Implementing feedback systems and content creation tools in an educational game

A Creative technology bachelor thesis by
Selwyn Nijpels

Supervision and guidance by
Job Zwiers
Mariët Theune
Janine Profijt

Abstract

This paper is about the implementation process and development of feedback systems in a serious game used for asphalt road paving education. The game itself was initially far from complete and required more features and polishing before it could be used. During this project significant development progress has been made; the game was polished on a technical level, multiple tests have been conducted, the feedback screen has been overhauled to be more appealing and a direct feedback system has been implemented. From this point more features can be added. The feedback system implementation is a step forward according to established learning theory, but more research should be conducted into the impact of these changes and how they can be improved.

Acknowledgements

The realisation of this project would not have been possible without the guidance Job Zwiers and Janine Profijt. They dedicated a lot of their time for meetings and providing valuable insights.

Likewise, I would like to thank ROC Hengelo and SOMA College Harderwijk for providing the opportunity to conduct various test with their students during school hours.

This project makes use of previous work done by Peter Verzijl. He was a student at the University of Twente and laid the groundwork for the game that is used in this project.

Table of contents

Abstract **1**

Acknowledgements **2**

Table of contents **3**

1. Introduction **5**

1.1 Project description 5

1.2 Terminology 6

2. State of the art **7**

2.1 Background 7

2.2 Challenges 7

2.3 Implementation in educational environments 8

2.4 Recommendations 8

3. Establishing starting point and heading **10**

3.1 MOSCOW method 10

3.2 Initial state of the game 10

3.3 User tests 12

3.4 User test #1 12

3.5 Exploratory testing 12

3.6 Discussion with stakeholders and final categorisation 16

4. Iterative design of project components **18**

4.1 Level Editor 18

4.1.1 Ideation 18

4.1.2 Specification 19

4.1.3 Realisation 21

4.2 Feedback screen 22

4.2.1 Ideation 22

4.2.2 Specification 27

4.2.3 Realisation 27

4.3 Direct feedback 28

4.3.1 Ideation 28

4.3.2 Specification 29

4.3.3 Realisation 30

4.4 Game structure realisation 31

4.4.1 Difficulty selection 32

4.4.2 Execution scene 32

4.4.3 Unity Version 32

5. Testing and results **33**
5.1 User Test #2 33
5.2 Follow up testing 33

6. Colour study **35**
6.1 Study results 37

7. Discussion **44**

8. Conclusion **46**

References **48**

Appendixes **50**
[A] Technology acceptance questionnaire 50
[B] Student drawings from first test 54
[C] Colour study questionnaire 59
[D] Ethical review 69

1. Introduction

1.1 Project description

This thesis is about the implementation and improvement of feedback systems in a serious game Feedback is an important part of any learning process. Some research even shows that it is the most important part [7]. The feedback is often provided by the teacher. However, in a scenario where a serious game is used the feedback would be provided or supported by the game itself. The game can display scores and performance overviews. This is only of added value if this feedback is useful, clear and can provide insights. Serious games can also be used to create adaptive content. The idea is that, based on the performance of the student, content can be adapted by the teacher to focus on strengthening weaker skills of that particular student. The goal of this project is allow for this by developing feedback systems and content creation tools in ‘Asphalt Paving Simulator’, the case and subject of this paper.

The following questions need to be answered: how to shape and present the feedback to students in ‘Asphalt Paving Simulator’ such that it is useful for the learning process? And what is the most effective form of feedback in this scenario? If additional content has to be created, how much control should be given to the teachers and how should this tool be presented?

The context for this project is the serious game ‘Asphalt Paving Simulator’. ‘Asphalt Paving Simulator’ was developed by Peter Verzijl in the context of a previous project. This serious game aims to train vocational education students of the ROC, a secondary vocational education institution, skills of managing the paving of an asphalt road. ASPARI (Asfalt Sector Professionalisering, Research & Innovatie), a network of organisations working together to improve the asphalt road construction process, is interested in the implementation of the game as part of a new minor. The game presents the player with a scenario in which a road has to be constructed, under varying conditions such as the weather and road specifications. The player gives commands to various machines in order to achieve an optimal road surface. For this the player first has to control the speed of the paver which lays down hot asphalt. Sequentially, the player commands the rollers to compact the asphalt. This has to happen at the exact right moment with the exact right temperature of the asphalt. Do it too early or too late and the road quality will suffer.

1.2 Terminology

The subject of this project, an asphalt paving interactive digital game, uses concepts from real world paving. In order to understand the content of the game and consequently this thesis, it is important to discuss these concepts.

In the process of paving a new asphalt road, two machines play the lead role: the paver and the compactors. The paver slowly drives along the route of the road and lays down the hot asphalt. At this point the asphalt starts to cool down. This cooling down process is crucial. The compactors should only compact the asphalt when it is exactly the right temperature. It is therefore very important to keep close attention to the temperature of the asphalt.

Once the compaction starts, the amount of compaction becomes the next factor of focus. A compactor has to drive over the asphalt not too many times or the asphalt will break. Conversely, too little compaction will also not yield the desired result.

In both procedures, one must take into account the weather conditions and the type of asphalt that is paved. In this project we limit this to three types: AC16 SURF, ZOAB and SMA. Each type has different characteristics and is used in different scenarios. The machinery and tools that need to be used for each type also differ.

The game that is used in this project is made using the Unity game engine. Within the Unity Editor, the game is divided into ‘scenes’. Examples of this are the ‘planning’ and ‘execution’ scenes. In the former, the game displays the outline of the level and allows for adjustment by the player of certain parameters. The latter displays the actual level and allows the player to play. Consequently, there no scenes for each individual level of the game. Rather, the game loads parameters for each level into the ‘execution’ scene. The level editor described above is also a separate scene in the game project. Scenes link to each other to create the desired flow in the game.

2. State of the art

In this chapter a state of the art review is done of serious games and feedback in general. Both challenges and recommendations are discussed based on previous research.

2.1 Background

Technology is making big waves in education. In the Netherlands alone, technology products like tablets, smart school boards and personal computers are used extensively across the whole country. Billions of euros are invested in the technology products in schools [1]. Sometimes the benefits are obvious. Computer systems can greatly streamline the performance tracking of students for instance. However, the results are not always satisfactory and some even claim that the quality of education has decreased since the introduction of technology products, resulting in pleads for reduction [2]. The use of technology raises questions with regards to its effectiveness and necessity. Technology is also used to enable development and use of serious games. Serious games are games that simultaneously provide entertainment, training and acquisition of knowledge in order to enhance professional skills [3] [4] [5]. Just like other technology implementations, serious games can have a positive effect on learning effectiveness [6]. However, the success of the game is dependent on a lot of factors, such as the subject and the motivation, which, some say, may get in the way of learning [7]. The development of a serious game is therefore challenging, as it should not only be fun but also teach users about a particular subject.

2.2 Challenges

There are two kinds of challenges regarding serious game development, challenges with regards to educators using the serious games and challenges with regards to the actual development process. In the former category, there are two main issues. Connolly et al. [8] state that most serious games belong to genre ‘simulations and puzzles’. The authors’ suggested reason being that educators are unclear about how to utilize serious games belonging to genres other than simulations and puzzles in teaching. More guidance for educators would be necessary. Perhaps this ties into the second issue, namely the acceptance and integration of serious games in educational environments. This issue was listed as ‘one of the most notable’ by Brom et al. [9].

The second set of issues lie in the category of the actual development of the game. The first, and perhaps most important issue in this category has to do with the translation of gained knowledge in the serious game to the real world. Brom et al. [9] state this as the transfer problem, on the other hand Kiili [10] points out that the virtual game worlds should stimulate reflective thinking. However, both accentuate that the challenge of the connection to the real world is important. Boyle et al. [11] provide the second issue with regards to serious game development, stating that understanding the learning goals is key to developing an effective serious game. The identification of all of the challenges, the acceptance by and lack of guidance for educators, establishing a connection of the game to the real world and understanding of learning goals, proves to be especially relevant. Not only

is ‘road paving simulator’ a game that teaches practical skills, it is also scheduled to be used in a respected college.

2.3 Implementation in educational environments

The implementation of a serious game in educational environments is largely dependent on three aspects. In addition to the aforementioned acceptance challenge, two other aspects have been identified. According to Franzwa et al. [3] aspects from mainstream games must be mixed with educational elements to make a successful and effective serious game. On the other hand, Noemí and Máximo [4] conclude that tutoring the students is key. They state that tutoring helps the learning process, guides students to achieve learning goals and prevents inappropriate behaviour. As tutoring is already part of traditional education methods, one can conclude that the authors of both articles agree on that topic: serious games need to acknowledge and incorporate existing educational elements to be successful and effective in an educational environment.

2.4 Recommendations

There are two main recommendations with regards to serious game development. First, serious games should be built on established learning theories. Three of the used papers state this as one of the recommendations. Mayer et al.[12] state that the connection of experiences in the game to theories, and the strength of it, noticeably increases the learning satisfaction of the students. Similarly, Kebritchi [13] states that developers of serious games should base the design of the game on established educational theories to enhance game based learning. Brom et al. [9] argue that it is beneficial to outline these theories specifically in the design phase, reinforcing the idea that serious game design should involve extensive research into educational theories.

Second, users of the serious game should be included during the design phase. Huizinga et al. [14] suggest that user inclusion during development could allow for a more personalized experience for the user because the needs of the user are identified early. This could in turn be beneficial to the learning process. Meanwhile, Knight et al. [15] conclude from feedback from a test that extensive user involvement was needed, as well as the involvement of subject matter experts. From the above recommendations, basing the game on established educational theories and including the user in the design process, it becomes clear that insight into educational theories and the involvement of the user, for instance in the form of user tests, is necessary in the game is to be successful.

A serious game combines fun and learning into one experience. This means that developers should pull inspiration from both ‘traditional’ games that exist to entertain and existing, established learning theories and combine them to create a game that teaches skills and/or concepts to the player. The first part, entertainment, is well established. The video game industry is big and still growing. However, not all games are equally successful. This signifies the importance of careful consideration of entertaining aspects during development. Looking at feedback specifically, these ‘traditional’ games could also prove useful. Even though these games are (usually) not designed to teach the player about skills or concepts in the real

world, they do provide the player with feedback about their performance. The structure and layout of this feedback from all of these game can therefore still be used as inspiration for a feedback system in a serious game.

The issue of feedback involves tutoring and the extensiveness of scoring. Feedback is an important part of the learning process in traditional educational environments, and the same holds true for serious games. Tutors can provide appropriate feedback at the appropriate time. Noemí and Máximo [4] even go as far as to say that the learning process is not complete without good tutoring. Meanwhile, Franzwa et al. [3] concludes that the outcome of the game play should offer more than just a pass or a fail. Otherwise "[...] students tend to not to seek out additional depth into a learning subject and do barely minimum as the result is the same regardless of the effort." Literature about this particular issue proves to be polarizing. First and foremost it should be noted that there is little to no recent (after 2013) literature regarding pass-fail grading in secondary vocational education. With regards to other education levels, research has been done, however most papers focus on medical or psychology students. The research in this field presents no conclusive evidence about the positive or negative effects of such a grading system. Some report an increase in performance, some report a decrease. Based on these finds the aforementioned literature about feedback in serious games will be regarded as most relevant. Therefore feedback should include tutoring that stimulates students to improve their results and seek out additional depth.

The idea of feedback and adaptive content is not new and multiple studies have been performed. Bellotti et al. [16] and Raybourn [17] for instance conducted research on this topic, but the focus is not on the linking of feedback to the player and content that is adapted to it. Research into both feedback and content exists, but linking the two directly is a lesser studied aspect. Besides, the research that does exist does not focus on either vocational education or construction work, let alone both. Namely the vocational (like the ROC colleges) education is important, as it concerns different students than those in other educational categories. It is important then that research is done into the linking of feedback and content adaptation in the context of vocational education.

Adaptive content can also be found in existing entertainment games and serious games. For instance, 'Memorize', a learning tool, adapts to the players performance by increasing the recurring frequency of questions that were answered incorrectly. If the player answers a question correctly the first time, it will recur less often. Adaptive content can even be found in AAA (informal classification used for video games with the highest development budgets and levels of promotion) entertainment games. For instance, 'Titanfall 2', lets players play through a short tutorial section to determine the difficulty setting that matches the players performance. Many online multiplayer titles match players with other players of similar skill levels to ensure fair matches and indirectly increase the player's enjoyment and engagement with the game.

3. Establishing starting point and heading

In this chapter the starting point of the project is determined and analysed. As this projects primary subject is an existing game from a previous project, it is important to establish the initial situation. After, exploratory testing and requirement setting for this project are discussed

3.1 MOSCOW method

Requirements in this chapter are identified using the MOSCOW method, where requirements are divided into the following categories: ‘must have’, ‘should have’, ‘could have’ and ‘won’t have’. Requirements in the first category are considered essential for the project and must be implemented in order to regard the project as successful. ‘Should have’ requirements are considered very important but not essential for the project to be successful. If a requirement is considered a valuable but not important it belongs to the ‘could have’ category. The ‘won’t have’ category is for everything that does not fit within the scope of the project.

3.2 Initial state of the game

The game, Asphalt Paving Simulator, played a crucial role in this project. Yet, the game itself is initially far from complete and requires more features and polishing before it can be used as an educational tool. In this chapter the game in its initial state is analysed, and a list of necessary improvements is compiled.

From the start, the game consisted of four main parts, the main menu, planning phase, execution phase and a feedback screen. After booting the game, a main menu is loaded. From there the player can access the level selection screen and the level editor. If the player chooses to play a level, they first have to complete the planning phase. Here the player can specify the number of machines used in the execution phase, as well as alter variables such as road length, width and asphalt mix. In this phase, the player should also pay attention to the goals of the level and the weather conditions. Whereas temperature is simulated, weather effects such as rain and snow are not. This phase did initially allow the player to select trucks, in addition to compactors and pavers. However, the trucks are not represented in the execution phase of the game.

Once completed, the player continues to the execution phase. Here the player is tasked with actually paving the road, using pavers and compactors. As mentioned earlier, delivery trucks are not simulated in this phase. The player has control over the speed and points between which the compactors pendle. The paver works differently, only its speed can be adjusted. Once set it will automatically follow the road. To aid the player, there are two visualisation options: asphalt temperature and amount of compaction. Both use the colours green and red to communicate their respective data to the player. The use of these colours is evaluated in this research too. For example, red means too hot to compact, and with the other filter on red means too much compaction. The same holds true for green, only that indicates the

opposite, positive state. By controlling the various machines, and paying close attention to the visualisations on offer, the player should achieve the highest possible compaction. 100 percent is considered perfect, and represents a perfect road in the real world.

After completing compacting the road, or whenever the player wishes to do so, the game presents a feedback screen. An example of this screen can be seen in image 3.2.1. The feedback screen presents certain statistics to the player, such as the time it took the player to complete the road and how well the road was compacted. All statistics are presented in a table. The feedback screen also includes a visual representation of the road the player worked on in the execution phase.

Image 3.2.1: feedback screen in initial state of the game.

3.3 User tests

To test the game, it was decided to conducts tests with the students and on the school where it would eventually be used. Three user tests were conducted and are described below. All three tests were conducted with students doing MBO level 3 ‘machinisten’ studies. The year they were in did vary from test to test.

3.4 User test #1

The first user test for this project was conducted at the SOMA college in Harderwijk. The participants were students in year 2 and all potential users of the game. For this test, the base version of the game was used. Meaning, only the essential bugs were eliminated and no content was added.

First, the students were introduced to the project and what it entails. A link to download the game to their own computers was provided, and thus every participant used their own computer to play the game. Students were allowed to talk and stimulated to work together. They were given 30 minutes to play the game. After the play session the students were given a technology acceptance questionnaire, which they did have to fill in individually. The questionnaire can be found in appendix A. For the third part of the session, the students were show examples of how a feedback screen might also look like. Interaction was stimulated by asking the students for suggestions. Finally, the students were given a blank sheet of paper and some pencils and asked to draw their ideal feedback screen. The drawings can be found in appendix B.

3.5 Exploratory testing

The goal of the test was twofold. One the one hand, the initial state of the game, as discussed in chapter 3.2, was evaluated. Students were tasked with playing through the levels during 30 minutes of play. After the play session, the students were presented with a Technology Acceptance questionnaire (appendix A). Questions were categorised, in the following categories: performance expectancy, effort expectancy, attitude towards the game and self effectiveness. The results of this test serve as baseline. The results are shown in Table 3.5.1.

