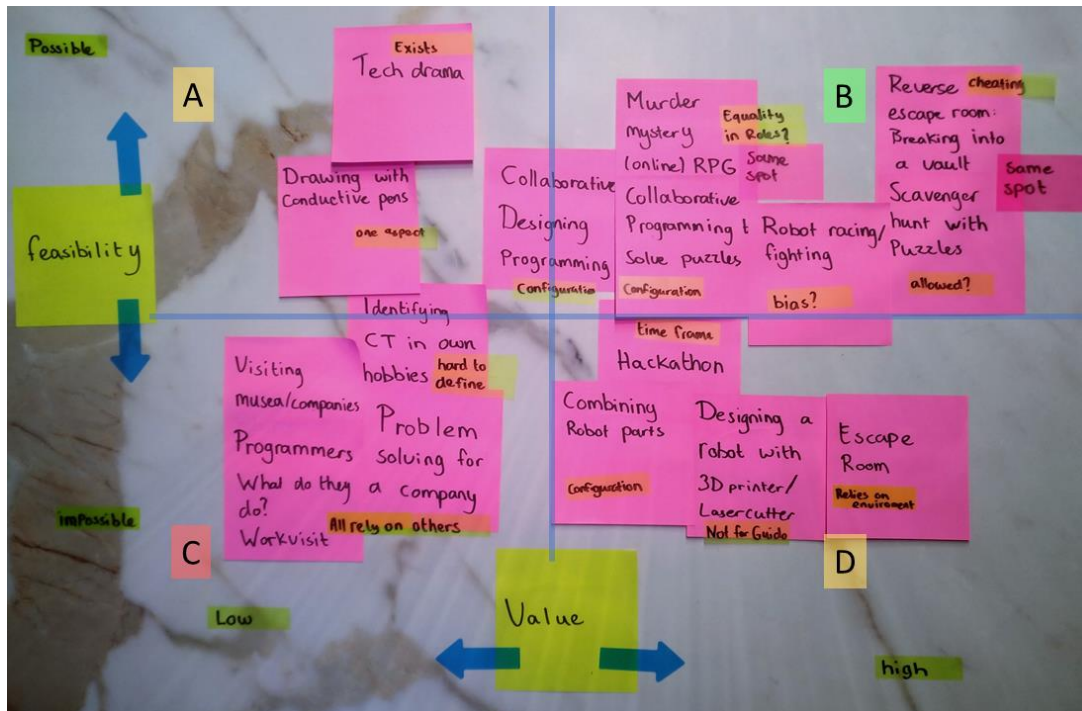


Figure 6: Value-Feasibility Grid

#### 4.5.1. Idea description

The ideas in the matrix that were placed in area B will be explained shortly for evaluation with the teacher(s). The matrix itself will also be shown as they might have different ideas and insights about it.

##### Murder Mystery (online) RPG

RPGs such as Weerwolven van Wakkerdam [31], Avalon [32] and Mafia [33] are hidden identity games where you have to gather information to find out the identity of the other players. This information is usually retrieved by a special power of your own role, such as the ability to ask game master a question. In order to connect this with CT, the game master should give out cryptic puzzle messages to the players. The games are originally played offline with cards, but online versions are available as well. An online based RPG is for example Among Us [34], where cognitive tasks have to be done in order not to lose the game. This project probably benefits most from a hybrid version of a RPG, as then most requirements can be met. A critical note is how to make sure that the roles are in workload evenly divided and how to make sure the learning objectives are met before the game ends.

### Programming Collaborative

Most programming tools currently used for CT allow for working together but do not make it a necessity to accomplish the end result. My personal experience is that collaborating with someone of a different programming level, results in a disbalance of work division. As a consequence, not every student meets the learning objective while they might pass the course. This can lead to problems in the future because the student cannot continue a follow up course with missing basic knowledge. A way to tackle this would be to make the collaboration part central. The program must be designed in such a way that they have to work together in order to reach the end goal. A puzzle-platform game such as Portal [35], would be a good starting point to achieve such program.

### Robot Racing/Fighting

Many of the current robotics sets for education are used with groups of about 8 students. This oftentimes leads to a division of work where not each student gets to be in touch with the CT part, which is in this case mostly programming. Making the robots simpler than the current ones, would reduce costs and gives the opportunity to work in pairs. Adding a competitive element such as racing or fighting can make it more engaging. Leaving out the physical appearance reduces costs and gives the opportunity to let the students create their own exterior. The prototype would be a toolbox with a robot, a guide how to program and possibly craft material. A starting point for the robot would be something like the Maqueen robot [36].

### Breaking into a Vault

An escape room allows for a lot of CT and having a game element. A limiting factor of it is that all the students are locked up in one space and therefore the design relies on the space, most likely a classroom. Therefore, it would not be easy to implement for a teacher, with a different setup. A reverse procedure would be to break into a room or vault. This takes away the limitation of the space and even time, since breaking in does not rely on a time frame necessarily. A vault can have a code and that code can be retrieved by solving problems which could be based both on and offline. These problems are based on CT related content.

### Scavenger Hunt

For students, it might be a welcome change to base some of the education activities outside the classroom. Just as breaking into a vault, this game would be based on CT problems where the solution would lead to a location instead of a code. A competitive element can be added by having a platform where students can see how many locations, which translates to something like badges, another student has visited. Students would work preferably in pairs. This idea is derived from Pokémon Go [37], where people could 'gather' Pokémon by walking around in real life. It is a very successful implementation of a hybrid location-based game.

## 4.6. Co-Creation

In a co-creation session with the client, the ideas of the concept generation were evaluated. The client was briefed before the session with the descriptions and the grid. The aim is to choose a design

direction and give the client the opportunity to make suggestions. This was done by having an open discussion with the ideas on the table.

At the start of the session, we ran through the ideas together to give the client time to ask questions and make sure that everything was understood. After this was ensured, the discussion could start where the client was given the lead on mentioning things that they disliked. With this, some of the ideas could be cancelled out. The client foresees that programming collaborative and robot racing or fighting would be too much of a hurdle for teachers to use as they would need to know some programming language. For the scavenger hunt, the client expects the lack of monitoring of students to likely become problematic as they might disturb others in their search. Then the two ideas of the RPG and the breaking into a vault are left over. Together we concluded that the latter would be more interesting since it gives more opportunity to implement different types of puzzles. The client found it also more appealing since collaboration plays a big part in this idea.

Now that the decision is made between, there is room for suggestion on the design. There was no preference for the storyline for the 'reversed' escape room. Two suggestions were made for the design: a manual for teachers and the option for different puzzles per group in one game. The last suggestion is made because it would enhance the competition between teams. Cheating by checking other groups solution would not be possible. Additionally, there could be a differentiation in level of difficulty in the puzzles. This will lead to a fairer competition where the outcome is not predicted by the most intelligent team as they could be served with a more difficult set.

The chosen idea is merely a framework where computational thinking puzzles can be put in. Solutions of each puzzle will be a partial solution for the final solution. CS4FN [38] and Informatica Unplugged [39] have lists with puzzles for inspiration. A list with various computational thinking puzzles can be found in Appendix D: Computational Thinking PuzzlesD. This list will later be revisited when choosing a selection of these puzzles for the prototype.

#### 4.7. Background on educational escape rooms

The idea of breaking into a vault instead of breaking out of a room is chosen because it is more practical to implement. However, the implementation can be approached as an escape room. Before thinking of a storyline, literature needs to be reviewed so (non) practical suggestions can be taken into account. Veltkamp et al. [40] conducted a systematic review on 39 educational escape rooms. Based on the findings in this research, they made recommendations for making an educational escape room. A summary of these recommendations and findings are provided below.

- Alignment of the puzzles and the context of the puzzles themselves should be aligned with the learning goals. The alignment options were divided into three categories, see Figure 7

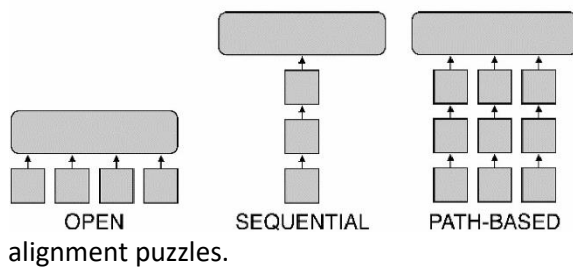


Figure 7 alignment puzzles. Source: [40]

A path-based or hybrid alignment is recommended when the teaching method is collaborative. Teams will split up with a path-based alignment so that they can work faster, divide and concur method, and this will ensure that they have to discuss the sub-solutions and work together to the end solution.

- Optimal team size is 4 students. Bigger will lead to freeriding and lack of overview by the students themselves as well as the teacher.
- The presence of a teacher does not have a negative impact on the level of autonomy and immersion in the game. Letting the teacher have a predefined role in the escape room will help them guide and monitor the students. An active role in the narrative of the escape room will lead to more immersion.
- Debriefing is crucial for the learning goals. It will help them connect the puzzles to the context of the subject. It is also done in recreational escape rooms to satisfy the need of the players to know all the answers.
- Grading is not necessary for external motivation as students highly enjoy the activity.

The last point will cover one of the preliminary requirements that were set, since students highly engage in the activity according to this review. However, one of the concerns described in Current Problems of Chapter 2 is that current material is more engaging for male student due to the topic and context. To find out whether escape rooms have a bias, it might be useful to know the target population of recreational escape rooms. Van Spronsen en Partners investigated this in [41] and found out there is no difference between numbers of male and female escape room visitors in the Netherlands. This finding is confirmed in [42] where the survey answers are from escape rooms all around the world with the majority in Europe. It is very likely that the context of the escape room might have a strong bias, but from these results can be concluded that the game itself is engaging for both genders.

#### 4.8. Storyline and Final Concept

The storyline of the escape room has a few boundary conditions. These should be considered while making the story.

- The teacher should have a role which fits the narrative
- Students are breaking into something like a vault. So, that should contain either something dangerous, valuable or secretive.
- It should make sense in the story that multiple people are in one room and work in teams trying to break into something.
- Should allow for different puzzles per team.
- Could allow for competition between teams.

With these boundary conditions the storyline beneath is written:

A class of Guido breaks into the Rabobank in Amersfoort at night. Their accomplice, the teacher, is a former Rabobank employee and knows how the security system works. She leads the group to the office room where the vault is with the key to open the ATMs in the building. The accomplice knows that you can open the vault with a staff pass and a unique code. However, she does not know the code of any of the staff members, so the group must find out for themselves. They decide to split into groups of 4 and all inspect a staff member's desk looking for the code. Rabobank has a policy that vault codes may not be written down for reasons of security. However, staff members are allowed to use an indirect way to write down the code so that if they forget it, they can still retrieve it.

Although the idea was to split the loot between all members of the group, several groups are secretly negotiating to break this agreement as soon as they get their hands on the code. Dividing thousands of euros over 4 people instead of the whole group is of course much more profitable...

The sketches beneath visualise the concept. The last figure of this section will be used to inspire in how to integrate the puzzles into the context of an office desk.



Figure 8 Office Desk





## 5. Specification

The preliminary requirements were set in chapter 4. First there will be an expansion upon Table 4: Preliminary Requirements and analysed with the MoSCoW method [43]. Afterwards, will be specified how these requirements will be met. The realisation of the requirements and thus the product will be done in the next chapter.

### 5.1. MoSCoW analysis

The table made with preliminary requirements in chapter four were made before knowing the final concept. Therefore, some requirements are missing and some need to be finetuned to fit the context. A division is made between functional and non-functional requirements as the evaluation of these will be done in chapter 6 and 7 accordingly.

A MoSCoW analysis is done to order requirements in importance and therefore give a priority during the realisation phase. MoSCoW is an acronym for Must have, Should have, Could have and Won't have. Must have is the highest importance and Won't have the lowest. Must have can be defined as something the prototype must have and otherwise it is not successful. Requirements denoted with should are essential for the prototype but not vital like the must have. Could have are defined as requirements that are nice to have but not vital nor essential. Won't have is for requirements that could be implemented in the future. Requirements that were made by the client have a high priority because the prototype is made for them.

Number	Functional Requirement	Source	Priority
FR1	Contains puzzles that cover the learning objectives of procedures & algorithms and problem-solving thinking.	Interview	Must
FR2	A vault that can be opened with a unique code per team	Co-Creation	Must
FR3	A guide for debriefing after the activity	Ideation	Should
FR4	An automatic overview of the progress of students	Stakeholder analysis	Won't
FR5	Red LED on the vault to showcase the state of the vault: password correct/incorrect.	Ideation	Could
FR6	Escape room and debriefing should not take more than 1.5 hours	Interview	Must
FR7	Site or app where teachers can change the passwords of the RFID	Ideation	Won't
FR8	Puzzles in context of escape room	Ideation	Should

*Table 5 Functional requirements*

Number	Non-Functional Requirement	Source	Priority
NFR1	No prior knowledge of CT, especially programming, needed for teachers	Interview	Must
NFR2	Engaging for students	Background	Should
NFR3	Stimulate collaboration between students	Interview	Should

Table 6 Non-functional requirements

## 5.2. Requirement specification

Now that the requirements are prioritised, it can be specified how the requirements will be met. This will be done in this section by referring to the numbers of the requirements. (N)FRx is an acronym for (Non)-Functional Requirement and the number. It will only be worked out for the requirements with priority must or should. Afterwards it will be specified how the requirements will be evaluated on whether they met the goal.

### 5.2.1. FR1 & NFR1

FR1: Contains puzzles that cover the learning objectives of procedures & algorithms and problem-solving thinking.

NFR1: No prior knowledge of CT, especially programming, needed for teachers

The puzzles provided in Appendix D: Computational Thinking PuzzlesD are puzzles related to computational thinking but not yet categorised by learning objective. These will be categorised with the division SLO made in [11]. SLO provided some context on what a student should be able to do and this will be compared with the puzzles, ensuring the best fit. The categories are reformulating problems, collecting data, problem decomposition, automation, algorithms and procedures, parallelisation, pattern recognition, abstraction, simulation and optimisation. Some of the puzzles will have overlap as many of these categories have overlap as well. The puzzles are categorized under the assumption that there will follow a debriefing on them after the activity. There is also a time indication for some puzzles as this will help structuring the alignment later. The places where the ~ symbol is used means that the given time is the least possible time the puzzle could be solved. The time indication is derived from [39] and [38]. By making the puzzle more complex, more time would be needed to solve it.

Puzzle	Learning Objective Category	Time indication
Towers of Hanoi	Algorithms and procedures	10 min.
Spanning Tree	Automation, optimisation	5 min. ~
Sliding puzzles	Decomposition	5min. ~
Sudoku variants; nonogram	Pattern recognition	5 min. ~
Encryption	Algorithms and procedures, pattern recognition	5 min. ~
Maze	Reformulation, simulation	5 min. ~
Logic puzzles	Problem decomposition, collecting data	20 min. ~
Compression code puzzles	Pattern recognition	5 min. ~



Sorting stacks	Algorithms and procedures	5 min. ~
Sequencing puzzles/riddles	Abstraction, decomposition	5 min. ~
Detecting errors	Algorithms and procedures	15 min.





Table 7 Learning Objectives of Puzzles

A variety of these learning objectives will be chosen but not all, since there are simply too much to put in one escape room. Note that parallelisation is not mentioned in the learning objectives of the CT puzzles as it refers to planning and working together as well as combining solutions to achieve a goal. This learning objective will be covered by the nature of the game as a whole.