Performance Expectancy		Average
1	I find this game useful in my training	3,000
2	Using this game enables me to learn more quickly	2,688
3	Using this game increases my productivity	2,625
4	If I use this game, I will get better at doing my job	2,333
Effort Expectancy		
5	It is easy for me to become skillful at using this game	3,688
6	I find this game easy to use	3,733
7	Learning to operate this game is easy for me	3,688
Attitude Expectancy		
8	Training with this game is a bad/good idea	2,938
9	this game makes training more interesting	2,938
10	Training with this game is fun	3,000
11	I like training with this game	2,750
12	I would recommend using this game to my colleagues	2,563
Self Effectiveness	**I could complete a training using this game:**	
13	...if there was no one around to tell me what to do as I go.	2,375
14	...if I could call someone for help if I got stuck.	2,875
15	...if I had a lot of time to complete the job for which the software was provided.	2,625
16	...if I had just the built-in help facility for assistance.	2,938

Table 3.5.1: results of technology acceptance questionnaire of first test.

The second goal, and part, of the test was more open ended in nature. Students were stimulated to discuss the current feedback systems featured in the game, as well ideas about improvements on those systems. To stimulate the discussion, an example of a feedback screen was presented to the students. After 10 minutes, the discussion was closed and the students were tasked to draw out there ideal feedback screen. All drawings can be found in appendix B.

Even though the drawings may not be statistically relevant, it is possible to analyse them. Almost all students drew some kind of graph or picture. Those that did not, did draw some kind of structured interface to display the information. An example can be seen in image 3.5.1. Even though the kind of graphs or pictures do differ from drawing to drawing, there commonalities to be found. For example, in image 3.5.2 and image 3.5.3. two different drawings are shown where different data visualisations are used for each kind of data set. This indicates that there would not be a ‘one size fits all’ solution for displaying the scores and data. Additionally, in both drawings their own scoring is compared to the goal that was set for each particular score.

Some students noted that they wanted to see the resulting road in the feedback screen, just like the initial feedback screen. One student pointed out that there should be more explanation on why some goals were or were not achieved. Notably, none of them drew anything like the table from the initial feedback screen. This is in line with their discussions prior, where they indicated that they spontaneously skipped through this page very quickly. Another interesting omission is the use of competitive elements in the drawings, even though they did mention it a few times during the session. Nevertheless, none of the students included a scoring display, comparing their own performance to that of other students.Therefore this aspect is not considered crucial for the success of this project.

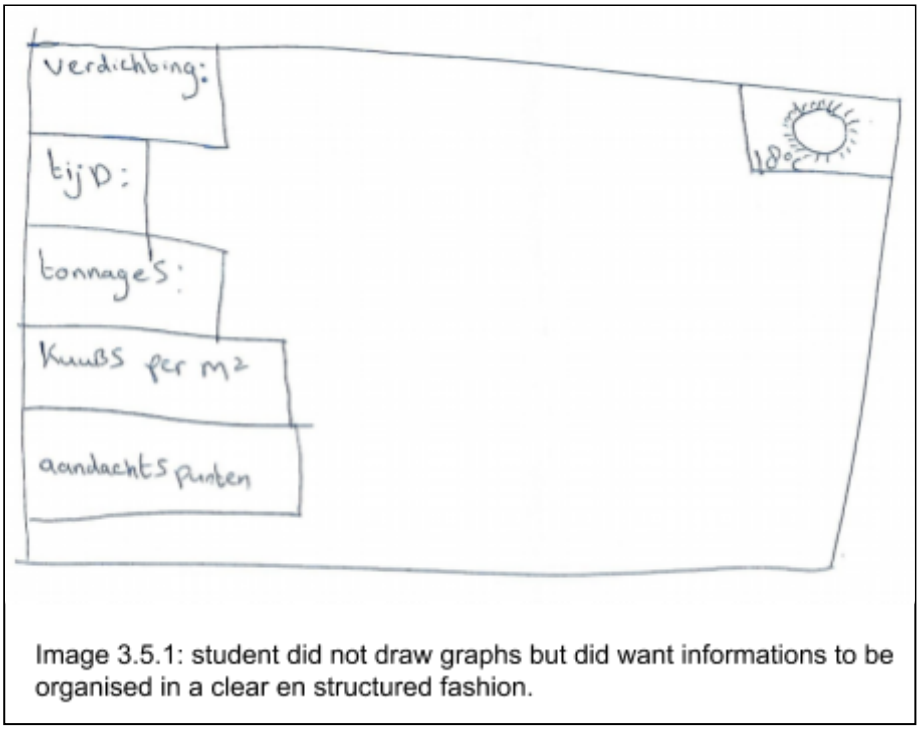


Image 3.5.1: student did not draw graphs but did want informations to be organised in a clear en structured fashion.

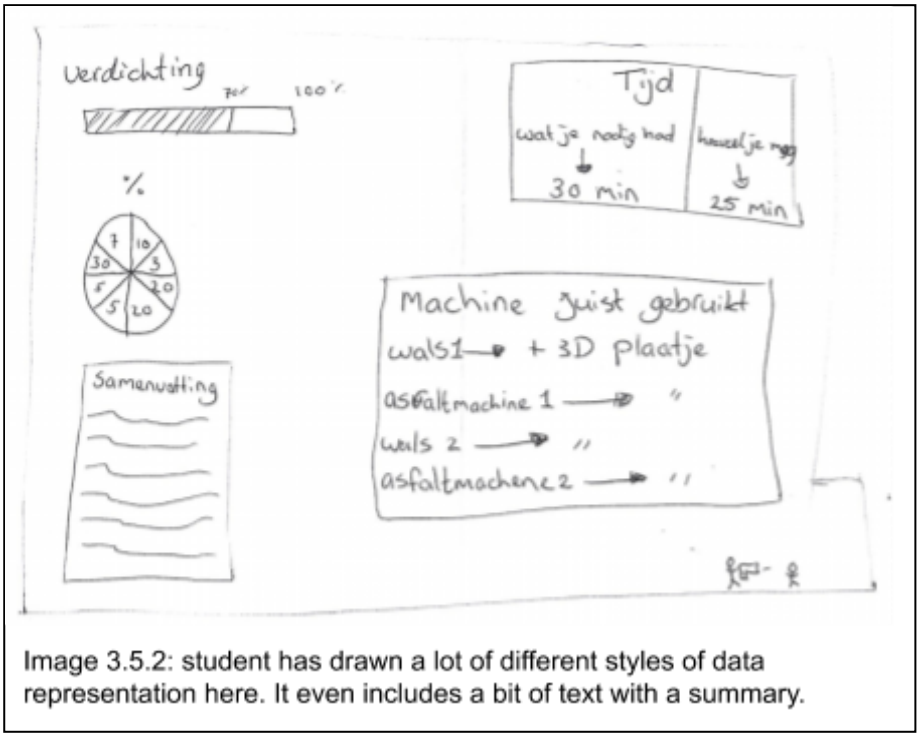


Image 3.5.2: student has drawn a lot of different styles of data representation here. It even includes a bit of text with a summary.

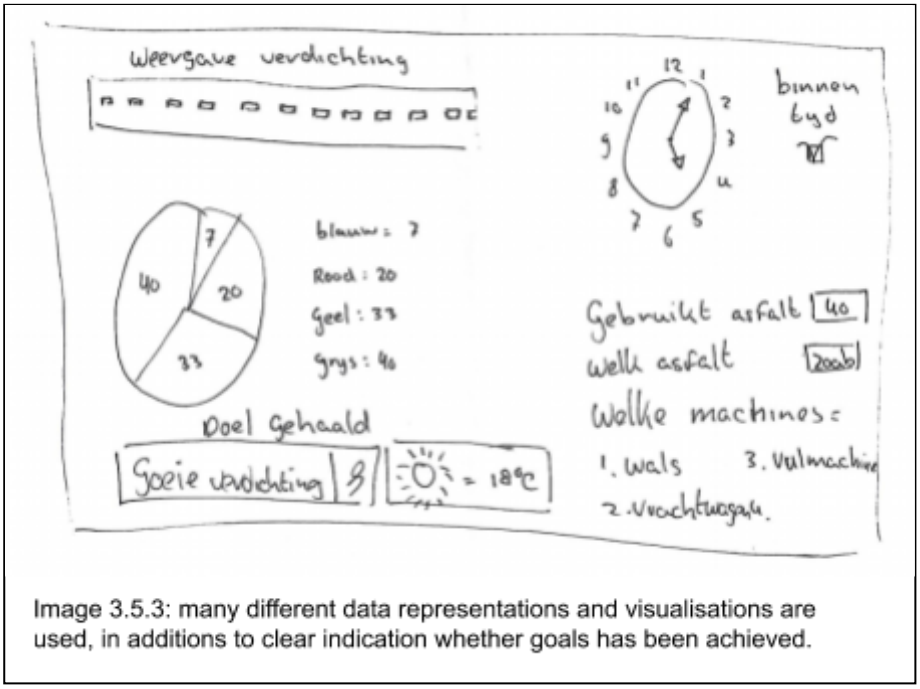


Image 3.5.3: many different data representations and visualisations are used, in additions to clear indication whether goals has been achieved.

From the drawings and a closing central discussion it became clear that the feedback screen needed more visual elements while also convey more clearly whether and how goals were achieved. Additionally, during discussions in class, many students indicated that in the initial version there was ‘too much text’ and information was not ‘organised in a logical manner’.

Based on this test it was determined that a different feedback system *must* be included in the final design. Feedback in the game can be divided into two categories: the feedback screen and direct feedback during gameplay. The feedback screen *must* be improved such

that it becomes both more appealing and easily readable. It *must* be clear whether goals have been achieved or not. During play, the game *must* be able to display direct, real time, feedback based on action of the player.

Furthermore, based on the student feedback it was determined that the game *should* include online functionality to enable the comparison of player performances. It *should* include a scoring system and it *should* allow for the access of performance data by the teacher remotely.

3.6 Discussion with stakeholders and final categorisation

To determine further requirements of the game, meetings with other stakeholders were arranged. Representatives from ASPARI and teachers from SOMA and ROC were able to share their priorities for the project. As 'must have' requirements are already known, any further requirements were evaluated to determine whether they would fit within the scope. Then they were categorised using the MOSCOW method.

The teachers indicated they find it important that the game is feature complete, including features such as weather condition simulation and different road shapes. Additionally, they stressed the need for teacher tools, including level creation and monitoring tools.

The final list of MOSCOW requirements is shown in Table 3.6.1

MOSCOW category	**Label**	**Requirement**	**Label**	**sub-requirements**
Must have	**A1**	Functionally more stable with less bugs and technical issues		
	A2	A more easily understandable feedback screen	**A2.1**	Goal achievement must be clearly displayed
	A3	The feedback screen must be more appealing for the target audience		
	A4	Real time and direct feedback	**A4.1**	The game must be able to nudge the player in the right direction
			A4.2	The game must notify the player if a mistake is made
Should have	**B1**	Online functionality	**B1.1**	The game should include a scoring system with which

				students can compare their performance to their peers Scores and performance reviews should be accessible remotely, by teacher and student
	B2	Teacher control and monitoring tools	**B1.1**	The game should allow for difficulty tweaking by the teacher
			B1.2	The game should include a tool that allows teachers to add additional content/exercises to the game
			B1.3	This creation of this content should be able to be easily adapted to the performance of the student
Could have	**C1**	Additional features to simulate real world scenarios	**C1.1**	The game could include multiple weather effects and be able to dynamically change between them
			C1.2	The game could allow for advanced movement of the compactors
			C1.3	The game could allow for all kinds of road configurations, including bends and elevations

Table 3.6.1: requirement categorisation according to MOSCOW method.

4. Iterative design of project components

This chapter features four different components of the game and the project. Due to the iterative nature of the project, for each component, the Ideation specification and realisation are discussed. All components were therefore developed separately, however they were all implemented in the same game.

4.1 Level Editor

The name ‘level editor’ in interactive software applications is used for tools that allow for the creation of additional content using the existing feature set. In other words, given the features of the game, additional levels can be created by the player of the game. In a serious game this feature is important for the teacher, so levels can be created to suit particular learning needs of the students. This is needed to satisfy both requirement B1.1 and B1.2.

4.1.1 Ideation

To determine what the level editor must include, teachers at both ROC Hengelo and SOMA college in Harderwijk were questioned. Their preference is to be able emphasise specific parts of the paving and compaction pronesses. For example, particular curves in the road, hilly terrain or extreme weather conditions. The editor must allow for easy creation of levels that allow for the training is these circumstances.

As described above, the editor is dependent on the already existing feature set of the game. Even though features have been added to the game, many features requested by the teachers to be in the editor are not in the game. Consequently, it was necessary to consider what is possible to realise within the scope of this project. From this stance, first paper prototypes were created and soon after a first digital prototype in Unity. This is shown in image 4.1.1.1

This version of the editor allows for the altering and tweaking of the following parameters:

- Level name
- Level description/briefing
- Road width
- Road thickness
- Road length
- Number of trucks
- Number of static compactors
- Number of dynamic compactor
- Weather temperature (C)
- Weather condition
- Minimal compaction target (%)
- Maximum compaction target (%)
- Average compaction target (%)
- Time limit (m)

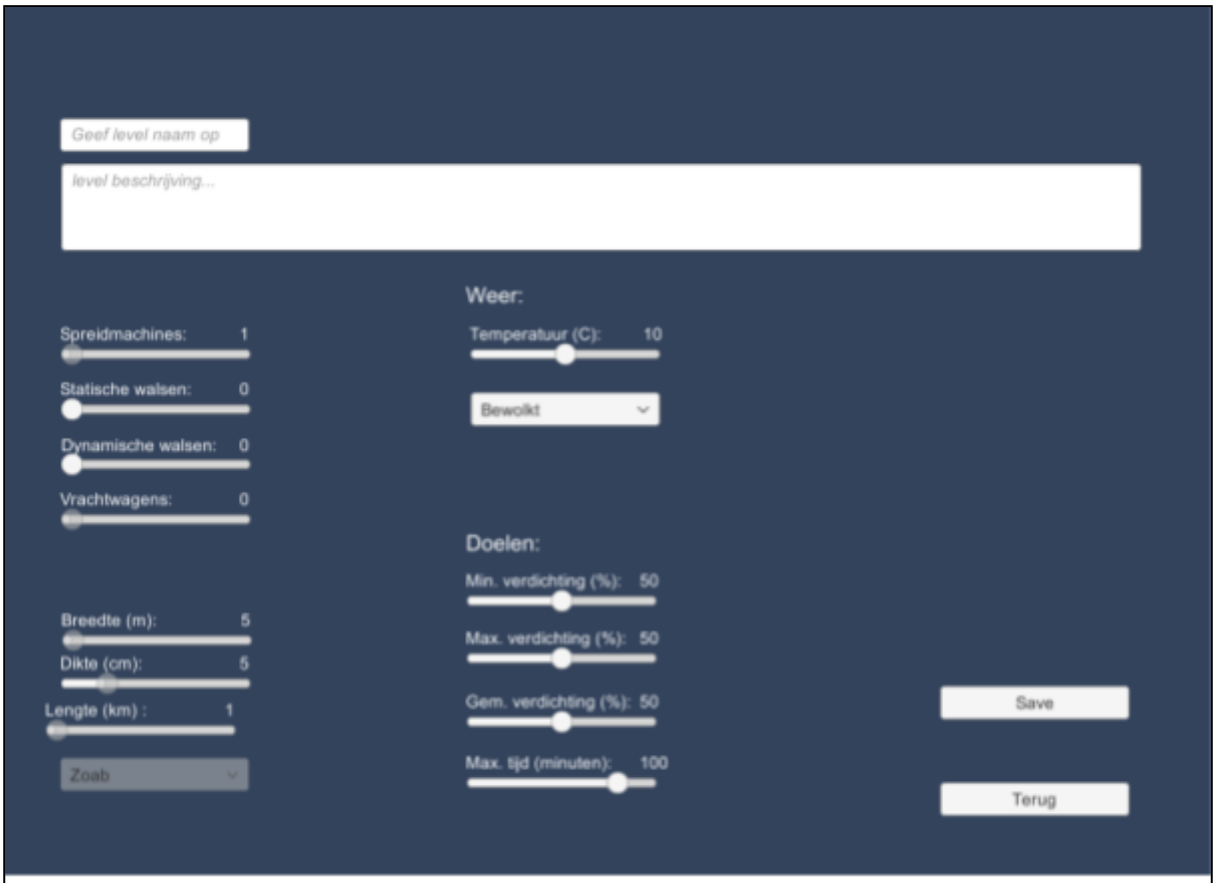


Image 4.1.1.1: first digital prototype of the level editor.