### 5.2.2. FR2

FR2: A vault that can be opened with a unique code per team.

The vault needs a microcontroller to check whether the combination of the code and the identifier is correct. The identifier will be the staff pass and the code will be the combined answer of the puzzles. The lock should be electronically controllable as well. A few hardware components are needed to realise this and are listed in the table below.

Component	Function	Image
Arduino Mega	To check the combination of pass and code and control the lock.	
Electronic lock	To control the lock of the vault. Giving a high signal 5V and 1.2 mA will open the lock.	
5V relay	Arduino does not have a 1.2 A output with 5V. The lock will have a separate power supply which will be converted to 5V with the relay.	
RFID reader RC522	To check the RFID card ID	




RFID card	Is the identifier for a group	
Keypad	Input device for the vault. This is where the code can be put in.	
Vault	Houses the electronics and the fictional key to the ATM machines. The vault is just simply a wooden cabinet with a door. Dimensions: 35x35x35 cm.	

Table 8 Hardware Components

All the electronics can be bought at [44] and this is also the source of the images in the table.

#### 5.2.3. FR3

FR3: A guide for debriefing after the activity.

The debriefing is needed to let the students connect the puzzles to real world applications and approaches to that. In addition, the teacher can check whether the learning objectives are met. The guide will be written for the teacher with examples on what they can ask the students and how it should be connected to the real world. As there might be variation in the time it takes to complete the escape room, the guide will provide a short version and a longer one. The short version will cover the necessary topics and the longer one provides more in-depth content and examples.

#### 5.2.4. FR6 & NFR3

FR6: Escape room and debriefing should not take more than 1.5 hours.

NFR3: Stimulate collaboration between students

There is no hard deadline of a set time beforehand since it relies on the competition between teams. However, the client has lessons of 45 minutes with two in a row. This means that the maximum of the whole activity cannot take longer than 90 minutes. The preparation time of setting everything into place will be outside these 90 minutes. The description of the setting and the rules will take approximately 5 minutes. The aim for the puzzles is to take 60 till 75 minutes to solve, leaving 25 or 10 minutes for the debriefing accordingly.

A path-based alignment was recommended for stimulating collaboration between students. This means multiple puzzles should be always solvable, so teams are inclined to split up and discuss results

while solving. There is no necessity to have a lot of paths, since the teams will consist of 4 members so more than that has no use. Two to three paths are probably the optimum for this configuration as collaboration is needed while still having an overview of the progress.

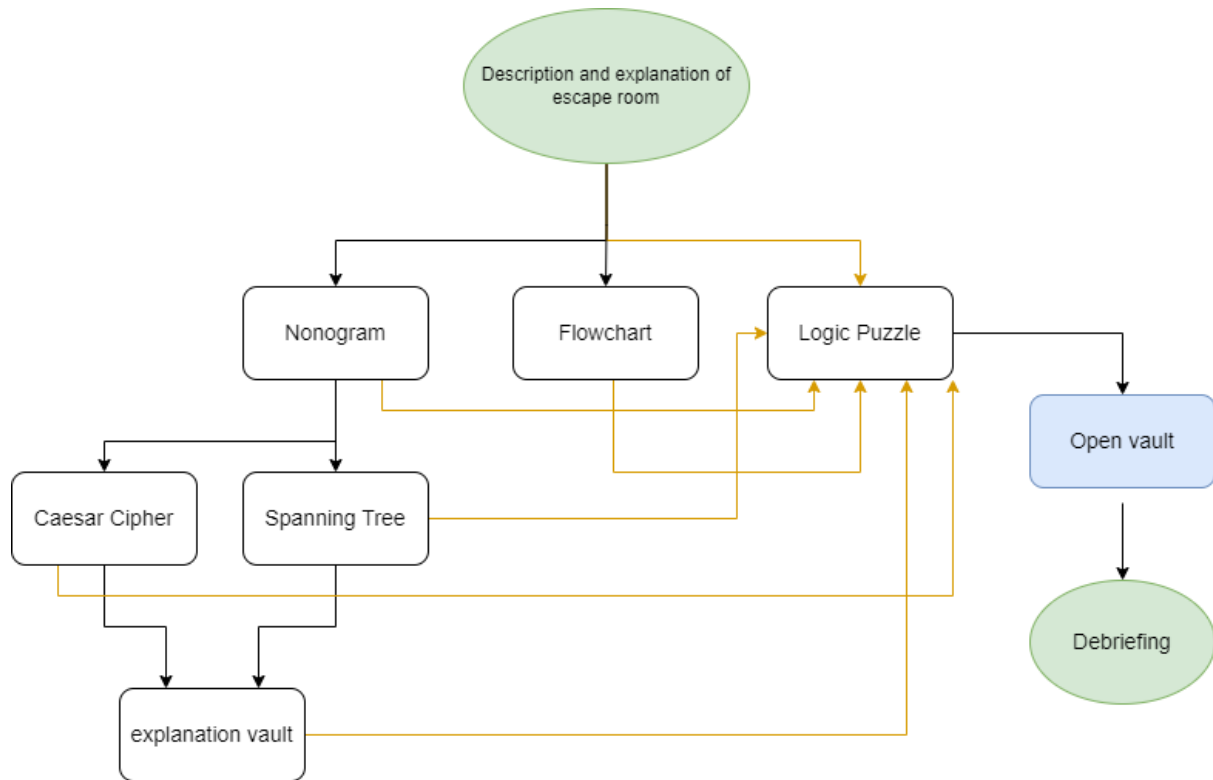


Figure 11 Logic of Escape Room

The diagram below shows the sequence and paths of the puzzles. The arrow means that one puzzle has to be solved in order to start with the other. The yellow arrows are cues for the logic puzzle. A selection is made of the puzzles that are mentioned in Table 7 Learning Objectives of Puzzles based on time and learning objective in a way that there are multiple covered. The shortest expected time that the escape room could be solved is according to Table 7 Learning Objectives of Puzzles 30 minutes. However, many puzzles depend on the level of difficulty of the puzzles. The time also assumes no errors are made and students know directly what to do.

#### 5.2.5. FR8

FR8: Puzzles should be in context of escape room.

Figure 9 Mood Board Office Supplies, provides some context of what supplies that lie on a typical office desk. A short overview of the puzzles in context is given in the table below. In chapter 6 Realisation the full explanation is given.

Puzzle	Context/place
--------	---------------

Nonogram	The outcome of the nonogram gives the password of the email program on the laptop. It can be found in the notebook of the employee.
Flowchart	On the desk there is a list of all the employees with their personnel number and the department they work in
Caesar Cipher	Another employee sent an email to the desk to be investigated. The email is on the laptop but decoded with the Caesar cipher.
Spanning Tree	The spanning tree is also in an email where another employee asks to find the shortest path while visiting all the nodes.
Logic Puzzle	Cues can be found on the desk and in the emailing program. It will be in the context of office rumours where one of the employees on the employee list has done something. The cues lead to a person and the personnel number of that person will be the code to open the vault.

*Table 9 Puzzles in Context*

## 6. Realisation

The previous chapter specified how the requirements would be implemented in the context of the escape room. In this chapter, the escape room will be realised. It will start by building the vault with the components of Table 8 Hardware Components Afterwards the puzzles will be made into the context of the escape room. Finally, the email client will be realised and the debriefing. A part of the functional requirements can be evaluated in the end of the chapter. The requirements that need user testing, will be evaluated in chapter 7.

### 6.1. The Vault

The vaults to have a RFID reader to check whether the ID of the card corresponds with the password that will be put in by the user via a keypad. If this is true, the lock should open. The lock, keypad and RFID reader are controlled by an Arduino Mega. The Mega version was needed because of the amount of input pins. The lock needs relatively high current to be opened, 1.2 A, which the Arduino cannot provide. Therefore, it needs a separate power supply and since batteries are not ideal to draw peak

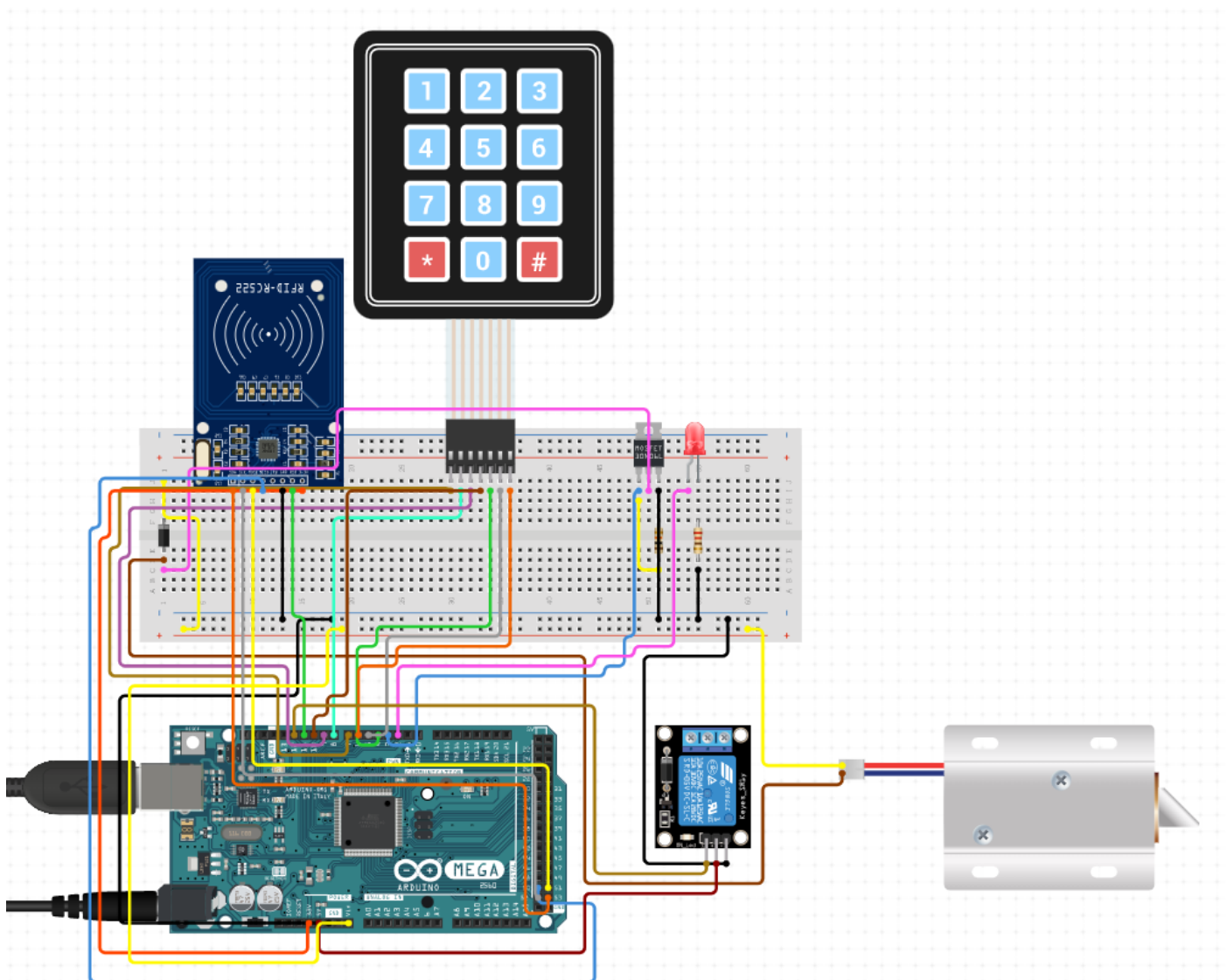


Figure 12 Vault Schematic

current, the lock has to be powered by wall power outlet. The 230V AC outlet is transformed to 5V DC with a relay and high enough current, max 10A. The Figure 12 Vault Schematic shows the schematic of the components with a 12V lock instead of the 5V lock, since it was not available in [45]. In Appendix E: Vault Code, the Arduino code can be found. The code is made for two RFID cards, but more can be easily added on. Tutorial [46] was used to make the lock and the keypad and RFID tutorial [47] for the reader. The combination of the two makes the vault and a red LED is added for the user to see if they put in incorrect input.

The lock has two ways to open: by supplying power or by pushing down the small lever in the back, see red circle in figure below.



Figure 13 5V Lock

Since the lock is in the inside of the vault and should also be able to be opened manually in case of an error. A small hole will be made in the vault so the lever can be pushed down from the outside with a bobby pin.

The next few images show what the final prototype looks like. Simple tools were needed to put it all together like screwdrivers and a drill. The framework is a DIY EKET Ikea cabinet [48].