This first prototype allows for the tweaking of all variables that the game is capable of interpreting. However, many of these features are not yet fully realised of simply do not work at all. In a discussion with Janine Profijt is was determined that the focus of the editor, and in fact the whole game, to polish what is already there instead of adding new features on top.

4.1.2 Specification

As many of the variables in the editor were not properly interpreted by the game because of lack of functionality, it was decided to remove some elements from the editor all together. The editor that was settled on is shown in image 4.1.2.1.

Initially the game was planned to have all of these parameters operational. However, in order to make them operational a lot of work to the core game would have been required. It was therefore decided to limit the number of features and consequently the number of alterable parameters. The only road parameter that the game actually takes into account in the length. This is the length of the road that the player needs to pave. That is why the other two parameters were removed from the editor and permanently set to their default value. In a real world scenario planning the arrival of the asphalt delivery trucks is very important. Once the paving has started, enough asphalt should be supplied to keep the process going. Initially the would have allowed for the planning of such supply. However, this aspect was never implemented. The option to set the number of trucks was therefore made unavailable and set to zero. The game includes the names and visual models of two types of

compactors: static and dynamic compactors. In real world scenarios each compactor should be used for certain types of asphalt and scenarios. However, functionally the compactors in the game are the same. It was therefore decided to remove their distinction and combine them in one category. Finally, the weather condition option was removed. The game takes the temperature into account but does have functionality in place to simulate weather conditions such as rain, wind and snow. With these changes the list alterable parameters becomes:

- Level name
- Level description/briefing
- Road length
- number of compactors
- Weather temperature (C)
- Minimal compaction target (%)
- Maximum compaction target (%)
- Average compaction target (%)
- Time limit (m)

Image 4.1.2.1: final version of the level editor.

4.1.3 Realisation

The initial games' code already contained a script to read level parameters from a text file to generate a level. In its initial state it was therefore possible to add levels by manually creating a text file manually and adding it to the right folder. That would require manual copying of the structure the game requires. This is not user friendly. Therefore it was decided to build a level editor which could create these text files and store them in the right location. The interface would be easier to use and less prone to errors than manual creation of text files.

The level editor scene was created from scratch. It consists of UI elements only, as shown in image 4.1.2.1. Each UI element determines the value stored in the text file for a particular parameter. The text entered in the text fields for the title and description are directly used for the level name and briefing respectively. Because the levels are stored in text files, and the editor creates a new text file for each level, the game needs to be forced check the folder with level files each time the editor is used. In order to tackle this issue, a button was added to the main menu that initialises the script that checks for the levels. Only after that button is pressed, becomes the button that leads to the level selection screen available. It is only possible to delete levels by manually deleting the text file in the relevant folder.

The level editor was developed first, and ended up playing an important role in the development of other components later. Before there was no easy and quick way to generate more levels. This would have been done by hand. Using the level editor many aspects of the game could be more easily tested, such as the feedback system.

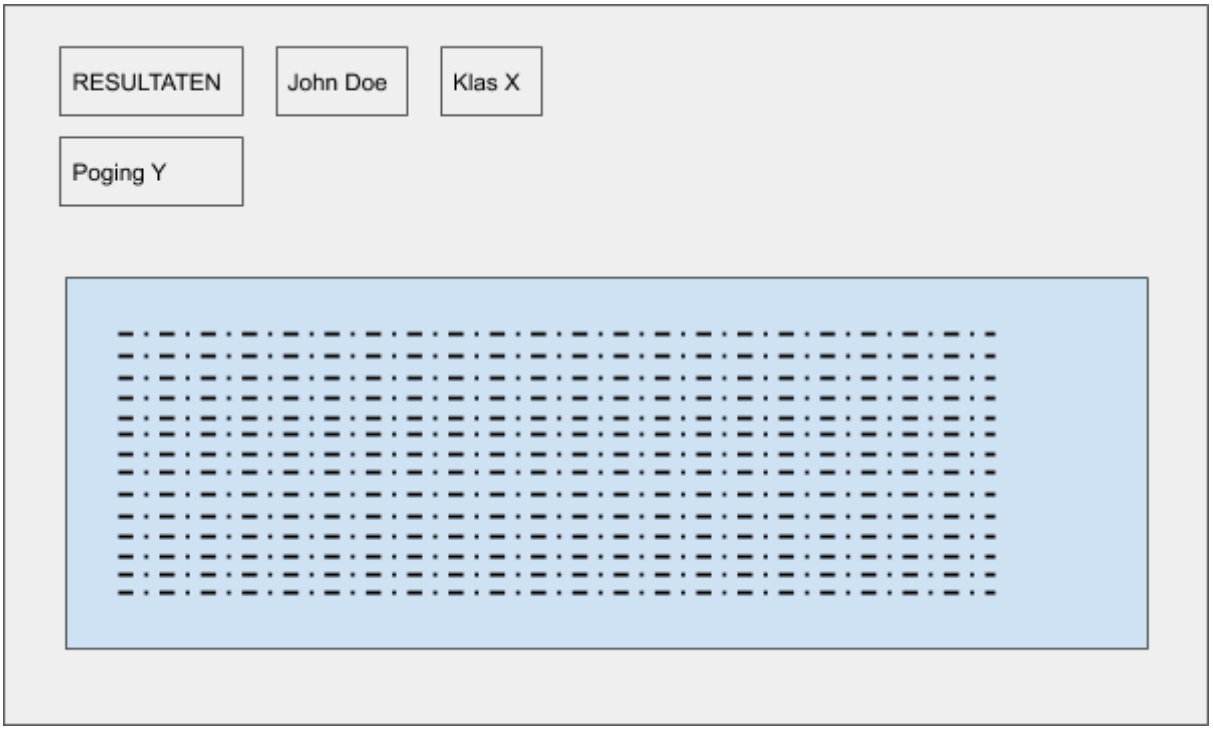
4.2 Feedback screen

One of two ways feedback to the player is implemented in this project, is via a feedback screen. As discussed in chapter three, the initial screen is considered to be insufficient. In order to fulfill the requirement set in chapter three, ways to improve this screen are discussed and explored in this chapter.

4.2.1 Ideation

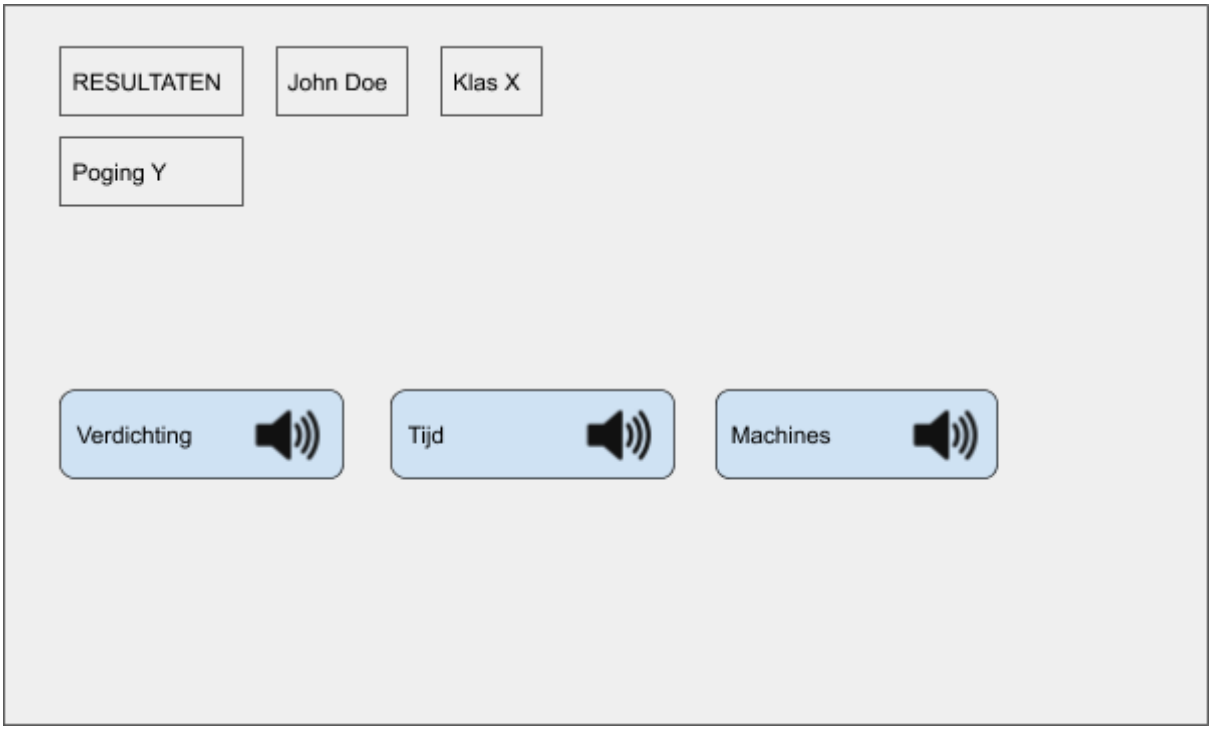
First, all different means to convey information to the player are listed. Then, the digital prototypes are discussed.

Text
A text based system. The students receive feedback by means of text, describing what they did well and what can be improved. Currently the game features such a system, whereby the text in organised in a table. It does not however, currently provide context sensitive descriptions.

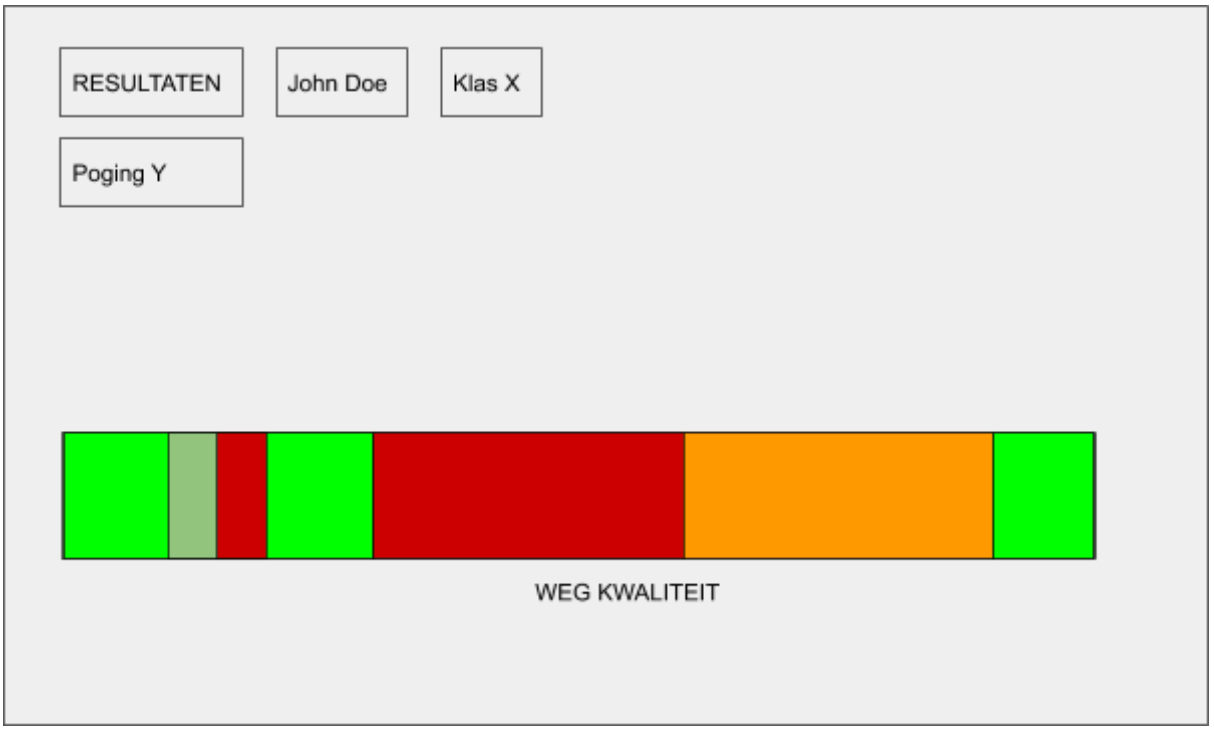


Graphs
A system based on graphs and tables. The students are presented with a visual representation of their performance in the shape of graphs and tables.

Audio
A system which provides the students feedback with a spoken voice.



Visual
A visual system. The students are presented with images that correspond to elements from the game and/or from the real world.



The audio option was removed from consideration to maintain a realistic scope and due to technical limitations. Users of the game would not always have equipment available to play audio and it is also not always desirable to have audio playing in class. All visual options were still considered.

Based on the results from the test described in chapter 3.4 and 3.5, the first new feedback screen prototype was developed, as shown in Image 4.2.1.1. This was done in Unity using a seperate scene. In this new version the table structure of the old screen was replaced by a more horizontal oriented layout with a couple visual elements at the center. At the top of the screen the road as seen in the game itself is displayed. To the left the parameters of the level are summarized. The big container in the center of the screen displays the goals of the level and whether they have been achieved. In actual use, the bars would fill according and relative to the score achieved.

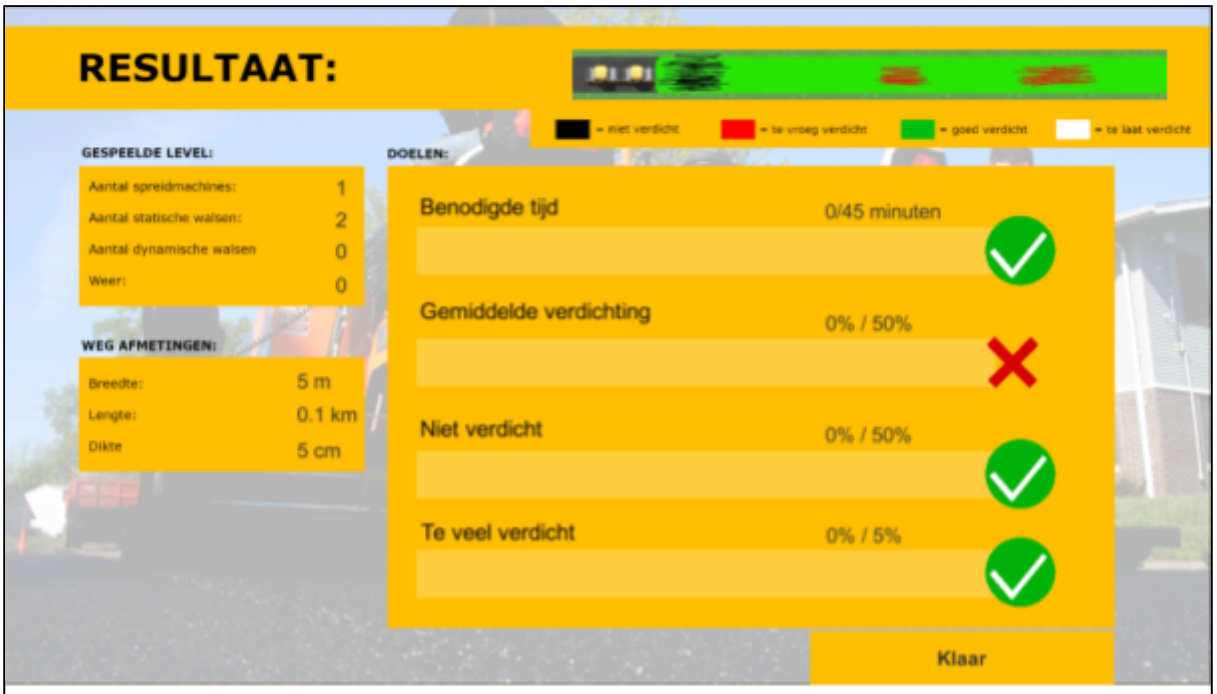


Image 4.2.1.1: the first digital prototype of the new feedback screen.

Even though this first prototype could be considered to be more visually appealing, it still contains a lot of information that is all presented at once. Additionally, the end result picture of the road is now displayed at the top right, when it is actually one of the most important elements. With this in mind a second prototype was developed, giving the road itself a more central position as well as removing the summary of the level parameters.This prototype can be seen in Image 4.2.1.2. In this prototype the ‘progress bars’ from the first prototype have removed in favor of a more compact design. The checkmarks and crosses are still present. The road is displayed prominently, with the goals below it, more directly indicating that they are directly connected to each other.

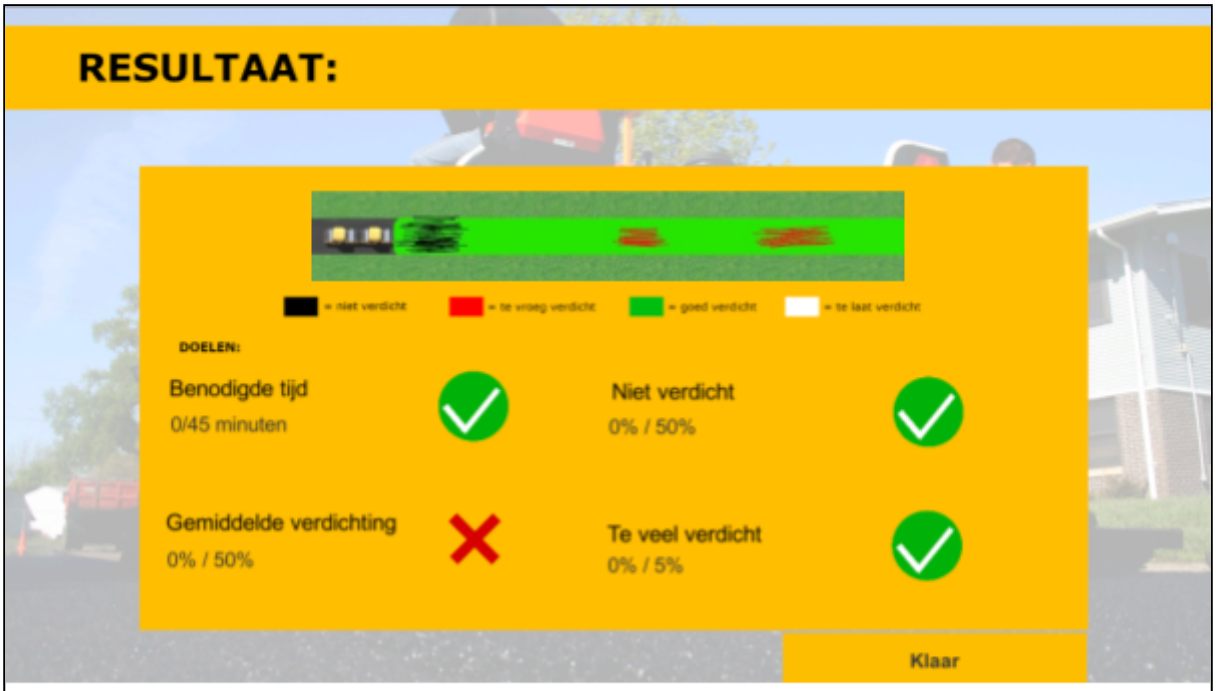


Image 4.2.1.2: the second prototype of the new feedback screen.

4.2.2 Specification

Considering the compromises made in the second prototype, it was decided to develop a third prototype, which would incorporate the best of both. The third prototype is displayed in image 4.2.1.3. The road is still displayed prominently, but also the progress bars are now visible below it. The legend for the colours on the road has been removed to keep the screen as clean as possible. The reasoning being that the meaning of these colours is already clear to the player once they have played the game. The third prototype was implemented in the game to use in all further developments.

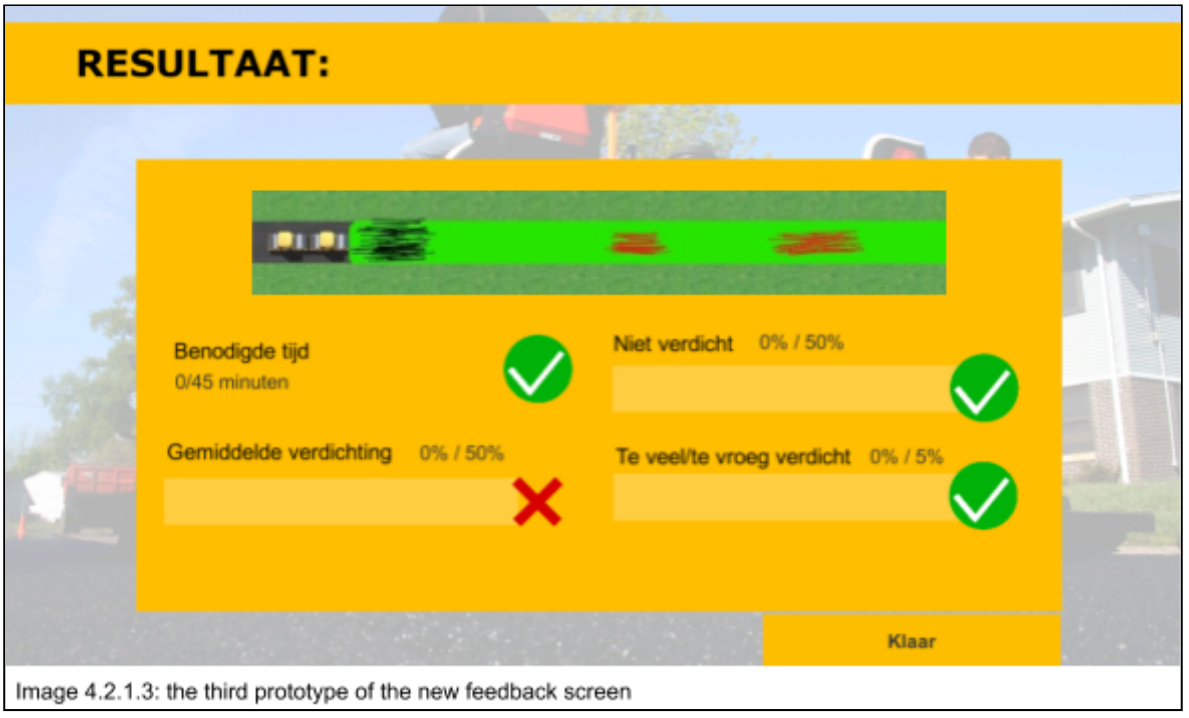


Image 4.2.1.3: the third prototype of the new feedback screen

4.2.3 Realisation

To create the feedback screen, a new empty scene was first created. None of the elements of the original screen were used in the new one. For the background, an image was created using Gimp. On top of the image UI elements were placed. An image of the road surface as created in the execution scene is loaded as an image. For the bar graphs, a free software addon from the Unity store (Simple Health Bar FREE) was used. The crosses and checkmarks are also images that were first created in Gimp. After each bar graph both a cross and check mark are placed, but by default they are hidden. Depending whether the goal relevant to that bar graph is achieved either the cross of check mark is made visible.

4.3 Direct feedback

The feedback screen described above displays after the player has completed a level. In order for this feedback to be effective, the level will have to be played again. This type of feedback display can not correct or nudge during the run of play. For this a direct feedback system is needed.

4.3.1 Ideation

A first concept for an active feedback system was developed. In this system, feedback needs to be provided to the player during gameplay. Five different ‘notifications’ were defined, using the available variables in the game. These notifications are divided into two categories:

- Hint notifications
- Warning notifications

Inspiration was pulled from video games, where the player often receives all kinds of visual stimuli as guidance. For example, in most ‘shooters’ the player receives feedback to help them along and hint to possibilities. A text pop-up could explain what each button does, or let the player know much time is left. These pop-ups are not initiated by the player. In a similar game, getting hit often prompt warnings to the player to mind their health and take appropriate action. These are initiated by the player, since it was because of their actions.

Examples of the pop-ups are show in image 4.3.1.1. The hint notifications are meant to guide the player in the right direction, before the action in question is taken. These notifications are not directly triggered by the player, but rather by certain parameters of the game, for instance the amount of time that has passed or the amount the asphalt has cooled down.

The warning notifications are triggered by actions of the player. They are meant to communicate to the player that said action wil negatively impact the result.

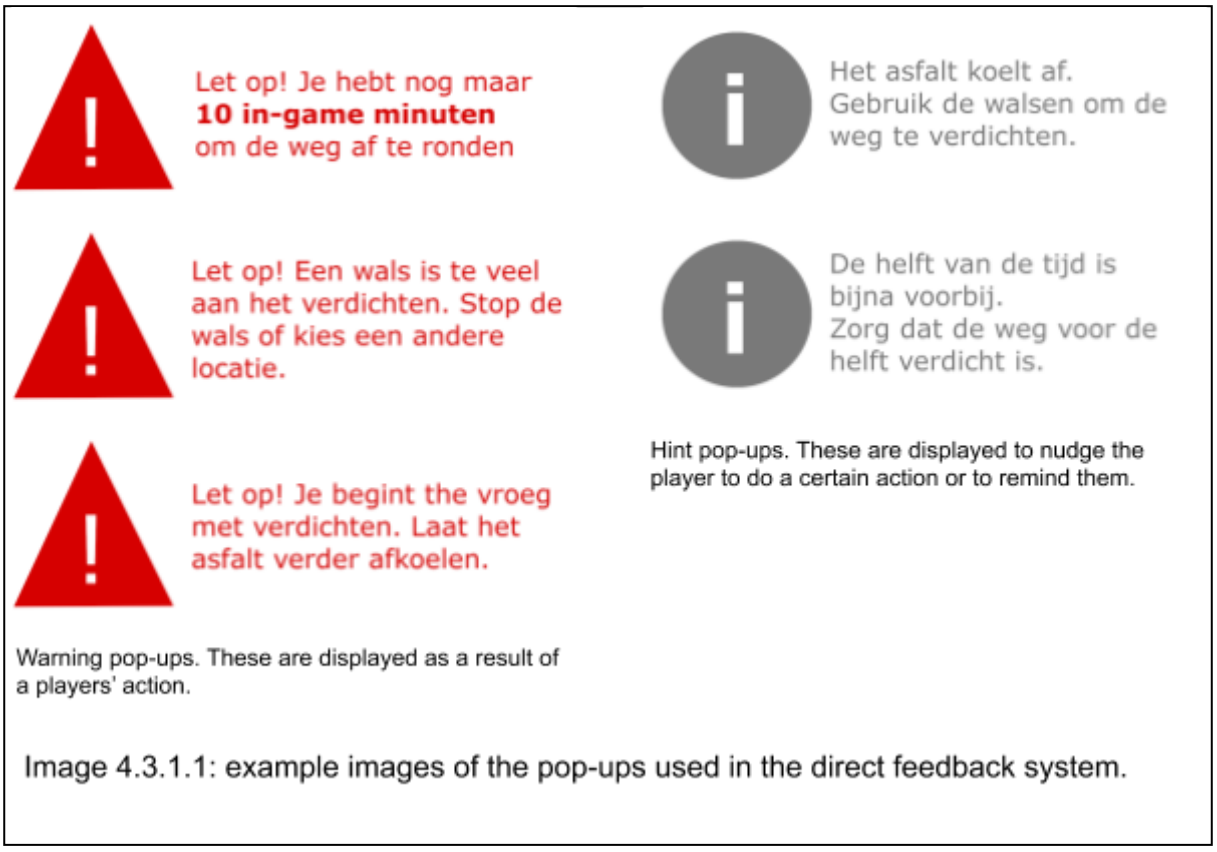


Image 4.3.1.1: example images of the pop-ups used in the direct feedback system.

4.3.2 Specification

The pop-ups described above were implemented in the game. With all feedback systems implemented it is possible to add difficulty layers to the game. It was decided to add three stages of difficulty to each level. The first, and easiest, stage allows for all systems to be active. The player is provided with all visualisation options and pop-ups with hints and warnings. The feedback screen is active in every stage. In the second stage the pop-ups are disabled. This means that the player will have no indication of their performance other than by using both visualisation options. In the third, and hardest, stage, the compaction visualisation is removed in addition to the pop-up hints and warnings. This stage is most similar to a real world scenario. In such a scenario the workers have access to measurement equipment to determine the temperature of the asphalt. That is why is was decided to keep that visualisation enabled instead of disabling all feedback systems. Image 4.3.2.1. shows a visual representation of the structure of the game.

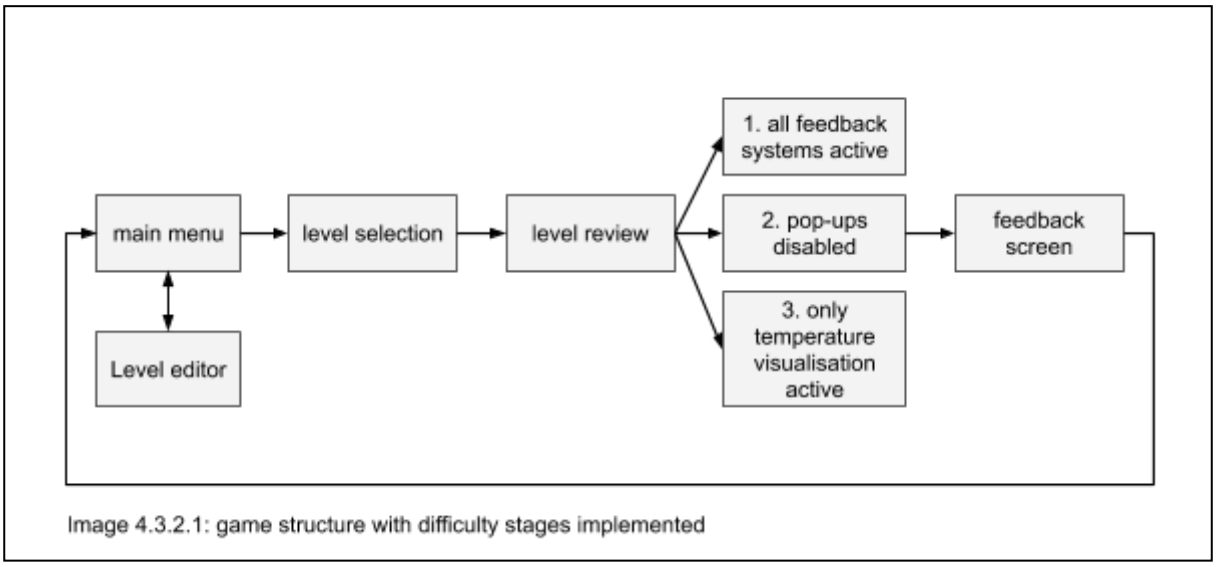


Image 4.3.2.1: game structure with difficulty stages implemented

4.3.3 Realisation

The pop-up notifications were added to the execution scene of the game. This is where the player is actively playing the level. The game is already actively keeping track of many variables in this stage, including but not limited to time played, compaction and asphalt temperature. In order to implement the pop-up images as shown in chapter 4.3.1, the images were converted to sprites and given a position on the screen. By default they are hidden. Each sprite is then tied to the according variable and the game now checks for all conditions needed for the pop-ups. Once a condition is met, the relevant pop-up appears. In order to prevent an overload of information, only one pop-up can be show at once. This means the game will disable any other notifications once another becomes active. Additionally, a timer is active, letting the notification appear for only a few seconds.

4.4 Game structure realisation

As mentioned in chapter 1.2, the game is build with game engine Unity. The game is split up into scenes. Each scene contains specific elements relevant to that scene. For example, the main menu scene contains buttons for the player to click. Some buttons are used to navigate through the menu, and other link to other scenes. The level editor button for instance, links to the level editor scene. The main menu contains the level selection interface. Likewise, clicking on a level loads the level review scene. Once a level is selected, in every scene that follows, it is only possible to go back to the main menu and start again from there. It is possible to stop during playing the execution scene, but you will go back to the main menu scene and not the level review scene. In part, this structure is necessary to facilitate the passing of certain data from scene to scene. For example, once a level is selected the data for that level is used in the level review scene, but also in the execution scene. This structure of scenes is visually represented in Image 4.4.1.