Figure 14 Front Vault



Figure 16 Side of Vault with Hole

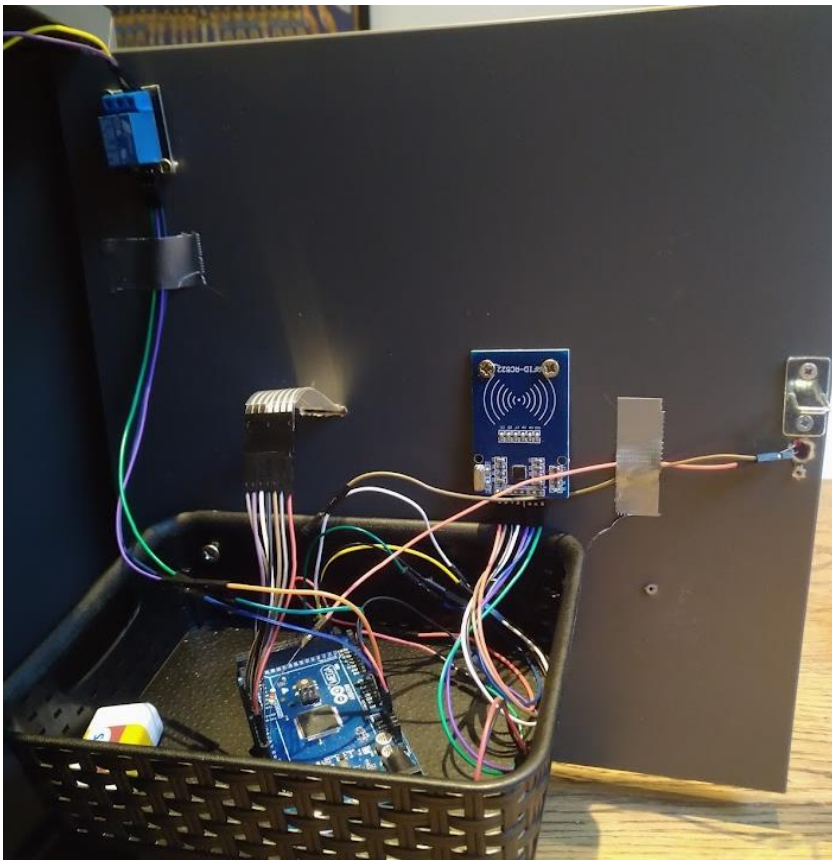


Figure 15 Inside of Door



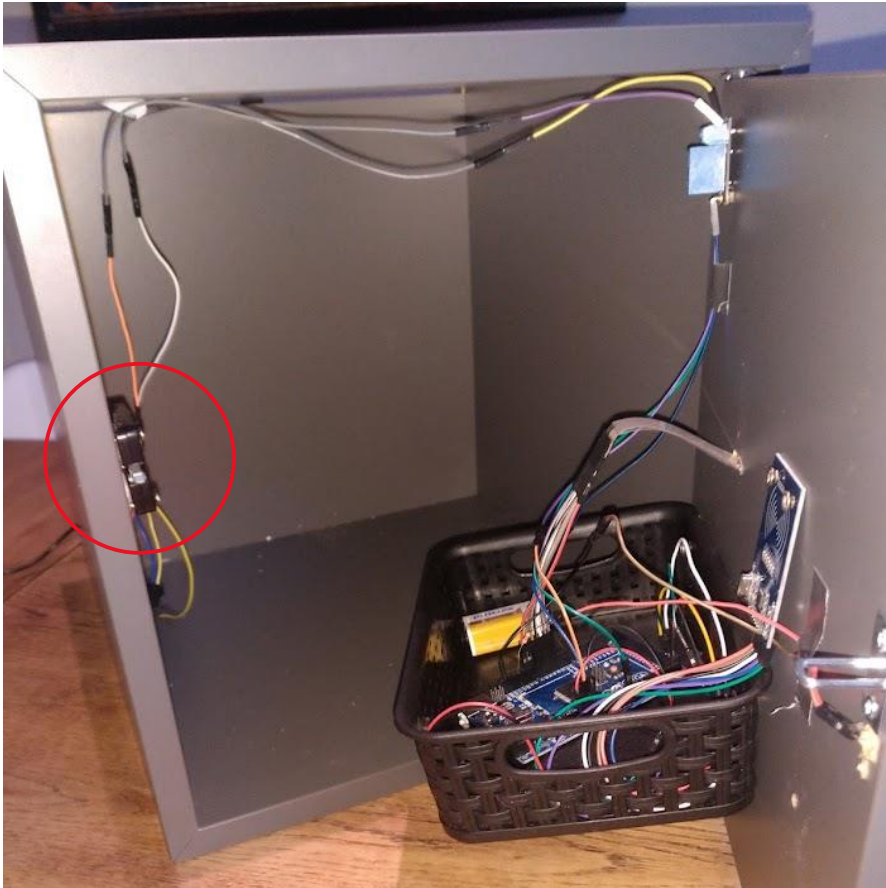


Figure 17 Door Open

The lock can be found in the red circle. In the back left corner of the vault, there is a small hole for the power cable. The basket holds the Arduino and the 9V battery.

## 6.2. Puzzles

Table 9 Puzzles in Context, shows how the puzzles will be linked to the context of the office desk. This section shows exactly how the puzzles will look like and what their solutions are. For the prototype, one set of puzzles will be made. In real setting, different configuration of puzzles are possible and different levels of difficulty can be made.

### 6.2.1. Nonogram

A Nonogram is a puzzle where cells in a grid must be coloured or left blank according to values given at the side of the grid to reveal a hidden image. The values display how many coloured cells are in line with that column or row. It can be solved by finding links between the values. A solved example can be found in Figure 18 Solved Nonogram below. The to be solved ones used in the prototype can be found in Appendix F: Nonograms These 5 Nonograms were made with [49] and together spell out *zout3*. This is the password to the email client. The puzzles can be found in a notebook on the desk. A whole overview of the setting can be found in Figure 22 Setup.



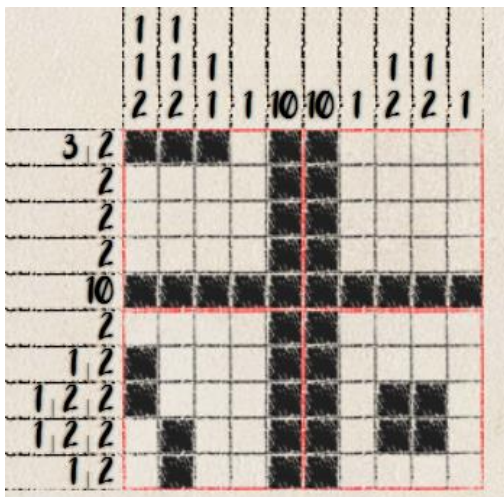


Figure 18 Solved Nonogram

### 6.2.2. Flowchart

On the desk of the employee there lies a list with all the employees, their personnel numbers and the department they work in. This list can be found in Appendix G:G and contains 200 employees. This list contains all the information they need to solve the flowchart below.

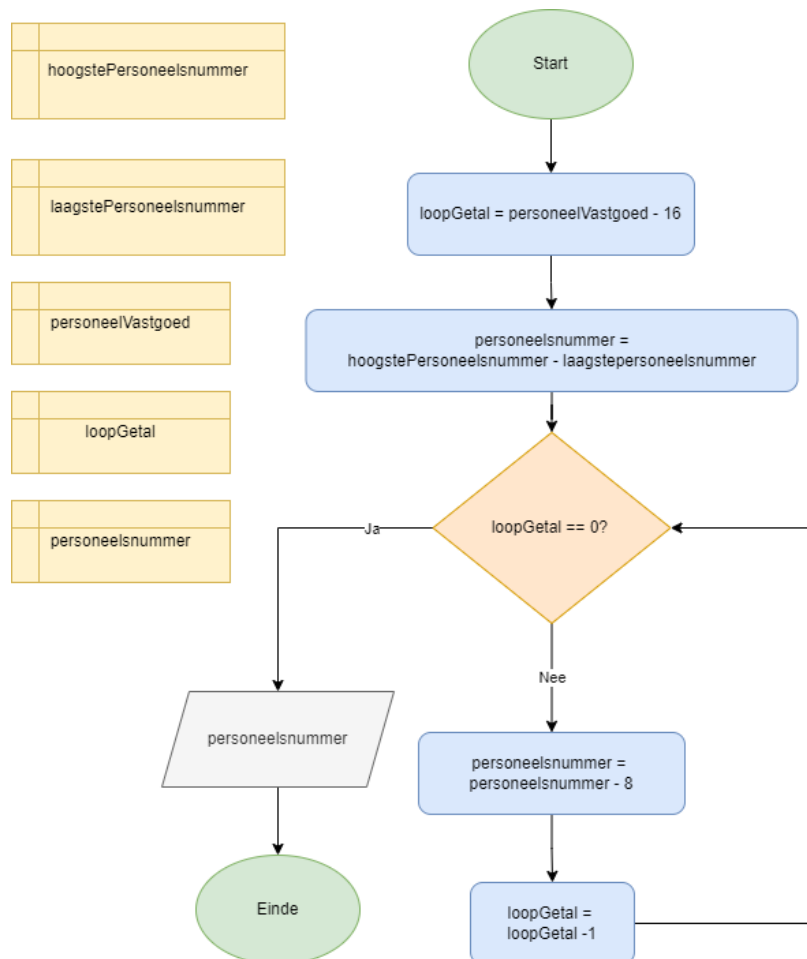


Figure 19 Flowchart

The outcome leads to a personnel number which leads to a cue for the logic puzzle. At the bottom of the flowchart, there is a note that says: “The employee with personeelsnummer is allergic to fish and doesn’t like peanut soup.” If student solve the flowchart they will find out that the solution is number 96566738. Which belongs to Brooklyn Brady. The names of the employees are randomly generated with [50] and the personnel numbers with [51].

6.2.3. Spanning Tree

Within the email client, another employee asks the question which the quickest path is to deliver invites to the houses of a couple employees for a staff party. The nodes of the spanning tree must represent their houses. The spanning tree below is made with [52] and during the debriefing an explanation is given on Kruskal’s algorithm. The solution is 27.

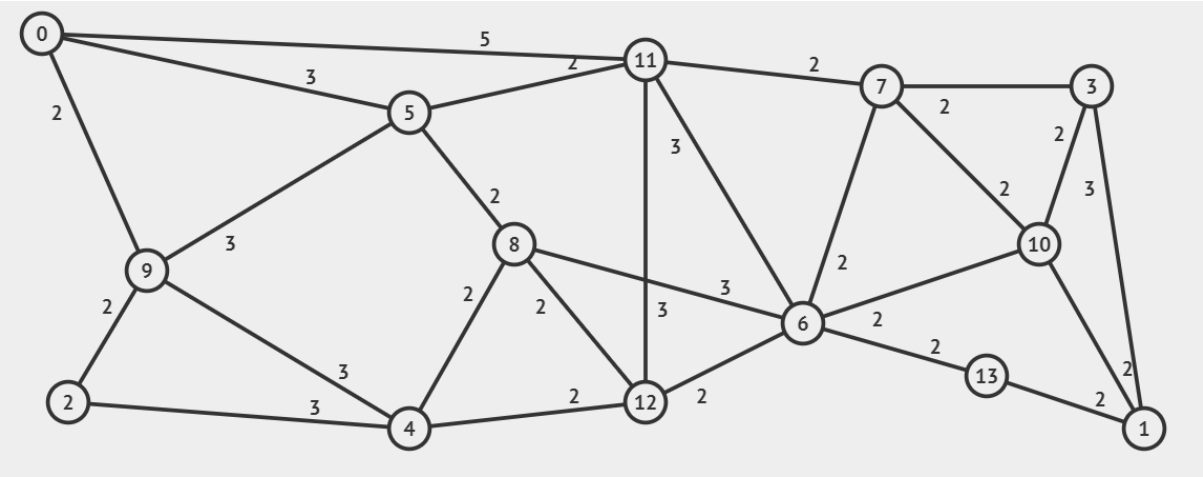


Figure 20 Spanning Tree

6.2.4. Caesar Cipher

In the email client there is email which is encoded with Caesar cipher. The topic of the email leads to the partial solution of the page that explains how to open the vault. The content of the email has some cues for solving the logic puzzle. Caesar cipher works with a shift for all the letters in the alphabet. This message is encrypted with key 11, which means that the a is the letter l and the b is the letter m and so on. The table below shows the encrypted message and the decrypted message. The topic is: nlpdlc ntaspc, which encodes to Caesar cipher.

Encrypted	Decrypted
Rzpopxtoolr!	Good afternoon!
Qtuy ole up spe mpoctuqdfteup htwe zcrlytdpcpy. Tv spm rppy lwwpctëy, xllc tv szza ytpë ole pc lwwppy yldt kzlwd mtu op vlyetyp gly op vwlyepydpçgtnp.	Thank you for organizing the staff party. I don't have any allergies, but I hope it's not just fried rice like at the customer service canteen.
Xpe gctpyopwtuvc rczpe, Rhpyozwjy	Yours sincerely, Gwendolyn

Table 10 Encrypted message

### 6.2.5. Logic Puzzle

The logic puzzle is linked to a rumour in the office: Who did Steven kiss with? Steven had to go to the hospital after the kiss, since he is very allergic to peanuts and the person he kissed with had peanut soup with lunch. The context of the logic puzzle described above is given in an email. The person with whom Steven kissed with is described in the email as culprit. The cues can be found in different places: on the desk on the bottom of the pen tray, in the sticky notes on the desk and in the context of the emails. All those cues lead to an elimination of possibilities. The 'culprit' has multiple attributes: the name, hair colour, department they work in and what they had for lunch. The last attribute leads to the solution: the person with whom Steven kissed had peanut soup for lunch. The context of the logic puzzle was chosen in this way to have a topic which is widely popular in drama series. Expectantly, the students will not think of solving a boring puzzle but rather interesting rumour.

	V a s t	K l a n t	H y p o	V e r z	B e l	R o o d	Z w a r t	B l o n d	G r i j s	B r u i n	S a n d	N a s i	P i n d	T o n	T o s t
Rylee	X								X		X				
Natalia					X		X						X		
Brooklynn		X				X						X			
Addison				X						X				X	
Gwendolynn			X					X							X
Sandwich	X								X						
Nasi		X				X									
Pinda soep					X		X								
Tonijnsalade				X						X					
Tosti			X					X							
Rood		X													
Zwart					X										
Blond			X												
Grijs	X														
Bruin				X											

Figure 21 Logic Puzzle Grid

Dutch word	Abbreviation in grid	Translation
Vastgoed	Vast	Real estate
Klantenservice	Klant	Customer service
Hypotheek	Hypo	Mortgage
Beleggen	Bel	Investments
Verzekeren	Verz	Insurance

Rood		Red
Zwart		Black
Bruin		Brown
Grijs		Grey
Blond		Blonde
Nasi		Nasi
Tosti	Tost	Grilled cheese sandwich
Sandwich	Sand	Sandwich
Pinda soep	Pind	Peanut soup
Tonijnsalade	Ton	Tuna salad

Table 11 Translation words

Cues:

- The woman with red hair eats nasi.
- The woman working in the real estate department had lunch break later.
- Natalia works at investments department.
- Gwendolyn works at the mortgages department does not have black hair.
- Addison is allergic to bread.
- The customer department service only could have had nasi for lunch.
- Brooklynn has a fish allergy and does not like peanut soup.
- The woman could not have had brown hair.
- The woman with black hair always eats warm food for lunch.
- The woman working in insurance has brown hair but is going to the hairdresser on Tuesday to colour her hair like Brooklyn red.
- Rylee has grey hair.
- The blond woman always eats grilled cheese sandwiches.

The answer can be found by filling in the logic grid. That grid can be found in Appendix I: Logic Grid filled out. The grid leaves only the possibility that the woman with black hair must have had the peanut soup. Following the cues, that must have been Natalia.

#### 6.2.6. Setup puzzles

The setup in which the group of students start can be seen in the image below. The blank card is the employee card with which the bank could be opened. These cards were borrowed so could not be personified but the design of the card can be found in Appendix J: Design Employee Card The numbers represent the place of the puzzles.

1. Nonogram
2. Flowchart
3. Spanning tree
4. Caesar cipher
5. Clues for logic puzzle



Figure 22 Setup

### 6.3. Email Client

An email client is a program which is used for writing and receiving emails. Gmail and Outlook are examples of email clients. The program does not have to be able to actually send emails but rather just a display which looks like it could be the email client of the Rabobank. Additionally, it needs to be able to handle text input and check whether this input is correct.

ProtoPie [53] seems to be the best fit for those two requirements as it can check for conditional input and perform actions based on that input while giving the freedom to design an email client. It is normally used for advanced prototyping.

The email client needs a navigation system between the emails and the menu. The figure below shows how the navigation works. The bidirectional arrows mean that they should be able to switch between the displays. The red colour shows that a correct answer needs to be given before the next scene can be displayed.