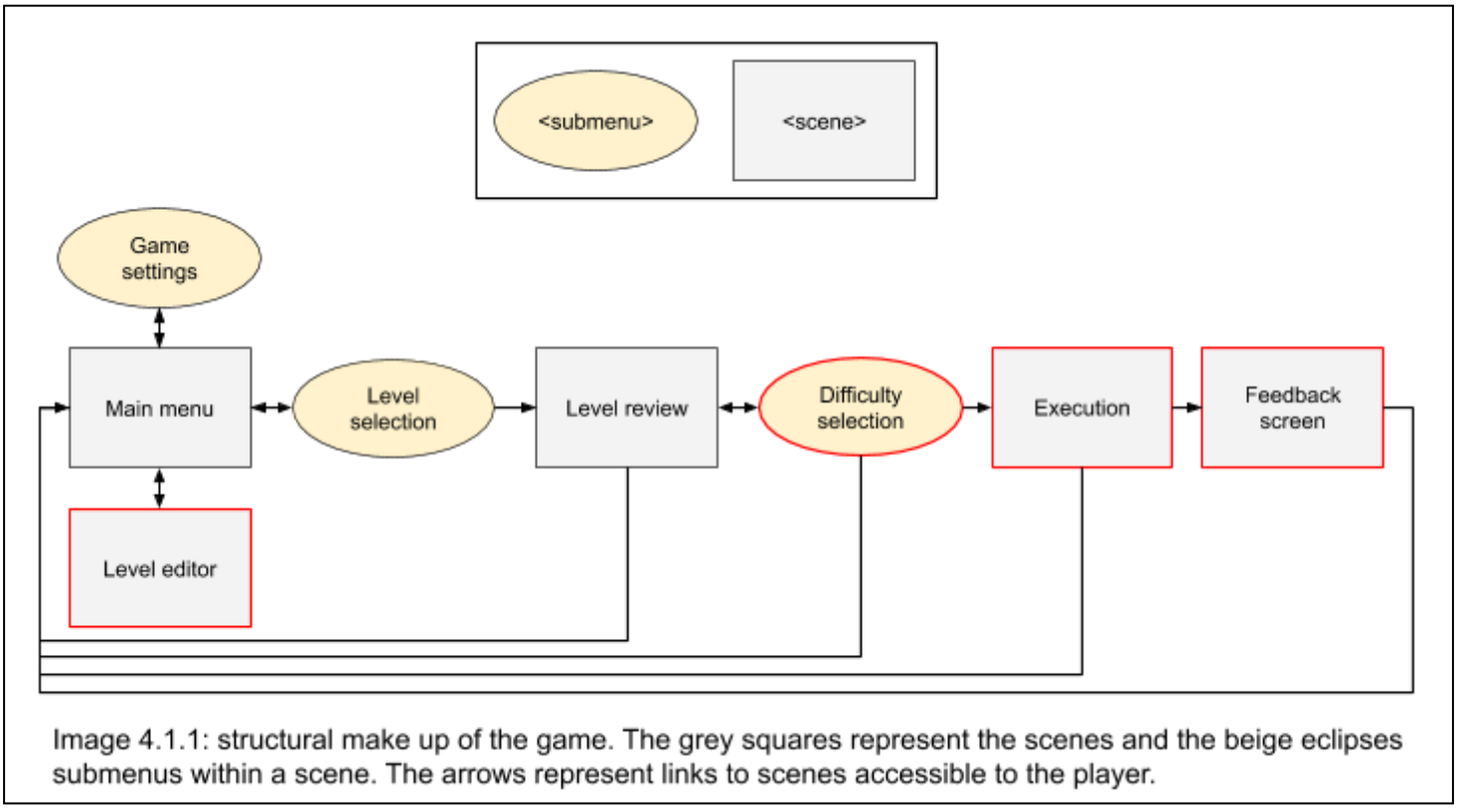


Image 4.1.1: structural make up of the game. The grey squares represent the scenes and the beige eclipses submenus within a scene. The arrows represent links to scenes accessible to the player.

All items highlighted in red have been changed or added in the scope of this project.The level editor scene was added and linked to the main menu, the difficulty selection submenu section was added to the level review scene and both the execution and feedback screen scenes were changed. The execution scene now includes the pop-up feedback hints and warnings. The feedback screen was changed all together. Below the technical realisation of each of these components is discussed.

4.4.1 Difficulty selection

The difficulty selection submenu was added to the level review scene. This scene is also build up from UI elements, which divide the scene into two parts. The first part show the description or briefing of the level. The second part summarizes the parameters for that level. Here the difficulty selection was added. Initially this screen included two buttons, one to go back to the main menu and the other to start the level. Instead of this start-button, three buttons were added. Each of the them start the level with a particular difficulty stage, as is described in chapter 4.3.2.

4.4.2 Execution scene

In order to implement the different feedback systems and facilitate the difficulty stages, multiple execution scenes were created. Each a copy of an already improved version compared to the initial game. For this improved version, the menu button were made bigger and clearer. Placeholder buttons for future features were removed.

The hint and warning pop-ups are images and were added as UI elements into the scene. The images were first created using Gimp (https://www.gimp.org/), free image manipulation software. Once added, their visibility was tied to the relevant data point.

The visualisations are activated by the player via a drop down menu. This means that it is not possible to activate both the heat and compaction visualisations at the same time. When the highest difficulty stage is selected the compaction visualisation option is simply removed from the drop down, leaving ‘none’ and heat as the only options.

4.4.3 Unity Version

Prior to working on the game, the project needed to be transferred to an up to date version of the Unity editor. This was done to ensure better support from Unity and access to the latest features of the release. The game was built in Unity version 5.5 and was updated to unity version 2019.1. The process resulted into a couple of minor errors that were resolved afterwards.

The updated version was then duplicated twice, one for each feedback version of the game. In each duplicate a variation of a feedback system could then be developed, while also maintaining an original backup.

5. Testing and results

With all the changes and development described in chapter 4, further testing with the game was conducted. In this chapter the testing set up en environment is discussed, as well as the results of the tests.

5.1 User Test #2

The second user test was also conducted at the Soma college in Harderwijk, only a year later. These students were also in year 2. For this test the game was updated to eliminate bugs, display feedback directly and have an altered feedback screen at the end of the level. In addition, the players were tasked to play through three levels. Rather than changing the parameters of the level, the amount of feedback was changed in each level. In the first level players receive all forms of feedback, direct via hints and warnings, via visual aids (colors on the road) and afterwards on the feedback screen. The second level takes away the direct feedback via hints and warnings and the third level removes the visual feedback. The feedback screen after the level is present in each of the three levels.

15 students participated in this test. They were able to download the game to their on PC and play it on there, just like they would if the game were to be part of their curriculum. Unfortunately, the game did not function correctly and the participants were unable to play the game as intended. The asphalt did not cool down, making it impossible to achieve a good score.

5.2 Follow up testing

The same test as described as above was conducted again. In between these two tests the game was fixed and fine tuned even further. The students in this test were in year 1. The students were able to play the games' first level with all three difficulty settings as described above. After, they were presented with the same questionnaire as in user test #1.

In this test 14 students took part. The students were presented with the game with minimal explanation or guidance, other than the basic instructions for how to use the game. The difficulty stages as described in chapter 4.3.2 were also included.

The students had approximately 30 minutes to play the game. They were allowed to ask questions and work together. After, the students were presented with the same technology acceptance questionnaire (appendix A) as used in the first exploratory test.

In table 5.2.1 the results compared to the first tests are shown. Notably, in all but one category the students rate the game lower compared to the first test. For three of the questions in the category Self Effectiveness the students do rate the game from the second test higher. A high score in this category amounts to effective autonomous use of the product. Looking at these test results, students are less content with the game with regards to learning effectiveness and enjoyment, but do rate the game higher when it comes to using the game without guidance.

	Average first exploratory test	Average second follow up test	Delta
Performance Expectancy			
1	2,214	3,000	**-0,786**
2	2,143	2,688	**-0,545**
3	2,071	2,625	**-0,554**
4	1,857	2,333	**-0,476**
Effort Expectancy			
5	2,500	3,688	**-1,188**
6	2,643	3,733	**-1,090**
7	2,500	3,688	**-1,188**
Attitude Expectancy			
8	2,571	2,938	**-0,366**
9	2,385	2,938	**-0,553**
10	2,769	3,000	**-0,231**
11	2,231	2,750	**-0,519**
12	2,231	2,563	**-0,332**
Self Effectiveness			
13	3,000	2,375	**0,625**
14	2,923	2,875	**0,048**
15	2,923	2,625	**0,298**
16	2,462	2,938	**-0,476**

Table 5.2.1: results of second test compared to first test.

6. Colour study

This chapter dives into the use of colour in the game. This study was done after the tests as described in chapter 5.

One the most important feedback systems in the game, is the visualisation of the asphalt temperature and compaction. Both can be called upon by the player to aid them in playing the game. These visualisations make use of various colours to convey data to the player. For instance, the initial version of the game uses ‘red’ for hot, ‘green’ to indicate the asphalt is the right temperature and ‘blue’ to indicate the asphalt is too cold. Alternatively, to visualise the compaction of the road, the game uses ‘black’ for an uncompacted road and ‘green’ is added the more compaction is done. Too much compaction is indicated with ‘red’. The colours ‘green’ and ‘red’ are both used but in both visualisations for different data points. This could be considered confusing.

In order to test the use of these colours, a questionnaire was designed. This questionnaire can be found in Appendix C. It is set up is such a way, that as little as possible biassing can occur. At first, context is given. This includes a brief explanation about the game itself and why we need colour. No specific colours are mentioned. The first part of the questionnaire focuses on the heat visualisation. Screenshot images from the game are provided. As shown in image 6.1. For each following question, the same image is used, along with it an open question about the colour. For example, a question could be ‘let us assume the asphalt is too hot to compact, which colour should the road be?’. By presenting this as an open question, participants were able to feely answer every question, without a list of options influencing their bias. After each open question about the colours, the participant is asked to motivate their answer.

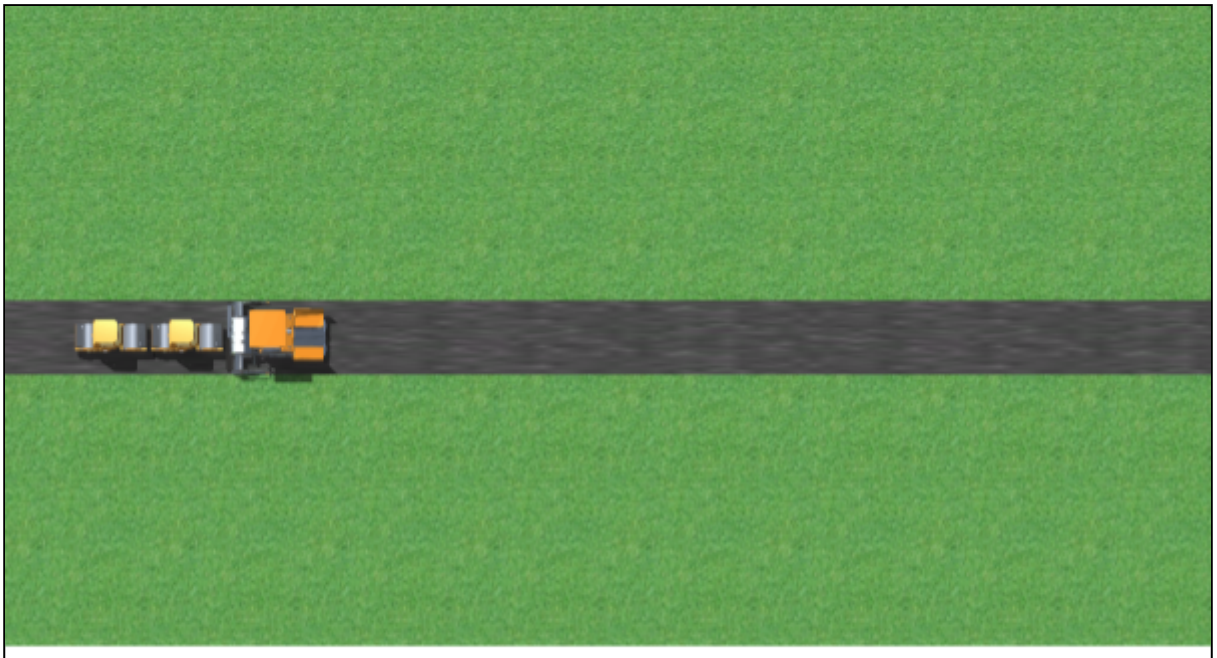


Image 6.1: image with default road texture as used in colour evaluation questionnaire.

After the open questions, three colour gradient are shown. As shown in image 6.2 ‘Gradient 1’ shows the colours used by the initial game, going from ‘red’ to ‘blue’ with ‘green’ in the middle indicating the right temperature. ‘Gradient 2’ Is the same gradient, but with the ‘green’ removed, now only leaving a gradient from ‘red’ to ‘blue’ with some ‘yellow’ in between. In the third and last gradient, ‘yellow’ is also taken out and the colours now directly transition directly from ‘red’ to ‘blue’. The participant is asked to choose which gradient they works best for them.

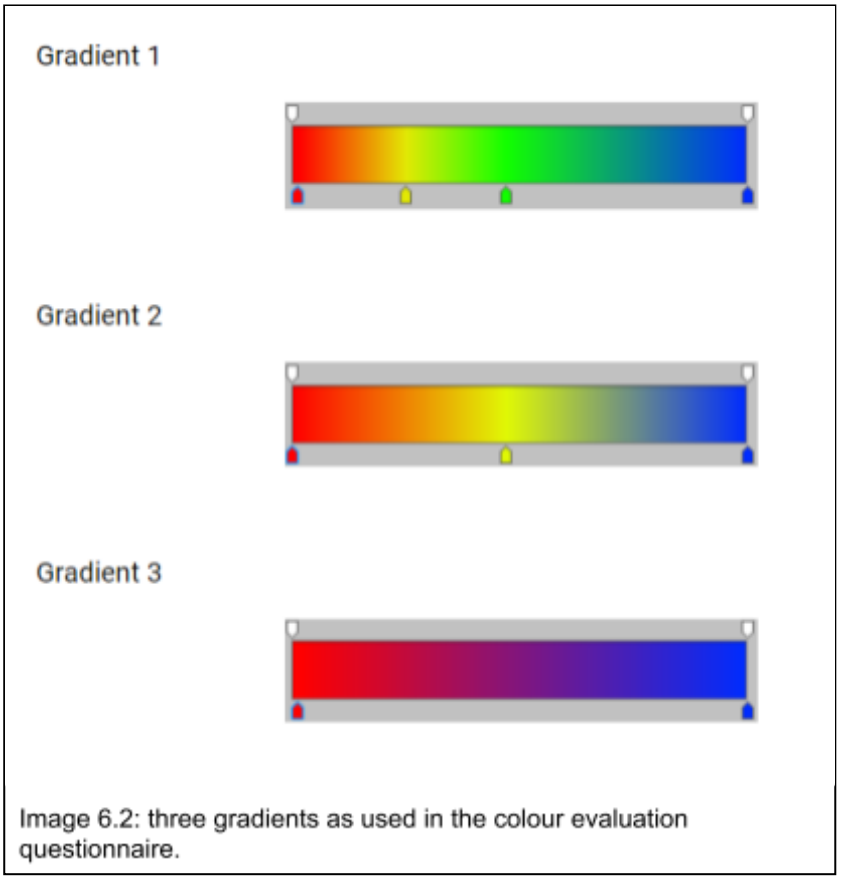


Image 6.2: three gradients as used in the colour evaluation questionnaire.

In the second part the participant is asked about colours in relation to the compaction of the asphalt. For this part, the questions are flipped on their head. The participant is presented with the same image as before, only now the road on that image has been given a colour. The participant is then asked to choose which of three scenarios fits this colour the best. The three scenarios are:

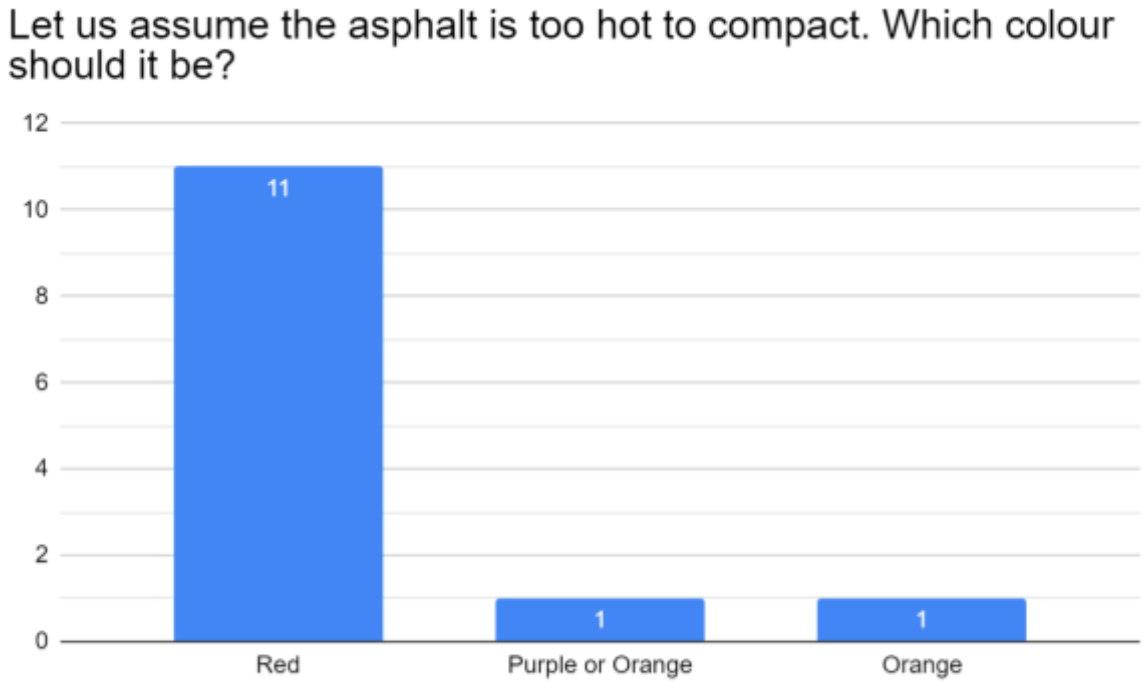
- Too much compaction
- Not compacted
- The right amount of compaction

The option add an additional answer was intentionally put in for every of these questions, to allow the participant to indicate that a certain colour should not be used at all for example. At the end, participants could add any additional comments they may have had.

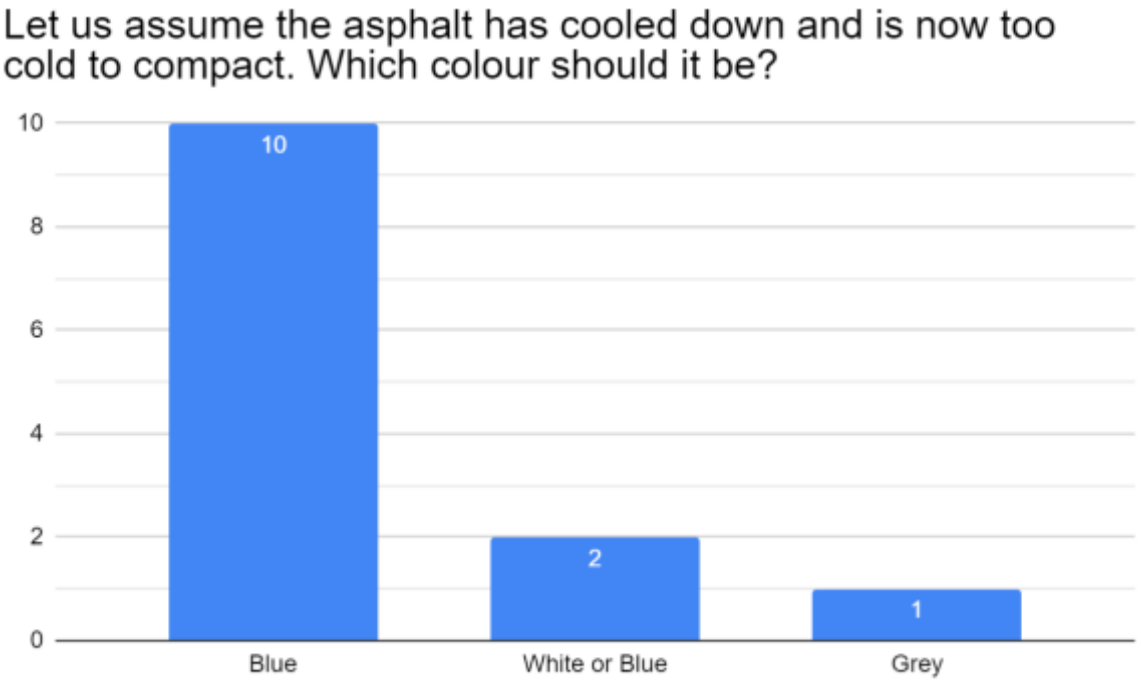
6.1 Study results

In this paragraph the results of the questionnaire are discussed. Thirteen people participated in this questionnaire. The questionnaire is anonymous.

In graphs 6.1.1, 6.1.2 and 6.1.3 the open answers for the different heat scenarios are shown. Perhaps unsurprisingly, both the colours ‘red’ and ‘blue’ are strongly represented. With regards to temperature, these to colours are often used in many places in our society. The answers to the question about the asphalt being exactly the right colour and ready for compaction are much more mixed. ‘Green’ is mentioned the most, but black and yellow are mentioned too. The participants who answered ‘black’ noted that black is the colour of asphalt when it is finished. It is the colour we all associate with asphalt. Participants who answered yellow had two different motivations. One participant noted that the colour ‘yellow’ indicates that attention is required, that action must be taken. Another participant noted that ‘yellow’ naturally falls between ‘red’ and ‘blue’. Participants who answered with ‘green’ all draw links to ‘green’ being the colour that means ‘go’ or ‘good’. Again, this is based on associations from situations and scenarios that are seen in daily live in our society.



Graph 6.1.1: answers to open question about scenario 1.



Graph 6.1.2: answers to open question about scenario 2.

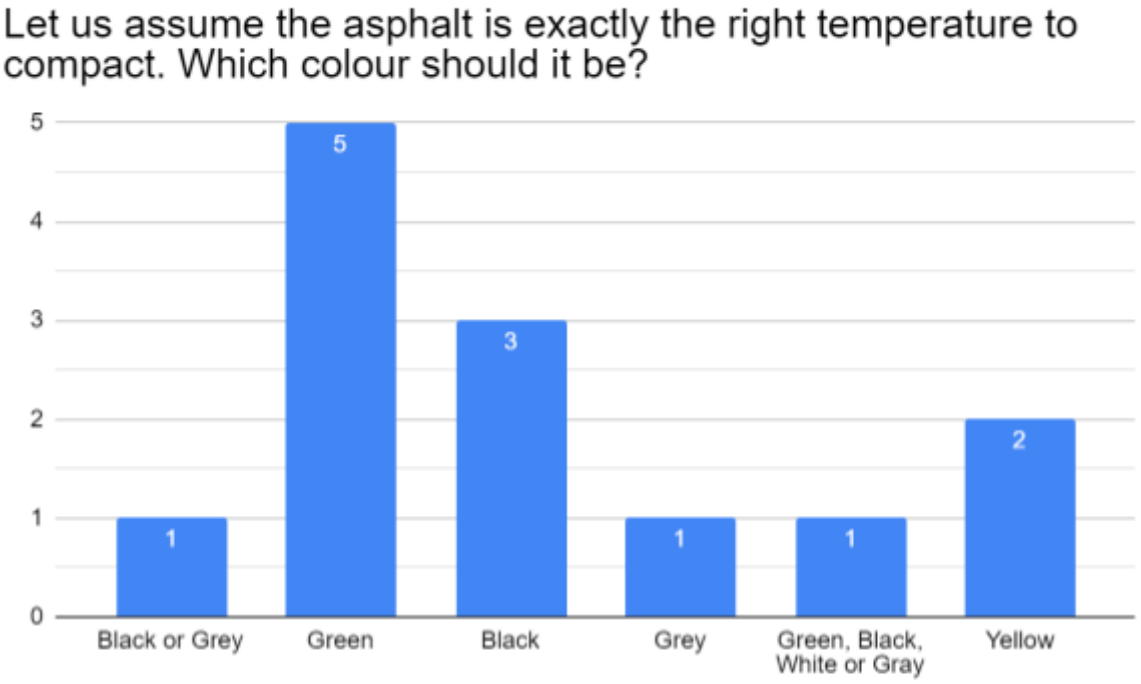
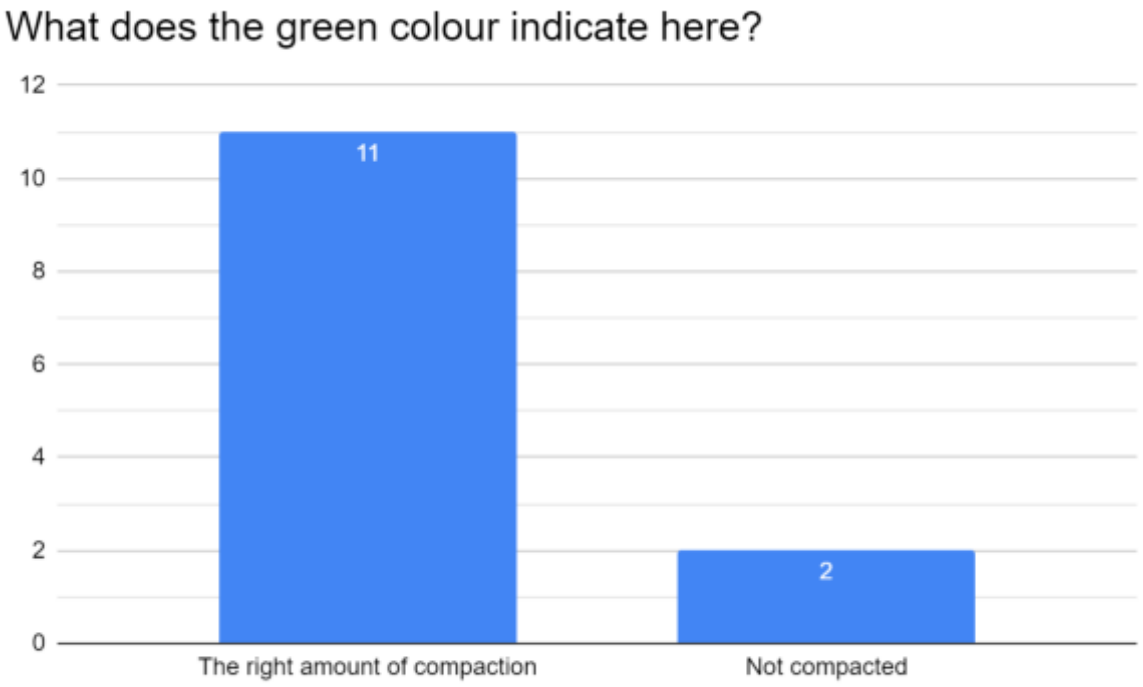
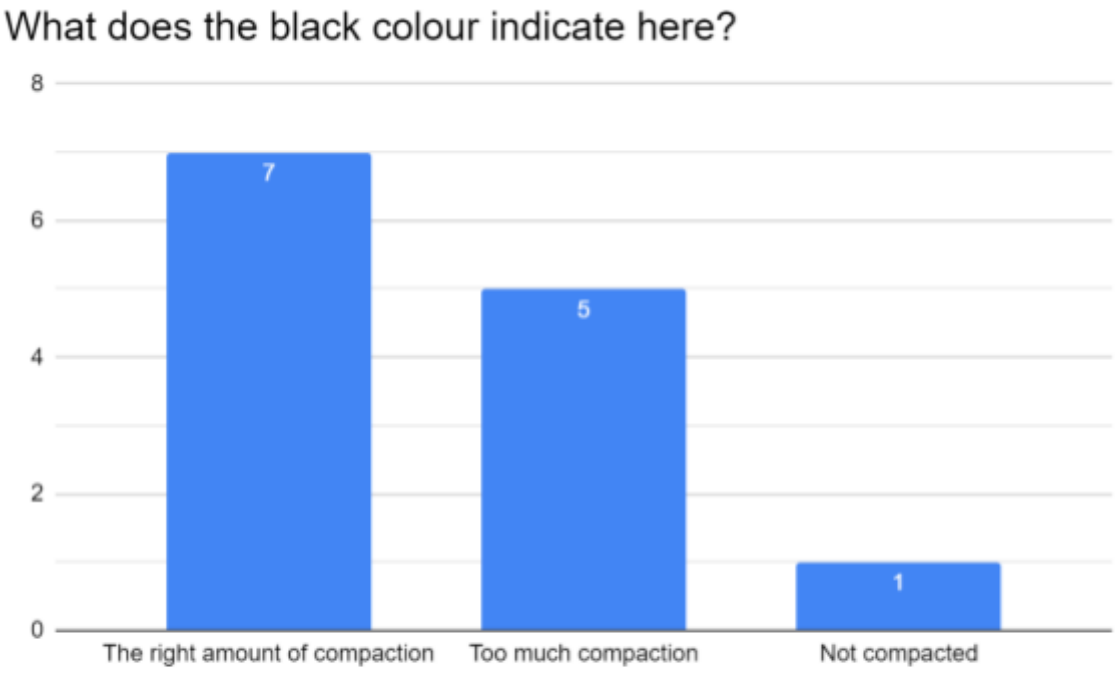


Image 6.1.3: answers to open question about scenario 3.

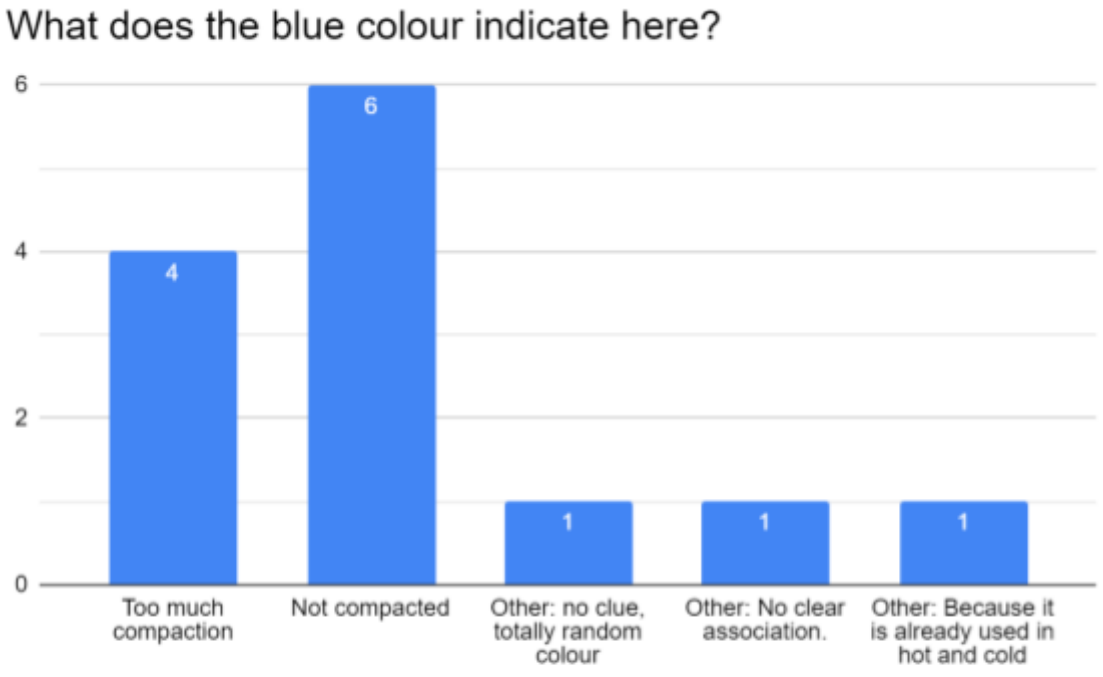
The results of the second part of the survey are shown in graph 6.1.4 through 6.1.10. Even though the answers are generally quite mixed, it is possible to spot trends. For example, two colours are most strongly associated with the right amount of compaction: ‘green’ and ‘black’. Notably, three participants who answered ‘green’ in the first part of the questionnaire, concerning the heat, also indicated ‘green’ to be the colour to be used for the right amount of compaction. Both ‘white’ and ‘blue’ were most strongly associated with the ‘not compacted’ scenario. The colour ‘yellow’ proved to be quite divisive, with almost equal votes for too much compaction and not compacted. ‘Orange’ and ‘red’ were most strongly associated with too much compaction.



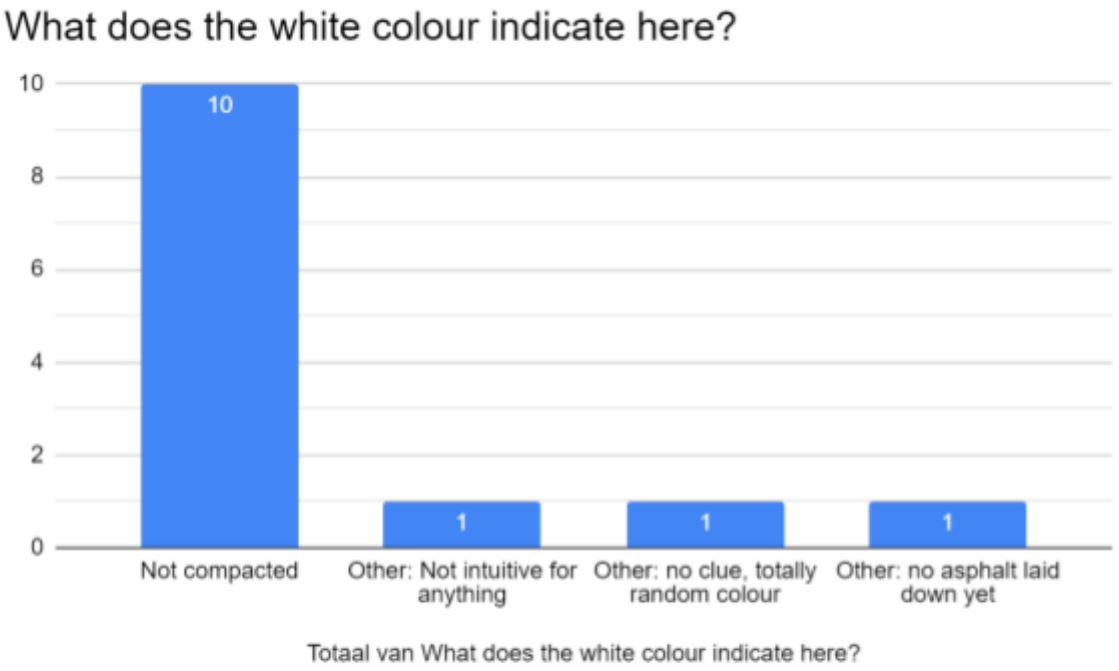
Graph 6.1.4: answers to multiple choice question about compaction.