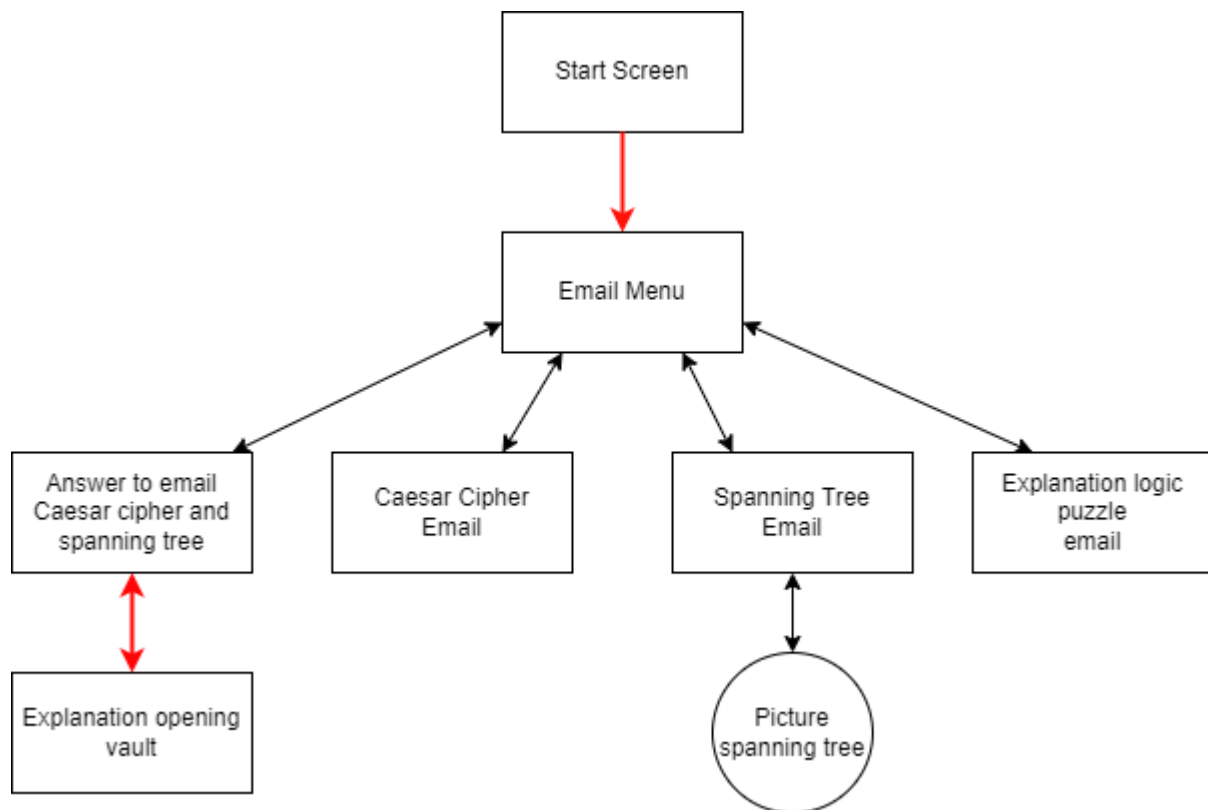


Figure 23 Navigation Schematic

The following images show the realisation of the emailing client. A green or red border is showed around the text input as indication whether the answer is correct or not.



Figure 24 Start Screen



judith.poortman@rabo

wrongPassword

Figure 25 Use Cues

Green for correct input and red for incorrect input

The lock navigates to Figure 32 Lock Screen.






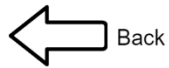
	Jayla Gross Kantoor roddels :P	23-01-2023 08:21
	Rylee Jimenez RE: Route	22-01-2023 16:46
	Gwendolyn Ashley nlpdlc ntaspc	22-01-2023 10:34



Figure 26 Email Menu





Rabobank



**From** rylee.jimenez@rabobank.nl  
**To** judith.poortman@rabobank.nl

**Topic** RE: Route



Dag Judith,

Ik vroeg me af of je voor mij kan berekenen wat het minimale aantal minuten is wat ik kwijt ben aan het rijden van de route. Ik moet langs iedere stop op de kaart. Alvast bedankt!

Groetjes,

Rylee

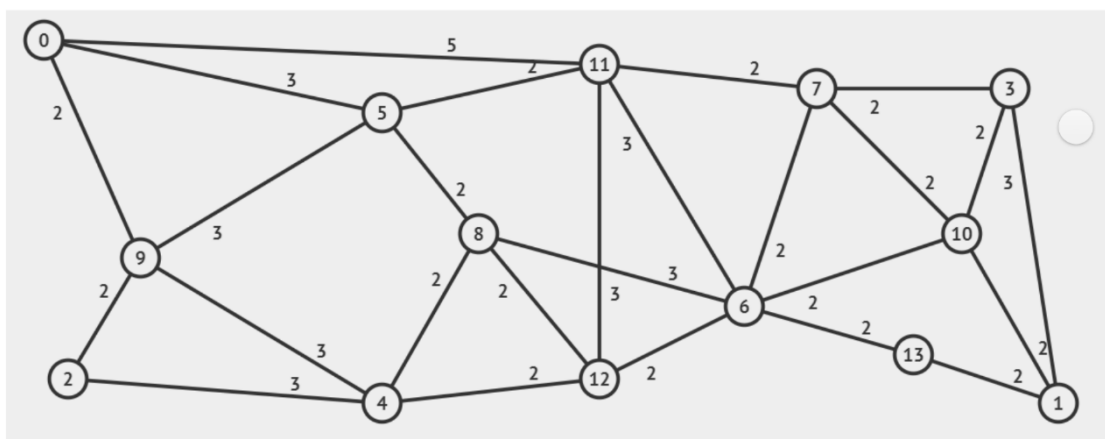
PS: je had helemaal gelijk, grijs staat mij goed! Hoef ik het lekker niet meer te verven. Natalia is nu de laatste met zwart haar van heel de Rabobank!

Figure 28 Email Spanning Tree

By hovering over the paperclip, the spanning tree displays.



Rabobank



verven. Natalia is nu de laatste met zwart haar van heel de Rabobank!

Figure 27 Spanning Tree Preview



Back



**Rabobank**



**From** jayla.gross@rabobank.nl  
**To** judith.poortman@rabobank.nl

**Topic** Kantoor roddels :P

Heey Judith,

Omg!! Heb je het al gehoord? Gister is Steve Berger afgevoert met de ambulance vanwege een allergische reactie op pinda's.. Super heftig, maar het gerucht is dus dat hij vlak voor het gebeurde stond te zoenen met een collega. Heeft hem bijna zijn leven gekost!  
En natuurlijk.. moet ik weten met wie hij was. Real life drama serie hier op het kantoor :P. Is er tenminste nog wat te doen haha. Anyway, ik heb dus 5 'verdachten' want er liepen 5 dames vanaf plaats delict. Ik probeer hier en daar wat rond te vragen zonder en dit is wat ik tot nu toe weet:  
Gister bij de lunch was er keuze uit: pindasoep, tosti, sandwich, nasi of tonijn salade. En het was niet de vrouw met bruin haar. Daarnaast weet ik dat Addison geen brood mag eten.  
Een klein beginnetje is er. Mocht jij nog iets horen, stuur het dan naar mij! Misschien moet ik toch een carrière switch maken naar detective ;)

Tot straks bij het bedrijfsuitje!

Figure 30 Explanation Logic Puzzle



Back



**Rabobank**



**From** gwendolyn.ashley@rabobank.nl  
**To** judith.poortman@rabobank.nl

**Topic** nlpdlc ntaspc

Rzpopxtoolr!

Qtuy ole up spe mpoctuqdfteup htwe zcrltydpcpy. Tv spm rppy lwwpctrëy,  
xllc tv szza ytpe ole pc lwwppy yldt kzlwd mtu op vlyetyp gly op  
vwlyepydpctgnp.

Xpe gctpyopwtuyp rczpe,  
Rhpyozwjy

Figure 29 Email Caesar Cipher



# **Rabobank**

Topic mail 1

Antwoord mail 2



Figure 32 Lock Screen



# **Rabobank**

Notities:

Blonde vrouw eet altijd tosti's

Openen kluis:

\* - antwoord personeelsnummer mail1 - pas scannen



Figure 31 Explanation Opening Vault

#### 6.4. Debriefing

The slides for the debriefing can be found in Appendix K: Slides Debriefing. The slide containing the spanning tree has a video made with [52] showing visually how Kruskal's algorithm works. The slides encourage a discussion-based teaching method. The class will be actively sharing their solution and how they came to that solution. The teacher will explain how it puzzles relate to computational thinking and some extra computer related topics. The slides contain click animations, so answers are not directly shared.

#### 6.5. Evaluation of requirements

Based on the final prototype, some of the earlier mentioned requirements can already be evaluated. The table below provides an overview. The other requirements will be evaluated in chapter 7 since these must be tested in order to be verified. For FR3, the slideshow is the guide.

Number	Requirement	Priority	Yes/No
FR1	Contains puzzles that cover the learning objectives of procedures & algorithms and problem-solving thinking.	Must	Yes
FR2	A vault that can be opened with a unique code per team	Must	Yes
FR3	A guide for debriefing after the activity	Should	Yes
FR5	Red LED on the vault to showcase the state of the vault: password correct/incorrect.	Could	Yes
FR8	Puzzles in context of escape room	Should	Yes

Figure 33 Requirement Evaluation

## 7. Evaluation

The final prototype will be evaluated on whether it meets the requirements that were set in chapter 5. Some of those requirements could already be verified in the end of chapter 6, after the realisation. The evaluation will be done by a user test with the target group. 8 Students of the second grade were selected by the teacher with whom the first interview was with. They deviate a bit from the target group since the students were tl/havo students instead of havo/vwo. However, the teacher selected on whether their preliminary advice is havo for the third grade.

All students and their parents were briefed beforehand with what the test would entail. Both were asked beforehand to give consent to participate in the test. The information and consent sheets can be found back in Appendix L: Information Parents and Consent Form and Appendix M: Information Students and Consent Form. There is no personal data gathered of the participants.

The user test consists of three parts: testing out the escape room, participating in discussion-based debriefing of the answers and filling in a questionnaire. The questionnaire is divided into three topics: quality of the puzzles, engagement and feeling of learning. The statements about the topic are all on a 5-point Likert scale. Quality of the puzzles is about the level of difficulty of them and the logic of the sequence. Engagement is about whether they enjoyed the activity. The last category is not an objective measure of learning as there is no reference value measure beforehand. The measure is subjective and the question types are on whether they felt they had learned something. To prevent bias in the statements, both negatively and positively put statements were inserted. Hence, making the opposite statement of I found the puzzles too difficult; I found the puzzles too easy as well. At the end, there are some open questions so students can provide general feedback.

The user test was conducted in a classroom at Guido. The setup of the escape room is exactly the same as in Figure 18 Setup for two groups of four students. The two groups were put in the opposite

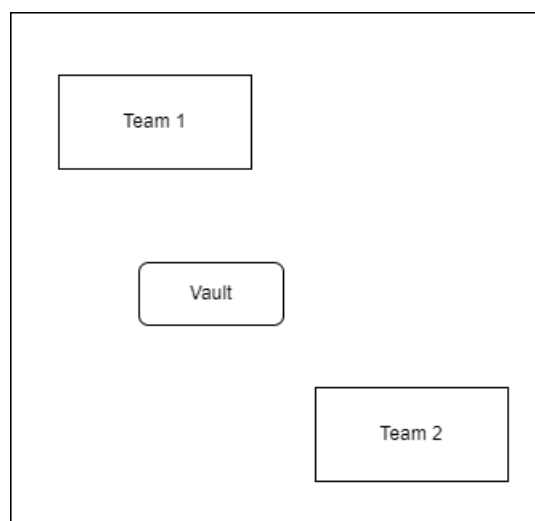


Figure 34 Test Setup

of another in the classroom to prevent overhearing answers. The vault was placed in the middle of the two groups. The map below shows the full setup:

During the testing of the escape room observations were made on how long it took to solve the puzzles, correctness of the solutions, collaboration, sequence of solving and general findings. This was done by the researcher only with the teacher being present.

### 7.1. Results Observation

The table below shows the two separate teams and how long they spend on solving the puzzles. The sequence is the chronological sequence in which they found solutions. The value on the left next to the solution is the time it took in minutes. The colours indicate on which puzzles/solutions they solved simultaneously by dividing the work among team members. ~ Indicates that the correct answer was not found, or time was up.

Team 1		Team 2	
16	Finding username in notebook	22	Finding username in notebook
30	Flowchart	44	Flowchart
10	Nonogram	16	Nonogram
20	Caesar Cipher	~	Spanning Tree
7	Spanning Tree	10	Caesar Cipher
~	Logic Puzzle	~	Logic Puzzle

*Table 12 Time and Sequence of Found Solutions*

After 70 minutes, the prototype testing was ended and none of the teams had time to find the solution to the logic puzzle. Team 1 completed all the other puzzles correctly and team 2 did not have the correct answer of the spanning tree. The first finding that is listed is the username to the email client which is the email of the employees desk they are investigating which is in the notebook together with the Nonogram. Although expected that an email dress is an easy guess for a username, it still took  $\pm$  20 minutes to find out for both teams.

Another unexpected finding is that the teams did not divided the work of the flowchart and the Nonogram among 2 sets of 2 team members but rather just solved both in sequence with four. This significantly increased the expected solving time as now the time to solve the flowchart and the Nonogram must be added. Team 1 divided the work of the Caesar cipher and the spanning tree while team 2 again tackled the problem with the four of them together. Team 2 was far behind team 1.

The Nonogram gives the answer to the password of the email client, but both teams solved the flowchart first instead. This answer gives a clue for the logic puzzle which is not explained in the beginning. This caused confusion for both teams and they tried the input of the flowchart outcome on the email client. This caused a large delay.

Team 1 did not find the pattern in the Caesar cipher email that the letters were shifted 11 places. Instead, they decrypted the message by manually checking for each letter and their corresponding

letter. This also took way longer than expected. Team 2 found a structured way in solving the Caesar email but did not find the correct answer to the spanning tree.

None of the teams came up with a structured way to solve the logic puzzle. Team 1 took extensive notes but could not conclude the answer. Team 2 opened the email client about 10 minutes after team 2 and was simply not that far in solving the other puzzles.

## 7.2. Results Questionnaire

As mentioned before, the 5-point Likert scale statements of the questionnaire were categorised in three topics: quality of the puzzles, engagement and feeling of learning. By combining multiple statements into one outcome, the validity of the outcome is higher as the response rate is higher. The rate is calculated below and the results on average are displayed in Figure 35 Results of Questionnaire. Engagement consists of 6 statements and has 8 responses so  $n = 48$ . Which questions are included per topic can be found in Appendix N: Questionnaire.

Engagement:  $n = 6 * 8 = 48$

Feeling of learning:  $n = 3 * 8 = 24$

Puzzle quality:  $n = 5 * 8 = 40$

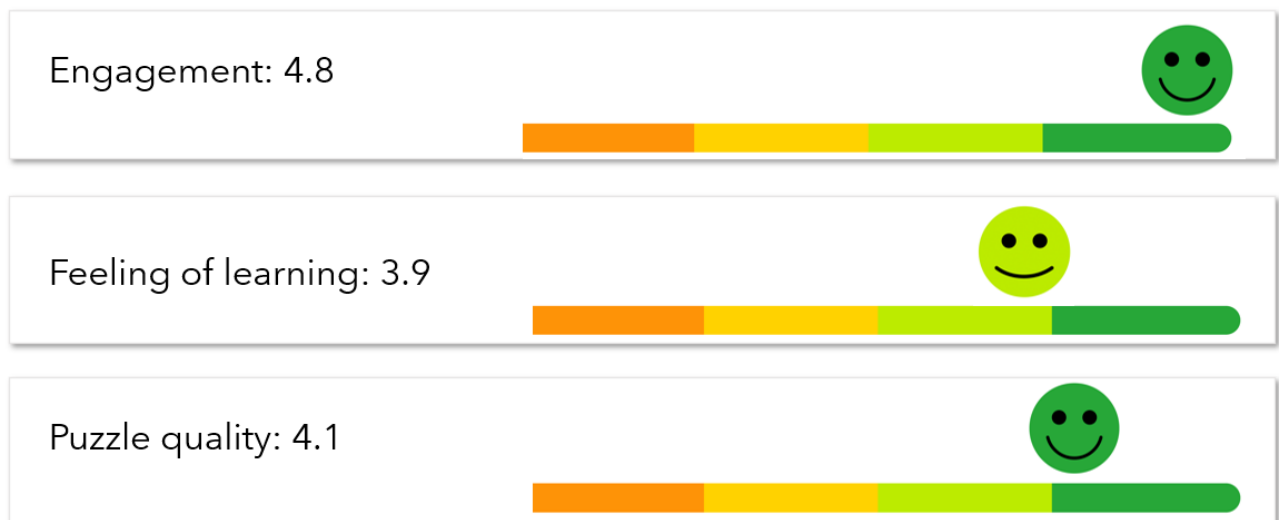


Figure 35 Results of Questionnaire

At the end of the questionnaire there were some open questions so students can elaborate on their answers or give more extensive feedback. 3 respondents commented in these additional questions. Two of them said they would like some more information/hints and one the rest answered they missed the feeling of an escape room. The last comment might relate to the fact that in this testing case there was no time constraint.



One of the participants had to leave early, making them not able to participate in the discussion after the escape room. It is noteworthy that this student scored the lowest on feeling of learning. This suggest that the presentation in the end helped the other students with their learning experience.

### 7.3. Conclusions

From the observations some improvements can be made on where solutions of puzzles need to be inserted in the email client since they were trying out the solution of the flowchart to get into the email client. This can be easily done by inserting a hint in the start screen that all the information for logging in can be found in the little blue notebook. This is accomplished with a hover over event. Once the mouse hovers over the logo of the Rabobank, the hint appears.



Figure 36 Hover Over Event

This improvement will also satisfy the need for more hints which was twice mentioned in the additional comments of the questionnaire.

Since the teams did not come up with a structured way to solve the logic puzzle, adding an empty logic grid will help them in the right direction. However, a new user test would be needed to evaluate the level of difficulty of the logic puzzle. The different attributes of the persons will not be provided. Providing these would be the next step into making the logic puzzle easier.

	Afdeling					Haarkleur					Lunch				
Naam															
Lunch															
Haarkleur															

Figure 37 Empty Logic Grid

Since the teams did not really start with a divide and concur approach to solve the different puzzles which made them lose a lot of time, it might be worth mentioning this tactic beforehand. However, teams might start doing it themselves when the competition is higher, more teams, and then it might be the divide and concur tactic might be that of the winning team. Thus, making it a learning moment for the class. A teacher knows their class best and they should decide whether they announce this tactic beforehand.

The results of the evaluation also can conclude whether the other requirements are met by the prototype. Building on the table of section 6.5, requirements FR6, NFR1, NFR2, NFR3 are added.

Number	Requirement	Priority	Yes/No
FR1	Contains puzzles that cover the learning objectives of procedures & algorithms and problem-solving thinking.	Must	Yes
FR2	A vault that can be opened with a unique code per team	Must	Yes
FR3	A guide for debriefing after the activity	Should	Yes
FR5	Red LED on the vault to showcase the state of the vault: password correct/incorrect.	Could	Yes
FR8	Puzzles in context of escape room	Should	Yes
FR6	Escape room and debriefing should not take more than 1.5 hours	Must	No
NFR1	No prior knowledge of CT, especially programming, needed for teachers	Must	~
NFR2	Engaging for students	Should	Yes
NFR3	Stimulate collaboration between students	Should	Yes

*Table 13 Requirement Evaluation*

As can be seen in the table, FR6 was not met with the user test. With the improvements mentioned in this chapter, the escape room has more chance to be solved in time. Again, a second testing round would be needed to verify this.

NFR1 was not tested as it was not possible to have a teacher test it out by themselves due to their time constraints. Expectations are that a teacher should be able to since the email client program is plug in and go and putting down the supplies is a simple task. Nevertheless, this could not be confirmed within the scope of this thesis.

## 8. Conclusion

This thesis started off with the main research question:

*Main RQ: How to design e-learning material for computational thinking in lower secondary education?*

The main research question was redefined after the answer to sub-RQ1 was found. Computational thinking was first digital literacy in this question. In order to answer the main research question, multiple sub-research questions had to be answered. A short conclusion of the sub-research questions and their answers are provided below.

**Sub-RQ1:** What are the challenges teachers face in teaching digital literacy?

Computational thinking is the most difficult domain to integrate for Guido. Teachers do not necessarily have a background in CT. A lot of the (free) current material relies on teachers having a background in programming which is too big of a hurdle to learn for teachers at Guido. The prototype that will be made should cover the topics of computational thinking.

**Sub-RQ2:** *What does computational thinking entail for lower secondary education according to SLO?*

Computational thinking is 21st century skill that gains more attention with the rise of technologies in day-to-day life. SLO divides CT in 3 subcategories:

- **Problem-solving thinking** (directly translated). The English equivalent which is often used is: critical thinking and problem solving. This subcategory holds the concepts of reformulating, problem decomposition and problem abstraction.
- **Working with digital data.** Applications of this sub-category: analysing, concluding and finding patterns in graphs as well as gathering, visualising and modelling.
- **Procedures and algorithms.** Using and creating a series of ordered steps to find a solution or goal.

Students need to be aware how computers operate. This will help them when they want to find a solution in which computer technology is involved.

**Sub-RQ3:** *What are the challenges of e-learning?*

The definition for e-learning was set on: the delivery of education and training through or with support of computer technology. As the definition of e-learning material should not limit the design scope of the project. A list of challenges that could be relevant for the project is made. These challenges were kept in mind when starting the ideation phase.

- Motivation and engagement
  - Little variation in material
  - Lack of interactivity in material

- If there is no physical teacher around, students lose motivation more easily
- Digital literacy
  - The digital literacy of a student has impact on learning performance
- Technical issues
  - Issues in the infrastructure
  - Issues on the student's side
- Inflexibility of material
- Credibility and plagiarism
  - Internet sources are not always reliable
  - Easier to copy another's work
  - Students might skip thinking steps because they can google questions
- Less student-to-student and teacher-student contact

**Sub-RQ4:** *How to design engaging materials for computation thinking?*

Current problems in engagement are that students, especially for algorithms and procedures, find the topic boring and difficult. This can be overcome by connecting the problems to the context of the student's life. Another problem is that the current materials tend to have a bias to male students as the context now given is stereotypically more in their interest. Since computational thinking is going to be a compulsory course, it should be equally appealing to all students.

Furthermore, three of the most used learning methods were compared in a literature review: programming with a virtual programming language, unplugged activities and robotics. Robotics tends to be the most engaging one, but only if the robot is physical. The engagement of unplugged activities relies mostly on the engagement and openness of the teacher. There was no difference in learning between the methods.

The prototype is one of the many solutions to the main research question. It follows the most important requirements set by the literature and the client. Nevertheless, more research would be needed to verify all the requirements and make the prototype an educational product. What that research entails will be discussed in the next chapter Further Research.

## 9. Further Research

The conclusions of chapter 7 Evaluation are a starting point for research that needs to be conducted to further improve the prototype. One of the things that is not tested is whether a teacher with little background in CT could setup the escape room, guide the activity and the discussion in the end. A user test with teachers and their students should be conducted in the same style as the user test of chapter 7. Teachers would be observed and questioned after the activity on whether it was doable or easy to use the prototype without having an extensive background in CT. Co-designing with teachers would be a great way to improve the product.

Another issue that is worth investigating further is whether multiple teams would have effect on the gameplay of the escape room. Not all the students questioned in the user test felt competition with the other team. Having bigger groups could give a different effect on this.

A limitation of this study is that it is not evaluated whether students made actual progress in their computational thinking skills or had a better understanding of it. The statements in the questionnaire were only based on how they felt. A user test with a reference test of their CT skills before and after activity should be conducted. This way, conclusions can be made on if the prototype has actually improved these skills or not.

One of the problems mentioned in chapter 2 is that current material tends to have a male bias and therefore has effect on engagement of female students. During the ideation and realisation phase, this was kept into mind, but it could not be evaluated during the user test as only female students participated. The students highly engaged in the activity, but this should be also tested for male students. Expectations are that they will like the storyline of cracking the code of a vault but might be put off by the context of the logic puzzle.

The vault allows for unique codes per team and therefore different levels of difficulty of the puzzles could be implemented. Differentiating by teachers on a student's educational level is encouraged in many teaching methods. However, it should be also be tested if this is doable for teachers who might not have a good understanding of the level of computational thinking skills of their students as it might not be their topic of profession. Secondly, it might have impact on the gameplay that some students have more difficult puzzles. Possible negatives effects could be that students do not find it fair or do not feel satisfied with their accomplishments if they know they perform on a lower level of difficulty than other students. In any case, it needs to be tested as well.

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## Appendix A: Consent Form Interview

Consent form template for research with human participants

Authors: Ethics Committee CIS (based on template by BMS EC)

Last edited: 19-01-2022

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1. Note that this is a template to assist researchers in the design of their consent forms. It is important to adapt this template to the outline and requirements of your particular study, using the notes and suggestions provided.
2. The consent form should be accompanied by an information letter that describes adequately and comprehensibly for the participants:
  - Purpose of the research
  - What will happen during the session, how long it will take, what will be asked of the participant, etc
  - Benefits and risks of participating (e.g. mention that your research project has been reviewed by the Ethics Committee Information and Computer Science)
  - Procedures for withdrawal from the study
  - Whether any personal information about the participant will be collected, processed and how and for what purpose; the right of the participant to request access to and rectification or erasure of personal data
  - Usage of the data during research, safeguarding personal information, maintaining confidentiality and de-identifying (anonymising) data, controlled access to data, especially in relation to data archiving and reuse, ways of dissemination, data archiving and possible publishing
  - Retention period for the research data, or if that is not possible, criteria used to determine that period
  - Contact details of the researcher (or his/her representative), contact details of the Ethics Committee Computer and Information Science to file a complaint, and if applicable another institution than UT, or a funding source.
3. Under General Data Protection Regulation (GDPR), consent needs to be:
  - affirmative
  - granular, seeking consent for different forms of data and for different use purposes
  - more information on the appropriate use of personal data in scientific research according to the GDPR can be found [here](#)
4. In this template:
  - square brackets indicate where specific information is to be inserted
  - black text forms the standard content of a consent form
  - red text is notes to help the researcher finalise the form, not to be included in the consent form.
  - grey text indicates extra optional questions

Study information

The aim of the bachelor's thesis is to design e-learning material for digital literacy in secondary education. The client is GSG Guido1, which is a school for secondary education (havo-vwo). The aim of this research is to find out how digital literacy currently is taught in Guido and what the preferences of the teachers are regarding the material that will be designed.

The research project has been reviewed by the Ethics Committee Information and Computer Science. The participant will take part in a semi-structured and audio-recorded interview which will take 30 minutes.

The participant can refuse to answer questions and withdraw from the study at any time, without having to give a reason.

Direct personal data such as names will be anonymised. However, there is a possibility that the identity of the participant could be derived from the information about the school and course they teach.

The audio recordings will be deleted after transcription.

The findings of the interview including the transcription will be published in the repository of bachelor theses of the University of Twente. The retention period is at least seven years.

Researcher and study contact for more information:

Karlijn Kole, [k.j.kole@student.utwente.nl](mailto:k.j.kole@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](mailto:ethicscommittee-CIS@utwente.nl)

## Appendix B: Outline Interview 1

### Achtergrondinformatie

De studie Creative Technology focust op het oplossen van maatschappelijke problemen met behulp van ICT. De studie heeft onderdelen van informatica, elektrotechniek en ontwerp. Creative Technology heeft een eigen designproces<sup>2</sup> om creatieve oplossingen te vinden. In mijn bachelor opdracht volg ik ook dit designproces, waarbij ik nu nog in de eerste fase zit. In deze eerste fase is het belangrijk om erachter te komen wat het programma van eisen is en waar de problemen liggen. Hier wil ik achter komen middels dit interview.

Mijn afstudeeropdracht heeft de voorlopige vraag: How to design e-learning material for digital literacy in lower secondary education? E-learning is het gebruik van digitale middelen voor educatie.

### Interview

Om de situatie op Guido beter te begrijpen en een gepaste oplossing te bedenken, zou ik eerst graag willen weten hoe de huidige situatie is. Daarom ga ik deze vragen stellen:

- Wordt er al lesgegeven in digitale geletterdheid?
- o Welke domeinen worden er behandeld?
- Hoe is deze verdeling? Per vak of per docent?
- o Is er een methode?
- o Wat is er geregeld vanuit de school?
- o Welke (digitale) hulpmiddelen worden ervoor gebruikt?
- Wat zijn de toekomstplannen voor digitale geletterdheid op Guido?

Met de vragen die hierna komen hoop ik een wat beter beeld te krijgen van de design richting. De hoofdvraag is hier: wat voor soort materiaal zou jullie het best ondersteunen met het geven van digitale geletterdheid? De vragen hieronder geven richting aan het gesprek:

- Welke werkvormen worden in de lessen gebruikt of zou je willen gebruiken?
- Waar hebben andere docenten/school behoefte aan met betrekking tot digitale geletterdheid?
- Is er een voorkeur voor een domein waar het prototype gebaseerd op zou worden?

Zoals je ziet zijn deze vragen nog heel open en wijzen niet naar specifieke oplossingen. Het is ook de bedoeling dat het tweede deel meer een gesprek is waarbij je input kan geven. Ik wil op deze manier de design opties breed houden en zo goed mogelijk de wensen in kaart brengen zonder hierbij een bias te creëren.

### Translation:

#### Background information

The Creative Technology study focuses on solving social problems with the aid of ICT. The study has components of computer science, electrical engineering and design. Creative Technology has its own design process to find creative solutions. In my bachelor assignment I also follow this design process, where I am still in the first phase. In this first phase it is important to find out what the program of requirements is and where the problems lie. This is what I want to find out through this interview.

My graduation assignment has the preliminary question: How to design e-learning material for digital literacy in lower secondary education? E-learning is the use of digital resources for education.