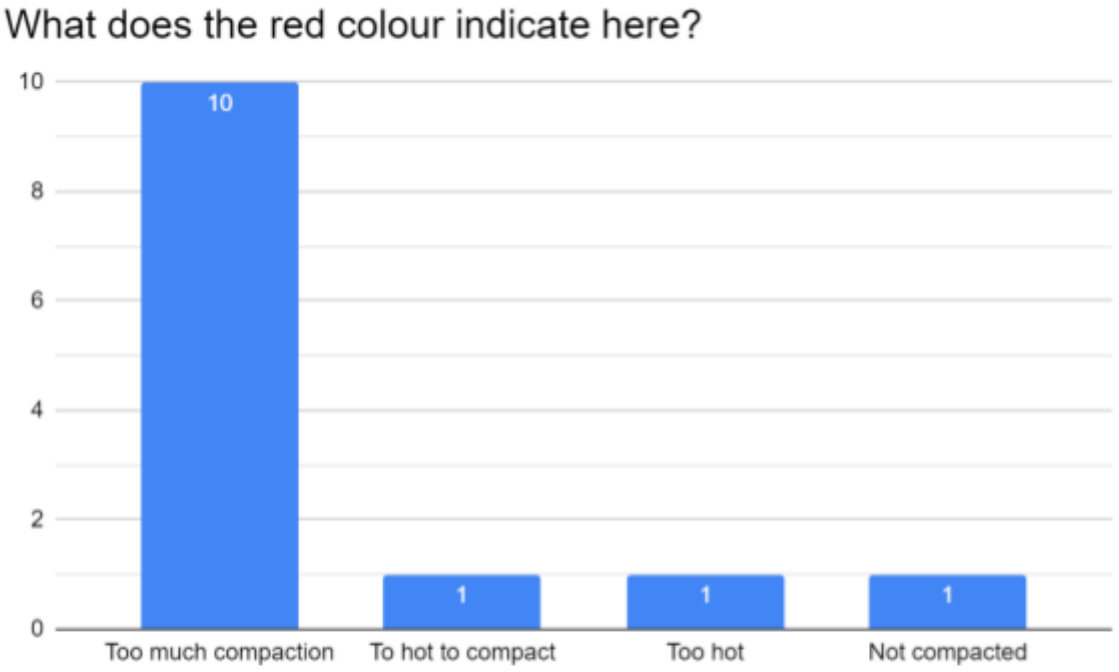
Graph 6.1.5: answers to multiple choice question about compaction.



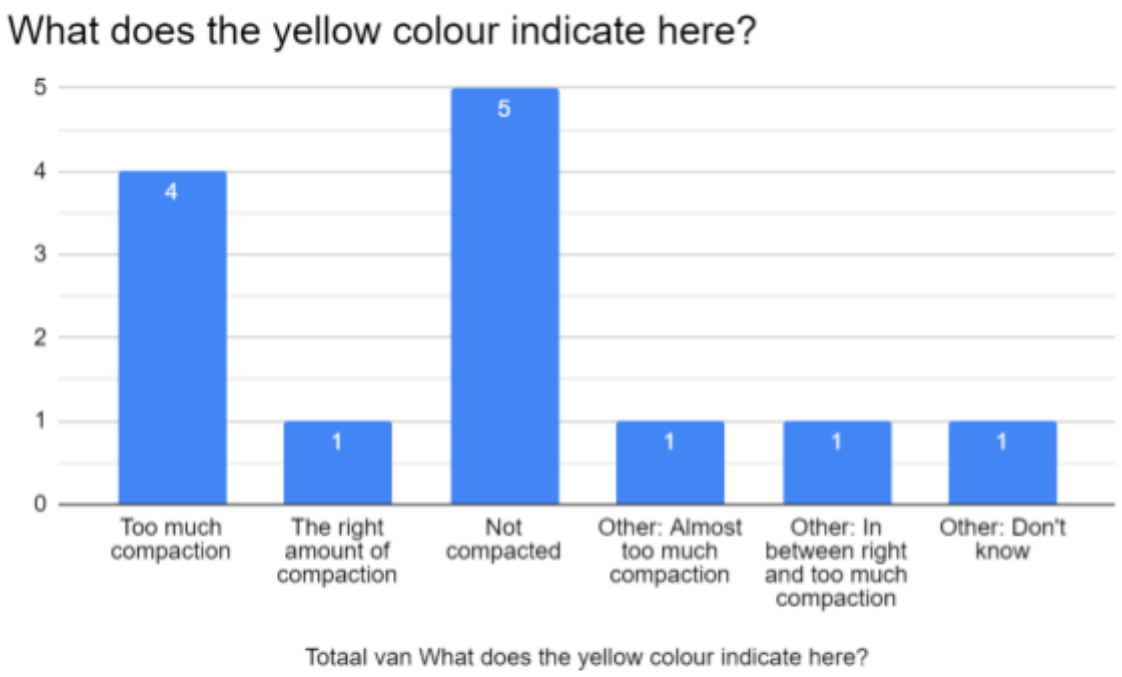
Graph 6.1.6: answers to multiple choice question about compaction.



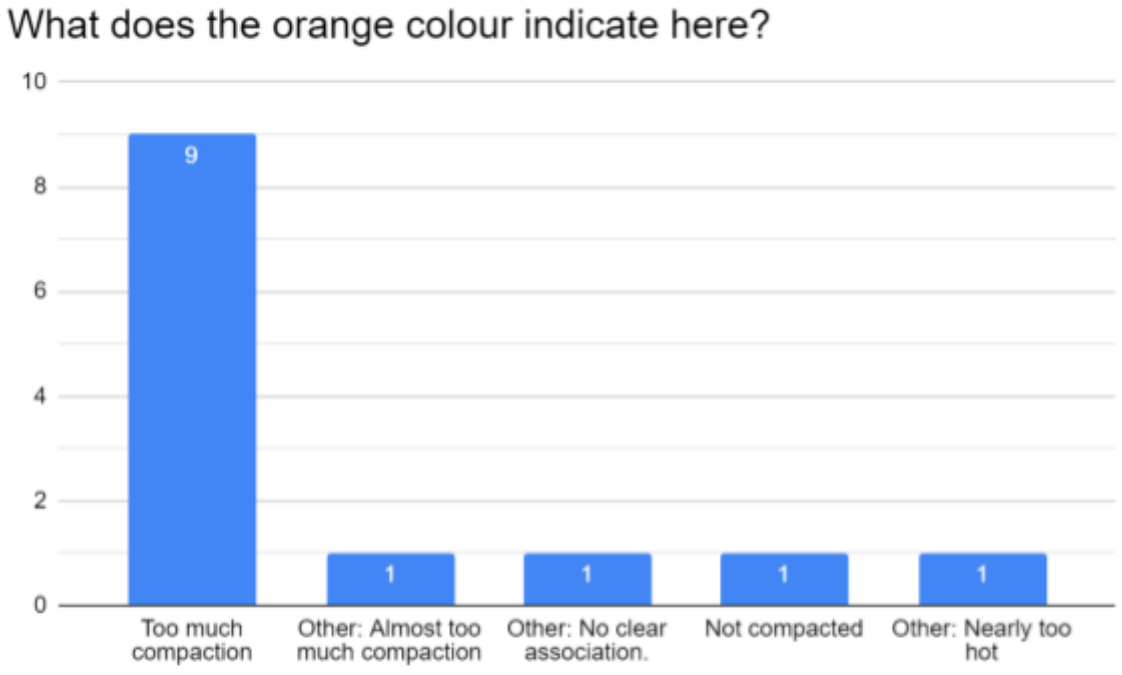
Graph 6.1.7: answers to multiple choice question about compaction.



Graph 6.1.8: answers to multiple choice question about compaction.



Graph 6.1.9: answers to multiple choice question about compaction.



Graph 6.1.10: answers to multiple choice question about compaction.

Based on the results described above, the initial game and the questionnaire already lineup for the most part. The colours indicating the temperature, according to the results of this questionnaire, should not be changed. Even though indication of the right temperature is divisive, the colour ‘green’ is mentioned more than others. In combination with the other results for this visualisation, the results indicate that gradient 1 is the best option.
For temperature visualisations therefore, the colours ‘red’, ‘green’ and ‘blue’ should be used.

The results indicate that the colours currently used for the compaction visualisation may benefit from change. It is clear that the colours that are currently used for the compaction visualisation are not optimal, as many other associations exist. The colour ‘black’ for example was used to indicate no compaction was done, but from the results it can be concluded that this is not the right colour. The participants indicated in this test that they associate ‘black’ with the right amount or even too much compaction. The latter even being the complete opposite of what the colour was used for. Conversely, white is strongly associated with indicating not compacted. According to the results, the colour ‘green’ clearly indicates a well compacted road, and likewise ‘red’ is strongly associated with to much compaction. Applying the results from this test, the colours used in the compaction visualisation should be ‘white’, ‘green’ and red.

7. Discussion

In this chapter various aspects of the project are critically discussed. The scope and focus of this project has shifted over the course of it, emphasising the need of critical discussion of the choices that influenced not only the focus and scope but also the results, outcome and final product.

In chapter 2 recommendations with regards to serious game development and features are discussed. One of these recommendations is with regards to user involvement in the design process. On this topic Huizinga et al. [14] suggest that including the end user of the game in the design process could allow for a more personalised experience for said user. The game that is subject in this project is aimed at a very particular user group. The game has a very specific purpose and was commissioned in the first place to enhance the learning of the student who would previously had no serious game to use for this particular part of their study. Therefore, including the users, or rather, students, could prove extra important. In chapter 3 the first user test is discussed. Here the students were directly involved in a designing part of the serious game. However, it is important to recognize that they were not involved in the core design process of the game to the same degree. The students were asked to provide insight in the design of the feedback screen, not the core gameplay loop for example. Notably, while the input of the students was used in the design process, the second test yielded results that were less positive than the first, as is discussed in chapter 5.2. Even though the results of this test do not provide any statistical proof, it does emphasise that making changes to a game like this, how much positive improvement the developer may believe this brings, is not clear cut. The user can and will experience this differently. It is important to stress that first and second test mentioned above were conducted with two different groups of students. Consequently, it is recommended to keep the user included in the process but extend this not only to part of the game but to core design elements as well. In the case of students, all groups taking part in the same study year should be included.

The other main recommendation discussed in chapter 2 is that serious games should be build on or include elements from established learning theories. During the development of the game as presented in this project, various learning theories were used as a basis for a design decision. As Franzwa et al. [3] concluded, the game should offer more than just a pass or fail. This concept is seen in education on multiple levels, the most notable of which is the use of grades. With this system two students who both pass, can still have different grades. In the game of this project, a similar system is employed. Even though the student is not presented with one final score, like a grade, each goal can be achieved but also exceeded. Consequently, students can pass a level with various degree of success. The difficulty stages also make use of established learning theory. Similarly to the learning structure in education, where students are first guided and advised and then have to autonomously test their knowledge via exams, the game allows for playing levels with guidance and without it. This structure can also be found in many other real world scenarios, for example driving tests. First the pupil is guided by the driving instructor. During the final

test no guidance is provided, while the student has to prove they gained knowledge from the guided attempts. These learning theories have been implemented mainly into the feedback systems of the game. The core gameplay elements were not based on such learning theories. In order to more closely match the game with the educational context of the students, the entire game should from the ground up be based on such theories. For instance, the level editor was build as an add-on to the game instead of being considered from start as a core element of the learning process.

It is also important to consider the other recommendations identified in chapter 2. Here the importance of tutoring is mentioned. Noemí and Máximo [4] even conclude that it is key to the learning process. In chapter 3 the requirement of teacher control and influence is listed. By narrowing the scope of this project, few of these tools for the teacher were implemented. The level editor does allow for the creation of new levels, but in its current state the game does not allow for the remote access to the players performance scores. In order to make tutoring possible when this game is used in a classroom environment, the game should include online components and allow for the storage and access to player performance data. The level editor should be expanded upon and linked to this data to allow for effective creation of new levels that are adapted to students' strengths and weaknesses.

The game extensively makes use of colour. The most relevant example of this are the heat and compaction visualisations. Here, the colour directly conveys important information. The warning pop-ups employ colour as well, but even without the colour, the shapes and text can still convey most of what is meant to be conveyed. Conversely, the visualisations use only colour to indicate something to the player. This could prove problematic for users of the game who suffer from particular variants of colour blindness. According to the National Eye Institute of the United States of America [18] red-green colour blindness is the most common type of colour blindness. Under this category four different types of red-green colour blindness are identified. Deuteranomaly and Protanomaly are both mild types and usually do not get in the way of normal activities, according to the NIH. However, Protanopia and Deuteranopia both make you unable to tell the difference between red and green. Both green and red are extensively used in the visualisations in the game. In the heat visualisation they have even completely different meanings. Not being able to tell the difference between effectively makes the game unplayable. Therefore, a colour blind mode should be added to the game which uses a different set of colours that are identifiable by people who suffer from colour blindness.

In general, the requirements set in chapter 3 proved to be to challenging to all implement. In the process of developing the game and conducting the tests, many technical issues were identified. Some of these issues were non critical, but others needed to be overcome in order to conduct tests of continue development at all. These challenges meant that the focus and scope of the project changed. For example, in chapter 3 requirements are listed with regards to online components and feature expansion of the game. Even though it is recommended that these requirements are set in future projects, it was not possible to implement them within the scope of this project. The focus was instead shifted to perfecting the features that were already implemented, as well as implementing a feedback system based on learning theories and student input.

8. Conclusion

In this chapter conclusions are given is relation to the requirements set in chapter 3 and the results achieved during this project.

There is no statistical proof to be gained from the tests, but in future work it is important to take into account the learnings from these tests. Not just the results, but also about the method of how they were conducted. More participants and more tests would be required to gain better insight in the impact of the changes to are made to game. It is also important to carefully review the requirements, especially in game development, as technical challenges are hard to overcome and can cost a lot of time.

During this project significant development progress has been made; the game was polished on a technical level, the feedback screen has been overhauled to be more appealing and a direct feedback system has been implemented. Furthermore, a working level editor was developed in order to allow for the creation of new levels in the game. Therefore requirements A1 through A4, which are considered crucial for the success of this project, are met. The sub-requirements have generally been met as well. However, it is important to keep in mind that requirement A4.1 has not been evaluated. The game is able to display hints, but it is unknown what whether these hints have the desired effect. Requirements in the category ‘should have’ (B) are considered important but not crucial. Here requirement B1 has not been met. No online functionality was added during this project. B2 has been met partially, considering the accompanying sub-requirements. B1.1 and B1.2 have been met. The game includes tools to create levels with various degree of difficulty and change parameters. However, it not possible for the teacher to access student performance data which makes it difficult to adapt new content to the students performance. Therefore, requirement B1.3 has not been met. All requirements in the category ‘could have’ (C) have not been met. All these requirements are considered to be nice to have, but were all technically and timewise too challenging to include. Therefore, these requirements have not been met.

From the colour study tests, one can conclude that the colours used for the visualisations in the game should be partially changed. The initial implementation was based on basic assumptions on how people perceive colour. The test shows that this assumption proved to be valuable for the temperature visualisation. Here, people generally agree with the colour setup already in place. However, the compaction visualisation should be changed. From the results one can conclude that black should not be used as a default colour. Instead white could be used to indicate that no compaction was done. Red and green are a good fit for representing too much and the right amount of compaction respectively.

By narrowing the scope a more usable and stable platform has been developed. In its current state the game can already be used in educational environments. Even though the feature set is limited, the features that are present do provide the basis for a learning experience. From this platform more features can be added. The feedback system

implementation is a step forward according to established learning theory, but more research should be conducted into the impact of these changes and how they can be improved.