### Interview

To better understand the situation on Guido and to come up with a suitable solution, I would first like to know what the current situation is like. That's why I'm going to ask these questions:

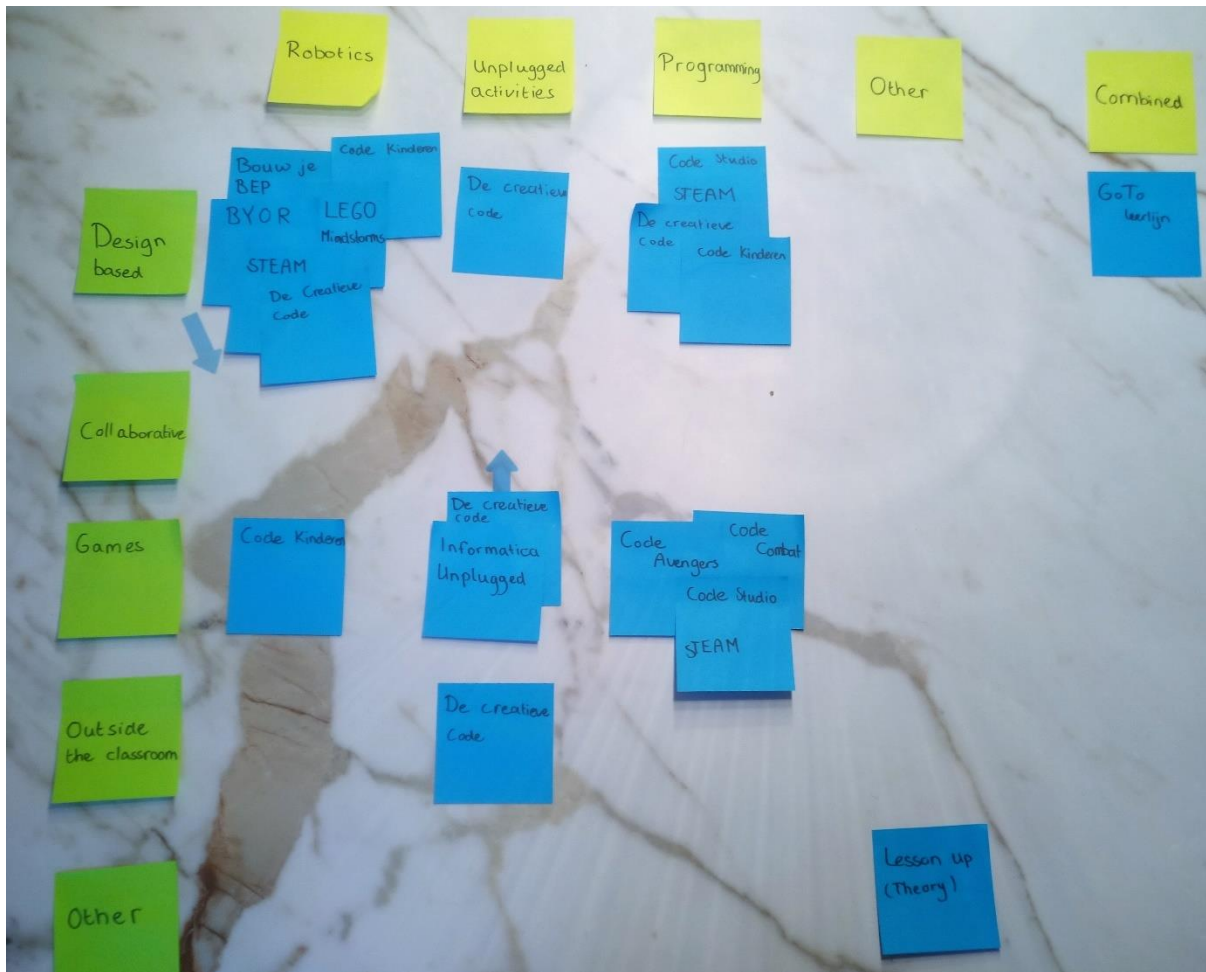
- Is digital literacy already taught?
  - o Which domains are covered?
  - o How is this distribution? Per subject or per teacher?
- Is there a method?
- What is arranged by the school?
- Which (digital) tools are used?
- What are the future plans for digital literacy on Guido?

With the questions that follow, I hope to get a better picture of the design direction. The main question here is: what kind of material would best support you in teaching digital literacy? The questions below will guide the conversation:

- Which working methods are used in the lessons or would you like to use?
- What do other teachers/schools need with regard to digital literacy?
- Is there a preference for a domain on which the prototype would be based?

As you can see, these questions are still very open and do not point to specific solutions. It is also the intention that the second part is more of a conversation where you can give input. In this way I want to keep the design options wide and map out the wishes as well as possible without creating a bias.

## Appendix C: Existing Ideas in Matrix

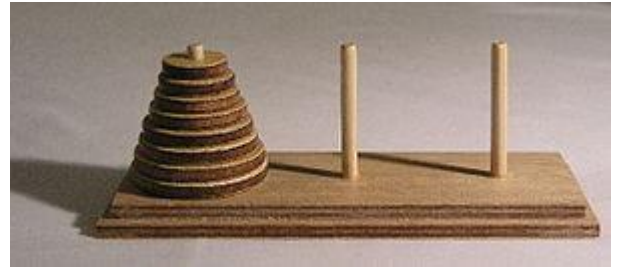




## Appendix D: Computational Thinking Puzzles

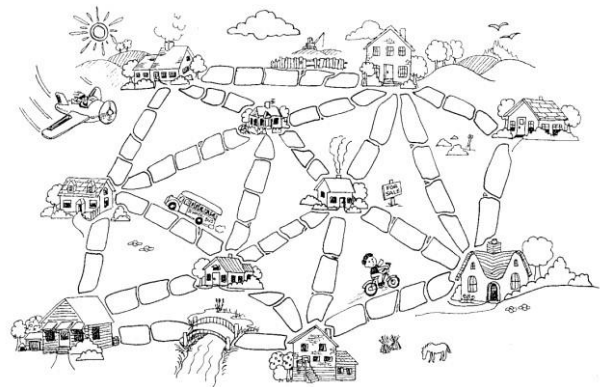
### Towers of Hanoi

It is a small puzzle game where an entire stack of disks must be placed on the last rod in a decreasing order of size as can be seen on image. Only one disk can be moved at the time. Secondly, it has to be the upper disk. Lastly, only smaller disks can be placed on bigger disks, not the other way around. The fastest way the goal can be reached is in  $2^n - 1$  moves, where  $n$  is the number of disks.



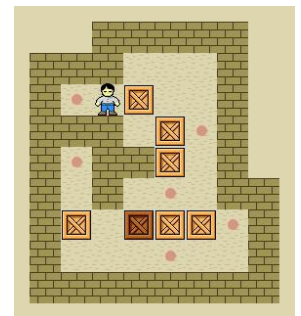
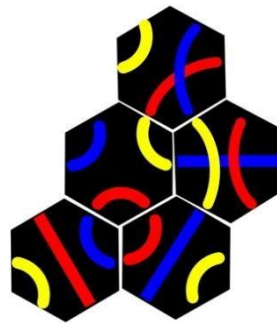
### Modderdorp

Modderdorp is a worksheet where you have to connect all the houses that are present with the least amount of 'blocks'. Usually, some structure is used such as: eliminating the largest routes first or connecting the smallest ones.



### Sliding puzzles

Sokoban is a puzzle game where boxes must be pushed into the designated places (right image). It forces players to decompose the problem into smaller sub goals. There are many games like this, online and offline on various levels. However, both display a  $P = NP$  problem, which means an algorithm that would always find the solution would take very long to solve it. This is due to the many different possibilities and therefore in contrast with the two puzzles above.



### Einstein's Riddle (logic Puzzles)

Einstein's Riddle and other logic puzzles can only be solved by systematically ordering the information, usually done in a grid. Sorting and extracting the right information by combining the clues will lead to the answer. This is Einstein's riddle, but can come in any form:

The Brit lives in the Red house. The Swede keeps Dogs as pets.

The Dane drinks Tea.

The Green house is exactly to the left of the White house.

The owner of the Green house drinks Coffee.  
The person who smokes Pall Mall rears Birds.  
The owner of the Yellow house smokes Dunhill.  
The man living in the centre house drinks Milk.  
The Norwegian lives in the first house.  
The man who smokes Blends lives next to the one who keeps Cats.  
The man who keeps Horses lives next to the man who smokes Dunhill.  
The man who smokes Blue Master drinks Beer.  
The man who smokes Blends has a neighbour who drinks Water.  
The German smokes Prince.  
The Norwegian lives next to the Blue house.

Sudoku and variants:

Seeking patterns in numbers and having a structured approach will lead to an answer. Sudoku is probably most famous but there are a lot of variants: Wordoku, Numbrix, Hidato, Kakuro, Latin Squares, Futoshiki, Jigsaw Sudoku, Nonograms, Logic Dots 2, Dots and Boxes, Rummikub, Blockudoku.

Sorting algorithms:

Sort [any sequence] in the least number of steps often with a restriction that you can only swap items or that you can only move an item one spot. Another way is giving an unstructured deck of cards which needed to be sorted according to symbol and number. 'Divide and concur' is a way of splitting responsibilities for sorting more easily and quick.

Maze:

Let an agent move through a maze by giving it a fixed set of instructions. For example: go straight, if you cannot go straight then turn left.

Encryption:

Caesars cypher with numbers, letter or word. Breaking the Caesar cypher can be done by pattern recognition or trial and error. The first one is much faster since you do not have to try 25 possibilities.

## Appendix E: Vault Code

```
#include <SPI.h>
#include <MFRC522.h>

#define RST_PIN    47    // Configurable, see typical pin layout above
#define SS_PIN     53    // Configurable, see typical pin layout above
#include <Keypad.h>
const String password_1 = "123"; // change your password here
const String card_id1 = "71 75 52 1C"
const int RELAY_PIN = A5;
const int LED_PIN = 11;
const int ROW_NUM = 4; //four rows
const int COLUMN_NUM = 3; //three columns
char keys[ROW_NUM][COLUMN_NUM] = {
  {'1', '2', '3'},
  {'4', '5', '6'},
  {'7', '8', '9'},
  {'*', '0', '#'}
};

byte pin_rows[ROW_NUM] = {9, 8, 7, 6}; //connect to the row pinouts of the keypad
byte pin_column[COLUMN_NUM] = {5, 4, 3}; //connect to the column pinouts of the keypad
String input_password;
Keypad keypad = Keypad( makeKeymap(keys), pin_rows, pin_column, ROW_NUM, COLUMN_NUM );
MFRC522 mfrc522(SS_PIN, RST_PIN); // Create MFRC522 instance

void setup()
{
  Serial.begin(9600); // Initialize serial communications with the PC
  pinMode(RELAY_PIN, OUTPUT); // initialize pin as an output.
  pinMode(LED_PIN, OUTPUT); // initialize pin as an output.
  digitalWrite(RELAY_PIN, LOW); // lock the door
  while (!Serial); // Do nothing if no serial port is opened (added for Arduinos based on ATMEGA32U4)
  SPI.begin(); // Init SPI bus
  mfrc522.PCD_Init(); // Init MFRC522
  delay(10); // Optional delay. Some board do need more time after init to be ready, see Readme
  mfrc522.PCD_DumpVersionToSerial(); // Show details of PCD - MFRC522 Card Reader details
  Serial.println(F("Scan PICC to see UID, SAK, type, and data blocks..."));
```

```

Serial.println("Approximate your card to the reader...");
Serial.println();

}

void loop()
{
  char key = keypad.getKey();
  if (key) {
    Serial.println(key);

    if (key == '*') {
      input_password = ""; // reset the input password
    } else if (key == '#') {
      if (input_password == password_1) {
        // Serial.println("The password is correct, unlocking the door in 20 seconds");
      } else {
        // Serial.println("The password is incorrect, try again");
      }

      input_password = ""; // reset the input password
    } else {
      input_password += key; // append new character to input password string
    }
  }

  // Look for new cards
  if ( ! mfrc522.PICC_IsNewCardPresent())
  {
    return;
  }
  // Select one of the cards
  if ( ! mfrc522.PICC_ReadCardSerial())
  {
    return;
  }
  //Show UID on serial monitor
  Serial.print("UID tag :");
  String content = "";
  byte letter;
  for (byte i = 0; i < mfrc522.uid.size; i++)

```

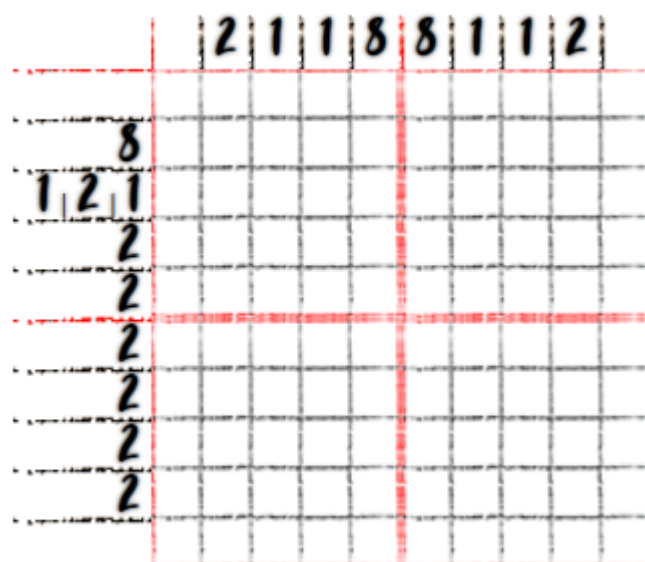
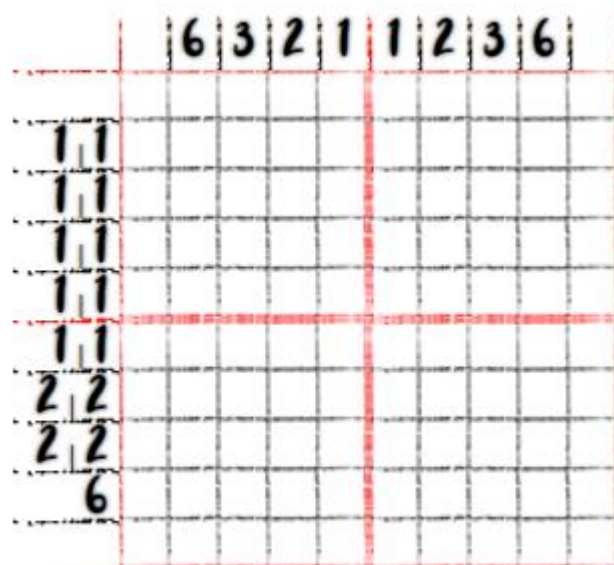
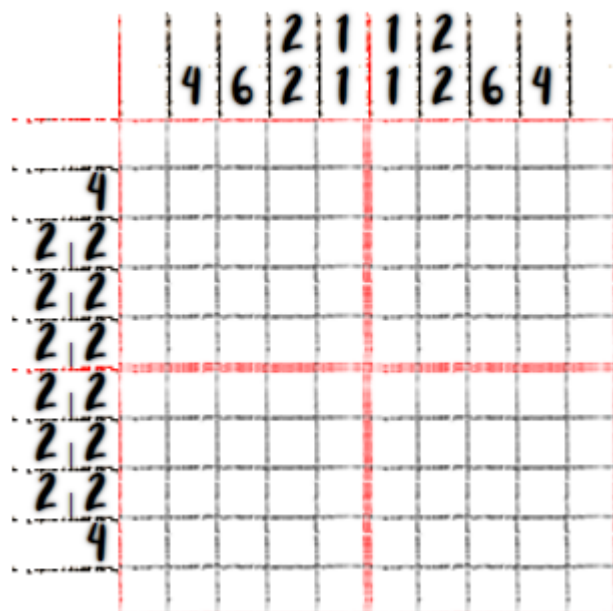
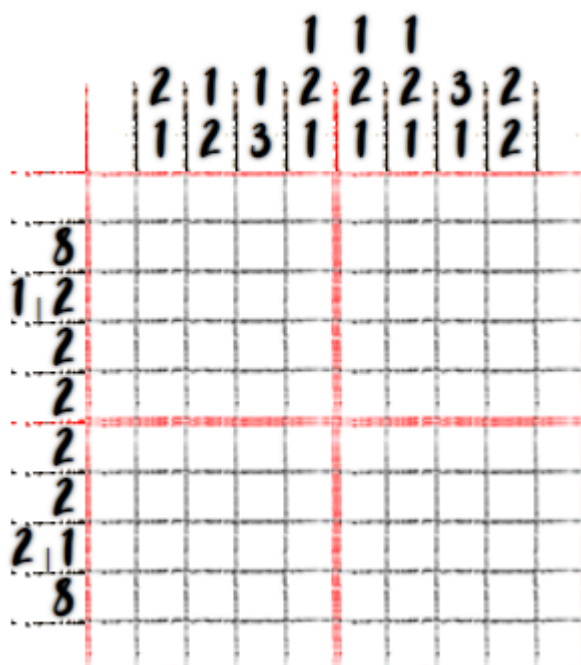
```

{
  Serial.print(mfrc522.uid.uidByte[i] < 0x10 ? " 0" : " ");
  Serial.print(mfrc522.uid.uidByte[i], HEX);
  content.concat(String(mfrc522.uid.uidByte[i] < 0x10 ? " 0" : " "));
  content.concat(String(mfrc522.uid.uidByte[i], HEX));
}
Serial.println();
Serial.print("Message : ");
content.toUpperCase();
if (content.substring(1) == card_id1 && input_password == password_1) //change here the UID of
the card/cards that you want to give access
{
  Serial.println("Authorized access");
  digitalWrite(RELAY_PIN, HIGH); // unlock the door
  Serial.println();
  delay(1000);
  digitalWrite(RELAY_PIN, LOW); //
}

else {
  Serial.println(" Access denied");
  digitalWrite(LED_PIN, HIGH); // Indication LED red when code is not correct.
  delay(3000);
  digitalWrite(LED_PIN, LOW);
}
}

```

## Appendix F: Nonograms



		2	2	1	1	1	2		
		2	2	1	1	1	3	3	
5									
2	2								
1	1								
2									
3									
2									
1	1								
2	2								
5									



## Appendix G: Employee List

<b>Voornaam</b>	<b>Achternaam</b>	<b>Personeelsnummer</b>	<b>Afdeling</b>
Sara	Abbott	4963172	Klantenservice
Kendal	Acosta	1945826	Beleggen
Darion	Adkins	82653710	Vastgoed
Jazlene	Archer	76821019	Klantenservice
Gwendolyn	Ashley	27548110	Hypotheek
Luis	Austin	2784136	Verzekeren
Ayaan	Ayers	17486103	Klantenservice
Maggie	Barrera	5378961	Hypotheek
Bethany	Barron	39210817	Beleggen
Miley	Bauer	37104615	Klantenservice
Reginald	Beard	24109173	Verzekeren
Izaiah	Beasley	8267914	Klantenservice
Ronald	Benton	8497356	Klantenservice
Steve	Berger	2735914	Klantenservice
Diamond	Bernard	21014786	Hypotheek
Raphael	Bishop	7458912	Vastgoed
Diego	Blackburn	3598164	Vastgoed
Paityn	Bond	56479103	Klantenservice
Jaidyn	Bonilla	69824105	Beleggen
Brooklynn	Brady	96566738	Klantenservice
Vivian	Branch	10759246	Beleggen
Tyrone	Braun	81102693	Klantenservice
Kelsie	Brock	71052918	Klantenservice
Lorelei	Browning	6794185	Beleggen
Landon	Buchanan	72105961	Klantenservice
Soren	Bullock	7392186	Verzekeren
Morgan	Burch	8439512	Klantenservice
Carl	Burgess	82361107	Vastgoed
Freddy	Cabrera	10493872	Verzekeren
Xander	Callahan	62743109	Klantenservice

Nola	Cannon	10741253	Hypotheek
Morgan	Carr	21810479	Klantenservice
Kiersten	Carson	6851297	Klantenservice
Peyton	Carter	10541862	Klantenservice
Rohan	Case	64210519	Klantenservice
Alena	Casey	9624813	Klantenservice
Madilynn	Castaneda	4259386	Beleggen
Zoey	Chan	13105982	Klantenservice
Jermaine	Cisneros	74101629	Verzekeren
Katrina	Clarke	56471012	Beleggen
Paxton	Cline	3486157	Verzekeren
Carter	Cochran	18104357	Verzekeren
Vance	Coleman	1375649	Verzekeren
Addison	Conrad	38725101	Verzekeren
Misael	Cooley	93104815	Klantenservice
Richard	Costa	82631094	Verzekeren
Gerald	Cuevas	51043682	Vastgoed
Melina	Dean	81074562	Hypotheek
Darien	Diaz	75396102	Vastgoed
Taniyah	Dodson	61710458	Klantenservice
Melany	Donovan	64231105	Hypotheek
Kendall	Dougherty	71051492	Beleggen
Diya	Duffy	9385172	Klantenservice
Blake	Duke	23461108	Vastgoed
Luka	Dyer	4253187	Vastgoed
Valentina	Eaton	39261015	Hypotheek
Jamar	Elliott	9182734	Verzekeren
Natalia	Esparza	85421091	Beleggen
Yaritza	Foley	86171052	Beleggen
Payten	Foster	51039461	Klantenservice
Ansley	Francis	97810635	Klantenservice
Franklin	Franklin	8463179	Verzekeren

Christine	Garza	73486210	Hypotheek
Lauren	George	14910268	Klantenservice
Jeffrey	Gould	10761395	Vastgoed
Martin	Grant	81103964	Vastgoed
Jayla	Gross	82679105	Hypotheek
Emerson	Hamilton	5918326	Verzekeren
Tabitha	Harrington	16751032	Beleggen
Danica	Harvey	48259310	Hypotheek
Lilah	Hawkins	74210935	Beleggen
Lucia	Haynes	10629453	Hypotheek
Cali	Henderson	19321046	Klantenservice
Zaniyah	Herrera	95417106	Klantenservice
Aimee	Herring	37109846	Hypotheek
Reed	Hess	93841056	Klantenservice
Bridget	Ho	96743101	Beleggen
Antonio	Hobbs	68151037	Vastgoed
Peyton	Holder	86910137	Klantenservice
Camden	Holloway	2586471	Klantenservice
Yadiel	House	10387491	Klantenservice
Kayden	Howe	7942165	Beleggen
Darian	Huang	41013285	Vastgoed
June	Huber	7298354	Beleggen
Jocelynn	Hughes	5742136	Beleggen
Kaliyah	Hunt	27103184	Beleggen
Pablo	Ibarra	91810756	Klantenservice
Laura	Irwin	31510972	Beleggen
Shayla	Jackson	3471589	Klantenservice
Maryjane	Jennings	75389110	Klantenservice
Rylee	Jimenez	3862571	Vastgoed
Madalyn	Johnston	63417210	Klantenservice
Kendall	Joseph	12394510	Klantenservice
Jaylee	Juarez	89710435	Beleggen

Jude	Kane	91084751	Vastgoed
Piper	Key	10729538	Beleggen
Kieran	Khan	25183106	Klantenservice
Alexa	Knight	1624835	Klantenservice
Marley	Koch	7498256	Vastgoed
Clayton	Lam	9523647	Verzekeren
Jacquelyn	Lang	21089635	Hypotheek
Santiago	Lawrence	46315108	Klantenservice
Christina	Lindsey	5163972	Hypotheek
Colin	Lucas	10617293	Klantenservice
Kiera	Lucero	86101495	Klantenservice
Gary	Luna	97104153	Klantenservice
Isabela	Lutz	89476110	Klantenservice
Demarion	Malone	10238574	Klantenservice
Meredith	Marks	9362541	Beleggen
Lily	Martin	51019286	Klantenservice
Kirsten	Maxwell	2568374	Beleggen
Jamiya	Mccall	65931081	Hypotheek
Will	Mccarty	7492386	Vastgoed
William	Mcintosh	91078623	Klantenservice
Tony	Mclaughlin	8297536	Klantenservice
Catherine	Melendez	94671028	Klantenservice
Jean	Michael	67851043	Verzekeren
Randy	Miles	74589106	Verzekeren
Arely	Miller	1243865	Beleggen
Dania	Mills	8694152	Beleggen
Mikayla	Mitchell	10495821	Hypotheek
Yadira	Monroe	10918346	Hypotheek
Giovanni	Mooney	10652891	Verzekeren
Mariam	Moreno	95216104	Klantenservice
Nylah	Morrison	84916710	Klantenservice
Imani	Morse	8419362	Hypotheek

Iyana	Moyer	71081235	Hypotheek
Roy	Newman	59102674	Klantenservice
Gisselle	Nguyen	31421086	Beleggen
Angela	Norman	5862349	Beleggen
Emmy	Ochoa	9284576	Klantenservice
Ally	Oneill	8547139	Hypotheek
Karly	Owens	78461210	Hypotheek
Felix	Parks	32751041	Klantenservice
Justus	Paul	3958726	Klantenservice
Camren	Payne	17324610	Klantenservice
Nancy	Phillips	38714109	Klantenservice
Joey	Pineda	1987362	Klantenservice
Kaitlynn	Pittman	87410639	Klantenservice
Judith	Poortman	47110982	Vastgoed
Franco	Preston	8524713	Verzekeren
Marlene	Price	5472361	Hypotheek
Zavier	Reed	23761085	Klantenservice
Tiara	Reid	6294137	Beleggen
Joaquin	Reilly	32154109	Klantenservice
Jovany	Reyes	46105813	Verzekeren
Carson	Rice	61038574	Klantenservice
Danika	Rios	58741310	Hypotheek
Jensen	Rivera	52681031	Verzekeren
Quinten	Robles	9735821	Verzekeren
Jaylynn	Rollins	17986310	Klantenservice
India	Rose	1572493	Klantenservice
Nayeli	Roy	97365210	Hypotheek
Leland	Russell	68511093	Klantenservice
Makhi	Salas	62317910	Verzekeren
Alexus	Salinas	10974518	Beleggen
Brisa	Santos	71012349	Klantenservice
Juliet	Schmidt	10629174	Klantenservice

Alia	Schroeder	21084139	Hypotheek
Leroy	Sellers	7138426	Verzekeren
Mitchell	Shannon	1685927	Verzekeren
Isabell	Shaw	5146297	Beleggen
Osvaldo	Shepard	2641785	Verzekeren
Kaley	Shepherd	6152387	Klantenservice
Dominik	Silva	52179410	Verzekeren
Marina	Sims	26710981	Klantenservice
Emerson	Small	93101754	Beleggen
Marshall	Smith	9182457	Klantenservice
Baron	Sparks	18451023	Vastgoed
Julianne	Stanton	72310981	Beleggen
Bernard	Stark	9724356	Klantenservice
Eve	Stone	41017852	Klantenservice
Vanessa	Suarez	6547913	Hypotheek
Derrick	Swanson	10314526	Vastgoed
Rey	Sweeney	21567108	Klantenservice
Jenna	Tapia	6345189	Beleggen
Carolina	Torres	8694137	Hypotheek
Gillian	Townsend	21048165	Klantenservice
Scarlet	Trujillo	11082374	Hypotheek
Alexia	Underwood	8291347	Klantenservice
Lucas	Vance	16210439	Verzekeren
Elaine	Vang	18210936	Hypotheek
Angeline	Vega	10581493	Beleggen
Karsyn	Villa	9427618	Hypotheek
Messiah	Villarreal	65310917	Verzekeren
Kyler	Waller	5781369	Verzekeren
Jolie	Walls	1493528	Beleggen
Janelle	Walsh	41261075	Hypotheek
Pierce	Walter	91871035	Verzekeren
Priscilla	Walton	52843610	Klantenservice

Bo	Ward	29587410	Klantenservice
Leslie	Warner	65108197	Beleggen
Conor	Washington	51039128	Verzekeren
Brodie	Waters	67513210	Vastgoed
Adrian	Watts	9583427	Verzekeren
Stephanie	Weaver	61410975	Beleggen
Darren	Weber	41089651	Klantenservice
Aliya	Werner	10427896	Hypotheek
Halle	Whitaker	57281109	Beleggen
Mila	Woodard	8947156	Hypotheek
Josephine	Wu	8513296	Hypotheek
Erick	Zamora	16594103	Klantenservice
Alisson	Zhang	92761034	Hypotheek

# Appendix I: Logic Grid filled out

	V a s t	K l a n t	H y p o	V e r z	B e l	R o o d	Z w a r t	B l o n d	G r i j s	B r u i n	S a n d	N a s i	P i n d	T o n	T o s t
Rylee															
Natalia															
Brooklynn															
Addison															
Gwendolynn															
Sandwich															
Nasi															
Pinda soep															
Tonijnsalade															
Tosti															
Rood															
Zwart															
Blond															
Grijs															
Bruin															

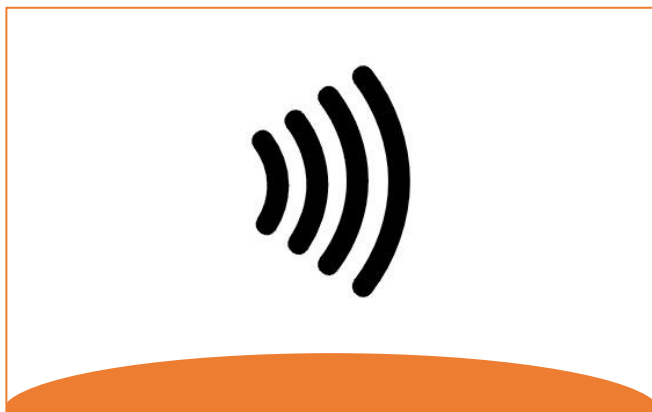


## Appendix J: Design Employee Card

### Front



### Back



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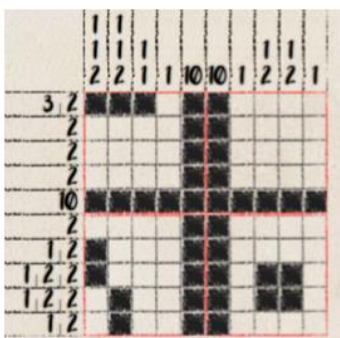
# Escape Room

Universiteit Twente  
GSG Guido Amersfoort

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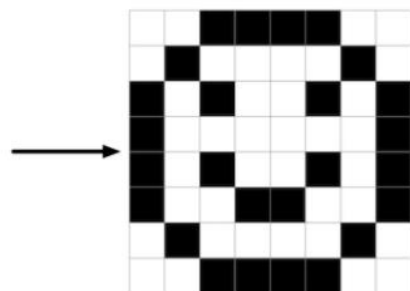
## Nonogram

Wie herkende de puzzel?



Bitmap:

1	1	0	0	0	0	1	1
1	0	1	1	1	1	0	1
0	1	0	1	1	0	1	0
0	1	1	1	1	1	1	0
0	1	0	1	1	0	1	0
0	1	1	0	0	1	1	0
1	0	1	1	1	1	0	1
1	1	0	0	0	0	1	1



## Zoeken in een lijst

Hoe hebben jullie dit aangepakt?

Computer kan dit op verschillende manieren doen. Voorbeeld:

Hoogste = 4963172

Hoogste = 82653710

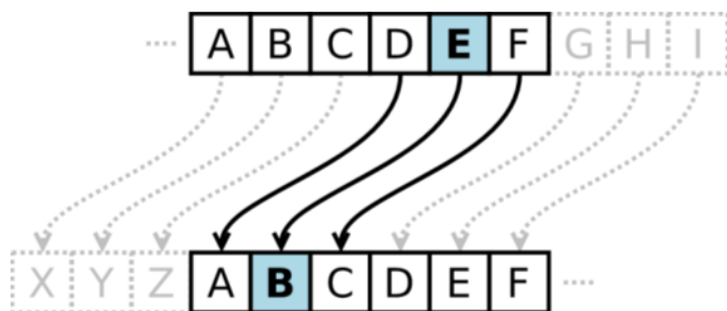
Hoogste = 96566738

Voornaam	Achternaam	Personeelsnummer	Afdeling
Sara	Abbott	4963172	Klantenservice
Kendal	Acosta	1945826	Beleggen
Darion	Adkins	82653710	Vastgoed
Jazlene	Archer	76821019	Klantenservice
Gwendolyn	Ashley	27548110	Hypotheek
Luis	Austin	2784136	Verzekeren
Ayaan	Ayers	17486103	Klantenservice
Maggie	Barrera	5378961	Hypotheek
Bethany	Barron	39210817	Beleggen
Miley	Bauer	37104615	Klantenservice
Reginald	Beard	24109173	Verzekeren
Izaiah	Beasley	8267914	Klantenservice
Ronald	Benton	8497356	Klantenservice
Steve	Berger	2735914	Klantenservice
Diamond	Bernard	21014786	Hypotheek
Raphael	Bishop	7458912	Vastgoed
Diego	Blackburn	3598164	Vastgoed
Paityn	Bond	56479103	Klantenservice
Jaidyn	Bonilla	69824105	Beleggen
Brooklyn	Brady	96566738	Klantenservice

## Encryptie

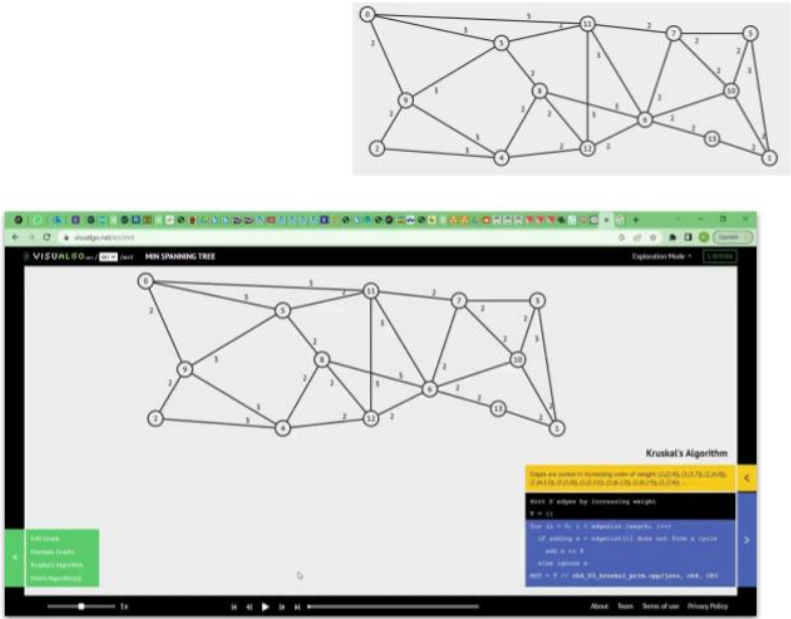
Waardoor kwamen jullie bij de oplossing?

Patroon herkenning



# Kortste pad

Wat was jullie aanpak?



# Raadsel van Einstein

Hoe hebben jullie dit aangepakt?

- Structureren
- In stukjes opdelen

		owners					breeds				
		Anita	Barbara	Douglas	Fernando	Ginger	beagle	bulldog	chow chow	great dane	maltese
years	2006	X		X	X				X		
	2007	X	X	X		X	X	X		X	X
	2008		X	X	X	X			X		
	2009	X			X				X		
	2010	X			X			X	X		X
dogs	Max					X					
	Molly	X	X	X	X						
	Riley			X		X					
	Samson	X				X					
	Shadow					X					

## Appendix L: Information Parents and Consent Form

Geachte heer, mevrouw,

Via deze mail wil ik uw toestemming vragen voor het deelnemen aan een onderzoek van uw zoon/dochter. Dit onderzoek is opgezet door Karlijn Kole, derdejaars student Creative Technology aan de Universiteit Twente. Om mee te doen aan het onderzoek zal er ook schriftelijke toestemming worden gevraagd aan uw zoon/dochter. Zonder expliciete toestemming van beide partijen is deelname aan het onderzoek uitgesloten. Uw toestemming geeft u door de bijlage 'Toestemmingsformulier' ingevuld terug te sturen naar dit emailadres: k.j.kole@student.utwente.nl. De informatiebrief van dit onderzoek is toegevoegd aan de bijlage van deze mail. Als u vragen heeft over het onderzoek of meer informatie wilt hebben kunt u ons via de mail of via de telefoon bereiken.

Met vriendelijke groeten,  
Karlijn Kole

Informatiebrief voor de ouder(s)/verzorger(s) van de deelnemer

### Algemene informatie

Dit onderzoek is opgezet door Karlijn Kole (onderzoeker), derdejaars student Creative Technology aan de Universiteit Twente. Het doel van dit onderzoek is het evalueren van educatieve escape room bedoeld om computational thinking vaardigheden te leren. Deze escape room is nog een prototype.

### Wat meedoen inhoudt

De deelnemer neemt deel aan een onderzoek waarbij informatie verzamelt wordt doormiddel van observatie door de onderzoeker tijdens het uitproberen van de escape room. In de escape room zitten verschillende puzzels waarbij de correctheid van de antwoorden wordt gecontroleerd en de tijdspanne waarin deze wordt volbracht. Het uittesten van het prototype gebeurt met een klein groepje mede scholieren. Na afloop van het uittesten, vult de deelnemer een vragenlijst in. Deze vragenlijst vraagt naar de mening over de escape room. Deze vragenlijst is anoniem. Het gehele onderzoek duurt ongeveer 90 minuten.

### Als de deelnemer niet wil meedoen of wil stoppen met het onderzoek

De deelnemer beslist zelf of hij/zij meedoet aan het onderzoek. Deelname aan dit onderzoek is geheel vrijwillig. Als de deelnemer wel meedoet, kan hij/zij zich altijd bedenken en toch stoppen, ook tijdens het onderzoek. Als de deelnemer niet wil dat zijn/haar gegevens worden gebruikt, kan hij/zij dit aan de onderzoekers laten weten binnen 24 uur na het onderzoek. Er zijn geen fysieke, juridische of economische risico's verbonden aan deelname aan dit onderzoek.

### Vertrouwelijkheid van gegevens

Voor dit onderzoek is het nodig dat gegevens worden verzameld en gebruikt. Er wordt op geen enkele wijze vertrouwelijke informatie of persoonsgegevens van of over de deelnemer naar buiten gebracht, waardoor iemand de deelnemer zou kunnen herkennen. De uitkomsten van het onderzoek worden gepubliceerd in de bachelor thesis van de onderzoeker.

De onderzoeksgegevens worden bewaard voor een periode van 15 jaar. Tot slot is dit onderzoek getoetst door de ethische commissie van de EEMCS Universiteit Twente.

Heeft u vragen of opmerkingen?

Bij vragen of opmerkingen kunt u contact opnemen met:

Karlijn Kole: [k.j.kole@student.utwente.nl](mailto:k.j.kole@student.utwente.nl) , +31 6 19880477

Supervisor van dit onderzoek: Angelika Mader [a.h.mader@utwente.nl](mailto:a.h.mader@utwente.nl)

Als u nog vragen of bezwaren heeft met betrekking tot de opzet en of uitvoering van het onderzoek die niet voor de onderzoeker bedoeld zijn, kunt u contact opnemen met de secretaris van de Ethics Committee Information & Computer Science:

[ethicscommittee-CIS@utwente.nl](mailto:ethicscommittee-CIS@utwente.nl)

Met vriendelijke groeten,

Karlijn Kole

## Appendix M: Information Students and Consent Form

Beste deelnemer,

Je ontvangt deze mail omdat je onderbouw scholier bent op GSG Guido in Amersfoort en uitgenodigd wordt om mee te doen aan mijn onderzoek. Mee doen aan dit onderzoek is vrijwillig. Om mee te doen is wel jouw schriftelijke toestemming nodig. Voordat je beslist of je wilt meedoen aan dit onderzoek, krijg je uitleg over wat het onderzoek inhoudt. Lees deze informatie rustig door en als je nog vragen hebt kan je ons mailen of bellen. Je kunt er ook over praten met je ouder(s) of verzorger(s). Je hoeft pas schriftelijke toestemming te geven vlak voor aanvang van het onderzoek.

Met vriendelijke groet,  
Karlijn Kole

### Informatiebrief

#### Algemene informatie

Dit onderzoek is opgezet door Karlijn Kole (onderzoeker), derdejaars student Creative Technology aan de Universiteit Twente. Het doel van dit onderzoek is het evalueren van educatieve escape room bedoeld om computational thinking vaardigheden te leren. Deze escape room is nog een prototype.

#### Wat meedoen inhoudt

Je neemt deel aan een onderzoek waarbij informatie verzamelt wordt doormiddel van observatie door de onderzoeker tijdens het uitproberen van de escape room. In de escape room zitten verschillende puzzels waarbij de correctheid van de antwoorden wordt gecontroleerd en de tijdspanne waarin deze wordt volbracht. Het uitproberen van de escape room doe je met een klein groepje medescholieren. Na afloop van het uittesten mag je een vragenlijst invullen die vraagt naar jouw mening over de escape room. Deze vragenlijst is anoniem. Het gehele onderzoek duurt ongeveer 90 minuten.

#### Als je niet wilt meedoen of wilt stoppen met het onderzoek

Je beslist zelf of je meedoet aan het onderzoek. Deelname aan dit onderzoek is geheel vrijwillig. Als je wel meedoet, kun je je altijd bedenken en toch stoppen, ook tijdens het onderzoek. Als je niet wilt dat jouw gegevens worden gebruikt, kan je dit aan de onderzoekers laten weten binnen 24 uur na het onderzoek. Er zijn geen fysieke, juridische of economische risico's verbonden aan jouw deelname aan dit onderzoek. Je hoeft geen vragen te beantwoorden die je niet wilt beantwoorden.

#### Vertrouwelijkheid van gegevens

Voor dit onderzoek is het nodig dat gegevens worden verzameld en gebruikt. Er wordt op geen enkele wijze vertrouwelijke informatie of persoonsgegevens van of over je naar buiten gebracht, waardoor

iemand je zal kunnen herkennen. De uitkomsten van het onderzoek worden gepubliceerd in de bachelor thesis van de onderzoeker.

De onderzoeksgegevens worden bewaard voor een periode van 15 jaar. Tot slot is dit onderzoek getoetst door de ethische commissie van de EEMCS Universiteit Twente.

Heeft u vragen of opmerkingen?

Bij vragen of opmerkingen kun je contact opnemen met:

Karlijn Kole: k.j.kole@student.utwente.nl , +31 6 19880477

Supervisor van dit onderzoek: Angelika Mader a.h.mader@utwente.nl

Als je nog vragen of bezwaren hebt met betrekking tot de opzet en of uitvoering van het onderzoek die niet voor de onderzoeker bedoeld zijn, kun je contact opnemen met de secretaris van de Ethics Committee Information & Computer Science:  
ethicscommittee-CIS@utwente.nl

Met vriendelijke groeten,

Karlijn Kole

#### Toestemmingsformulier

- Door dit toestemmingsformulier te ondertekenen erken ik dat ik voldoende ben geïnformeerd over het onderzoek door middel van een informatiebrief. Ik heb de informatiebrief gelezen en heb daarna de mogelijkheid gehad vragen te kunnen stellen. Deze vragen zijn voldoende beantwoord.
- Ik erken dat ik 12 jaar of ouder ben.
- Ik neem vrijwillig deel aan dit onderzoek. Er is geen expliciete of impliciete dwang voor mij om aan dit onderzoek deel te nemen.
- Het is mij duidelijk dat ik deelname aan het onderzoek op elk moment, zonder opgaaf van reden, kan beëindigen. Ik hoef een vraag niet te beantwoorden als ik dat niet wil.
- Ik weet dat als ik mij terugtrek, mijn gegevens tot dat moment gebruikt kunnen worden, tenzij ik ook vraag om de reeds verzamelde gegevens te wissen. Dit kan enkel binnen 24 uur na het onderzoek.
- Ik geef toestemming voor het verzamelen, bewaren en gebruiken van mijn gegevens voor dit onderzoek. Als mijn resultaten openbaar worden gemaakt, zal dit volledig anoniem zijn. Mijn persoonsgegevens worden niet verstrekt aan derde partijen zonder mijn toestemming. Ik geef toestemming om de gegevens die gedurende het onderzoek bij mij worden verzameld te verwerken zoals is opgenomen in het bijgevoegde informatieblad.

Als je klachten hebt over dit onderzoek, neem dan contact op met de secretaris van de Ethics Committee Information & Computer Science:  
ethicscommittee-CIS@utwente.nl



Supervisor van dit onderzoek: Angelika Mader a.h.mader@utwente.nl

Naam Deelnemer:

.....

Naam Onderzoeker:

.....

Handtekening:

.....

Handtekening:

.....

Datum:

.....

Datum:

.....

## Appendix N: Questionnaire

Topic puzzle quality: 1, 3, 10,11

Topic engagement: 5, 7, 8, 12, 13, 14

Topic feeling of learning: 2, 9, 15

	Dutch	English
1	Ik vond de puzzels te moeilijk	I found the puzzles too difficult
2	Ik heb het gevoel iets geleerd te hebben	I feel like I've learned something
3	Ik vond dat er te weinig verschillende puzzels inzaten	I thought there were too few different puzzles in it
4	Het programma op de laptop was makkelijk te gebruiken	The program on the laptop was easy to use
5	Ik vond het samenwerken leuk	I liked working together
6	Ik voelde competitie met het andere team	I felt competition with the other team
7	Ik heb mij vermaakt	I enjoyed myself
8	Ik had net zo lief alleen de powerpoint presentatie op het eind gehad	I would have loved to have just had the PowerPoint presentation at the end
9	Door de escape room snap ik beter wat computational thinking is	Because of the escape room I understand better what computational thinking is
10	De puzzels waren te makkelijk	The puzzles were too easy
11	De opbouw van de escape room vond ik logisch	I thought the structure of the escape room was logical
12	Ik vind het leuk om op deze manier te leren	I like learning this way
13	Ik zou het leuk vinden als lesmateriaal vaker op deze manier wordt aangeboden	I would like it if teaching materials were offered in this way more often
14	De verhaallijn vond ik leuk	I liked the storyline
15	Door de presentatie op het eind heb ik wat geleerd	I learned something from the presentation at the end
16	Wat zou je verbeteren of anders willen zien aan de verhaallijn?	What would you like to improve or see differently about the storyline?
17	Wat miste je?	What did you miss?
18	Algemeen: opmerkingen/verbeteringen?	General: comments/improvements?