References

[1] Schipper, N. (2015). *Slechtere onderwijsresultaten door verkeerd gebruik computers*. [online] Trouw.nl. Available at: https://www.trouw.nl/home/slechtere-onderwijsresultaten-door-verkeerd-gebruik-computers~a40f6a35/.

[2] Tippe, R. (2015). *De digitalisering in het onderwijs moet geminderd worden*. [online] Opiniestukken.nl. Available at: http://www.opiniestukken.nl/opiniestukken/artikel/918/De-digitalisering-in-het-onderwijs-moet-geminderd-worden.

[3] C. Franzwa, Y. Tang, and A. Johnson, “Serious Game Design: Motivating Students through a Balance of Fun and Learning,” 2013 5th Int. Conference on Games and Virtual Worlds for Serious Applicat. (VS-GAMES), 2013.

[4] P. Noemí , S Máximo. “Educational Games for Learning” , *Universal J. of Educ. Research*, vol. 2, pp. 230 - 238., 2014. doi: 10.13189/ujer.2014.020305.

[5] T. Mitamura, Y. Suzuki, and T. Oohori. "Serious games for learning programming languages." Systems, Man, and Cybernetics (SMC), 2012 IEEE International Conference on. IEEE, 2012.

[6] E. Oprins, M. Bakhuys-Roozeboom, L. Kistemaker, G. Visschedijk, G. and W. Trooster, “Effectiviteit van serious gaming in het onderwijs,” TNO., Soesterberg., Ned, 2013. [online] Repository.tudelft.nl. Available at: http://repository.tudelft.nl/view/tno/uuid%3Af2926327-60ac-4517-beb8-4c6cd9b3f00b/.

[7] W. Coppes, P. Fisser, M. Smit, and J. Voogt, “De zin en onzin van gaming in het onderwijs,” SLO., Enschede., NED, 2009. [online] www.slo.nl. Available at: http://www.slo.nl/downloads/2009/De-zin-en-onzin-van-gaming-in-het-onderwijs.pdf.

[8] T. Connolly, E. Boyle, E. Macarthur, T. Hainey, J Boyle, "A systematic literature review of empirical evidence on computer games and serious games." *Comput. & Educ*., vol. 59(2), pp. 661-686, 2012.

[9] C. Brom, V. Šisler, R. Slavík, “Implementing digital game-based learning in schools: augmented learning environment of ‘Europe 2045’”, *Multimedia Syst.,* vol. 16, no. 1, pp. 23-41. 2010. doi:10.1007/s00530-009-0174-0

[10] K. Kiili, "Digital game-based learning: Towards an experiential gaming model." *The Internet and higher educ.,* vol. 8, no. 1, pp. 13-24, 2005.

[11] E. Boyle, E. MacArthur, T. Connoly, T. Hainey, M. Mainea, A. Kärki, P. van Rosmalen, "A narrative literature review of games, animations and simulations to teach research methods and statistics." Comput. & Educ, vol. 74, pp. 1-14, 2014.

[12] I. Mayer, H. Warmelink, G. Bekebrede, "Learning in a game-based virtual environment: a comparative evaluation in higher education." European J. of Eng. Educ. vol. 38, no. 1, pp. 85-106, 2013.

[13] M. Kebritchi, "Examining the pedagogical foundations of modern educational computer games.", Comput. & Educ., vol 51, no.4, pp. 1729-1743, 2008.

[14] J. Huizenga, W. Admiraal, S. Akkerman, G. ten Dam, "Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game." J. of Comput. Assisted Learning., vol. 25, no. 4, pp. 332-344, 2009.

[15] J. Knight, S. Carley, B. Tregunna, S. Jarvis, R. Smithies, S de Freitas, I. Dunwell, K. Mackway-Jones, "Serious gaming technology in major incident triage training: a pragmatic controlled trial." Resuscitation., vol. 81, no. 9, pp. 1175-1179, 2010.

[16] Bellotti, F., Berta, R., De Gloria, A., Lavagnino, E., Antonaci, A., Dagnino, F., … Mayer, I. S. (2014). Serious games and the development of an entrepreneurial mindset in higher education engineering students. Entertainment Computing, 5(4). https://doi.org/10.1016/j.entcom.2014.07.003

[17] Raybourn, E. M. (2007). Applying simulation experience design methods to creating serious game-based adaptive training systems. Interacting with Computers, 19(2). https://doi.org/10.1016/j.intcom.2006.08.001

[18] Types of Color Blindness | National Eye Institute. (z.d.). Consulted on January 5th 2020, from https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/color-blindness/types-color-blindness

Appendixes

[A] Technology acceptance questionnaire

Vragenlijst Game

PRESTATIEVERWACHTING

Ik vind deze game nuttig bij mijn training.

	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

Het gebruiken van de game zorgt ervoor dat ik sneller leer.

	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

Het gebruiken van de game verhoogt mijn productiviteit.

	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

Als ik de game ga gebruiken, wordt ik beter in mijn baan.

	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

INSPANNINGSVERWACHTING

Het is makkelijk om goed te worden in het gebruiken van de game.

	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

Ik vind de game makkelijk te gebruiken.

	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

Leren de game te gebruiken is makkelijk voor mij.

	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

HOUDING TEGENOVER DEZE GAME

Oefenen met deze game is een goed/slecht idee.

	1	2	3	4	5	
Slecht idee	○	○	○	○	○	Goed idee

De game maakt het oefenen boeiender.

	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

Oefenen met de game is leuk.

	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

Ik gebruik de game graag om te oefenen.

	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

Ik zou deze game aanraden aan andere studenten.

	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

ZELFEFFECTIVITEIT

Ik zou een opleiding met deze game kunnen doen:

...als er niemand bij is om uit te leggen wat ik moet doen.

	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

...als ik iemand op hulp kan vragen als ik vast kom te zitten.

	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

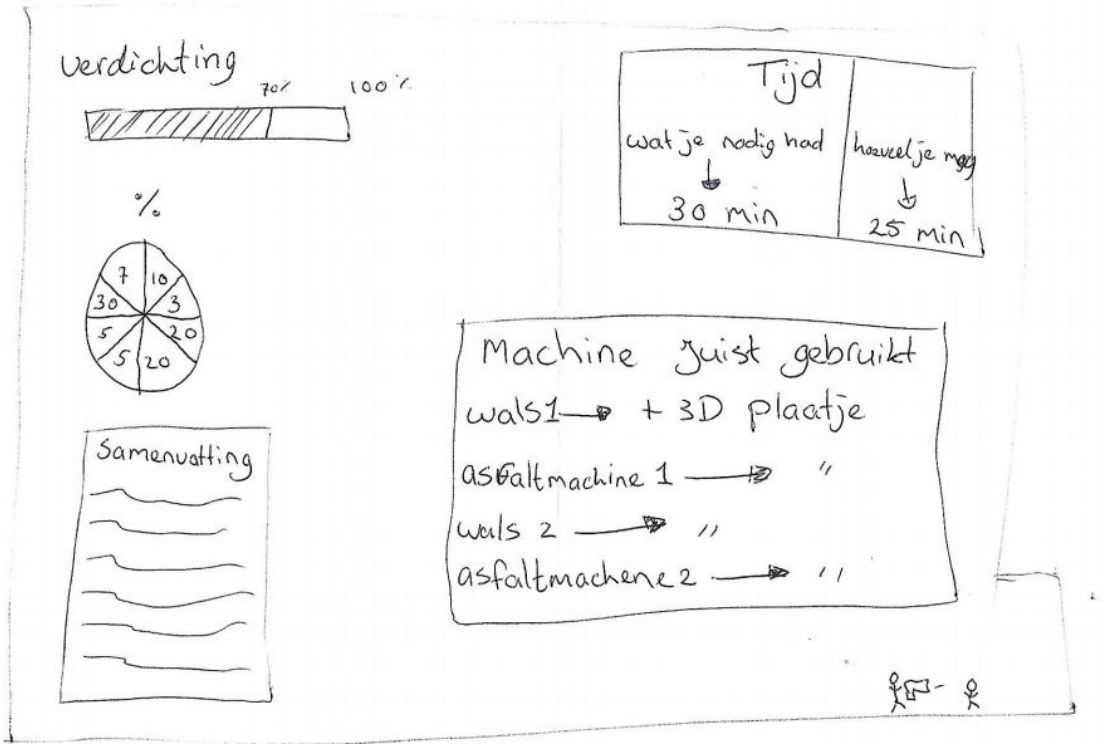
...als ik veel tijd had om het doel waarvoor de game bedoeld is te halen.

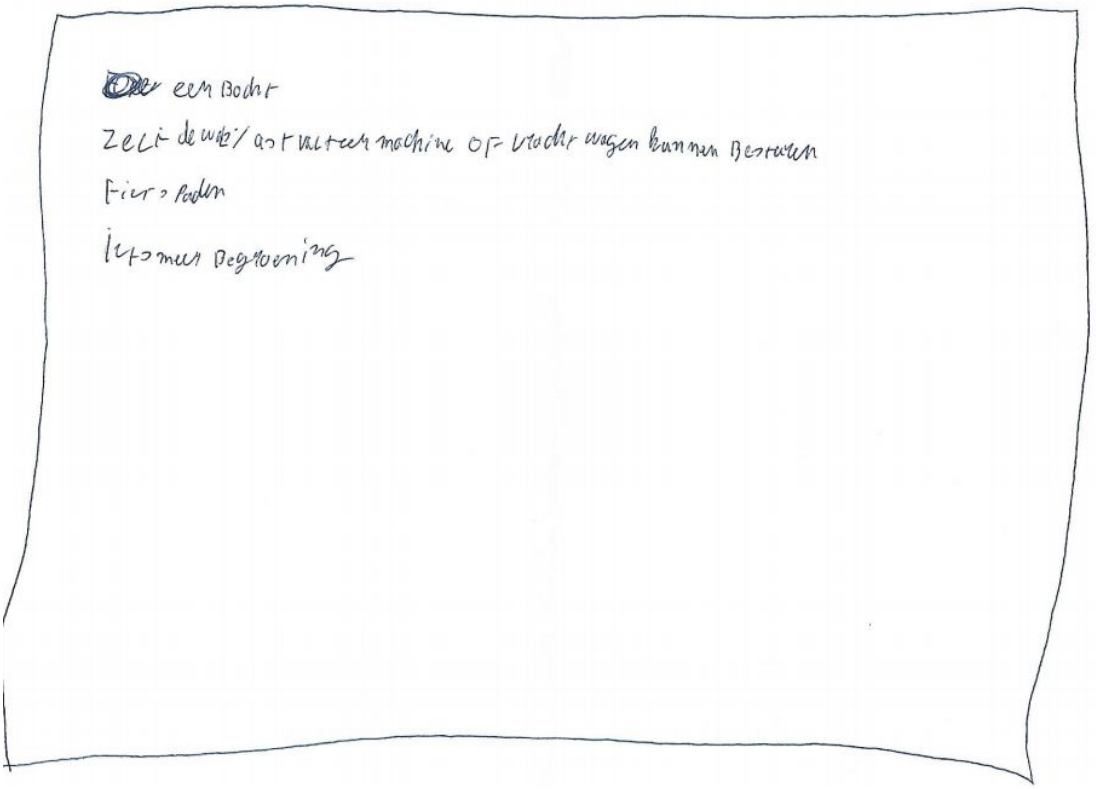
	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

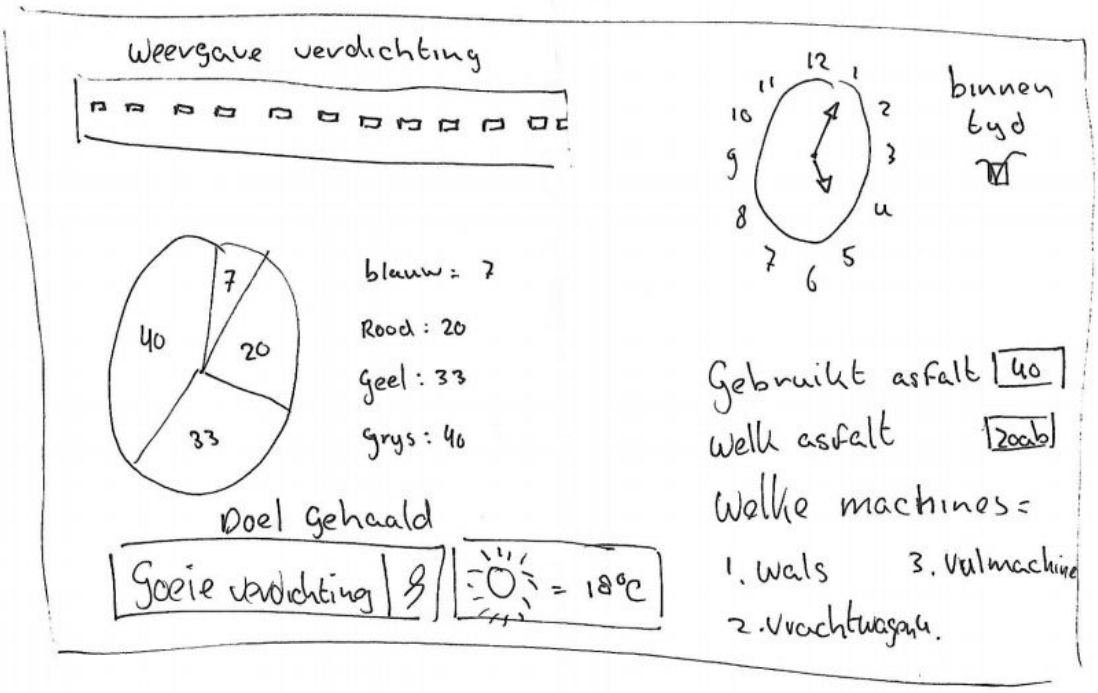
...als ik alleen de uitleg in de game kan gebruiken voor hulp.

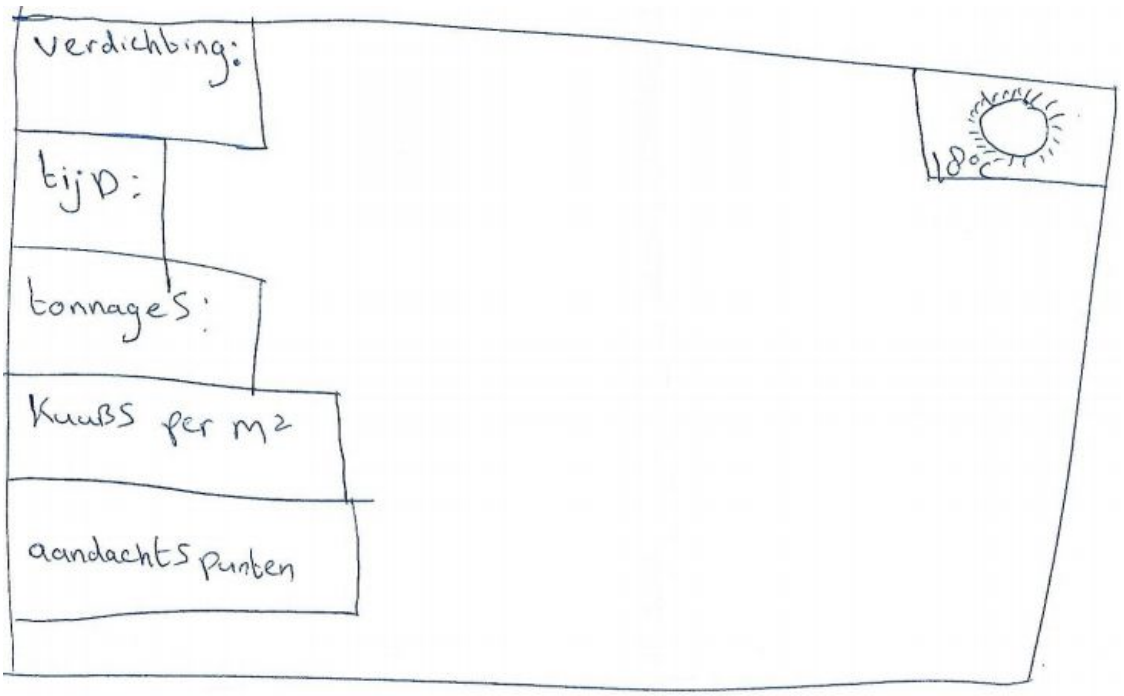
	1	2	3	4	5	
Volledig mee oneens	○	○	○	○	○	Volledig mee eens

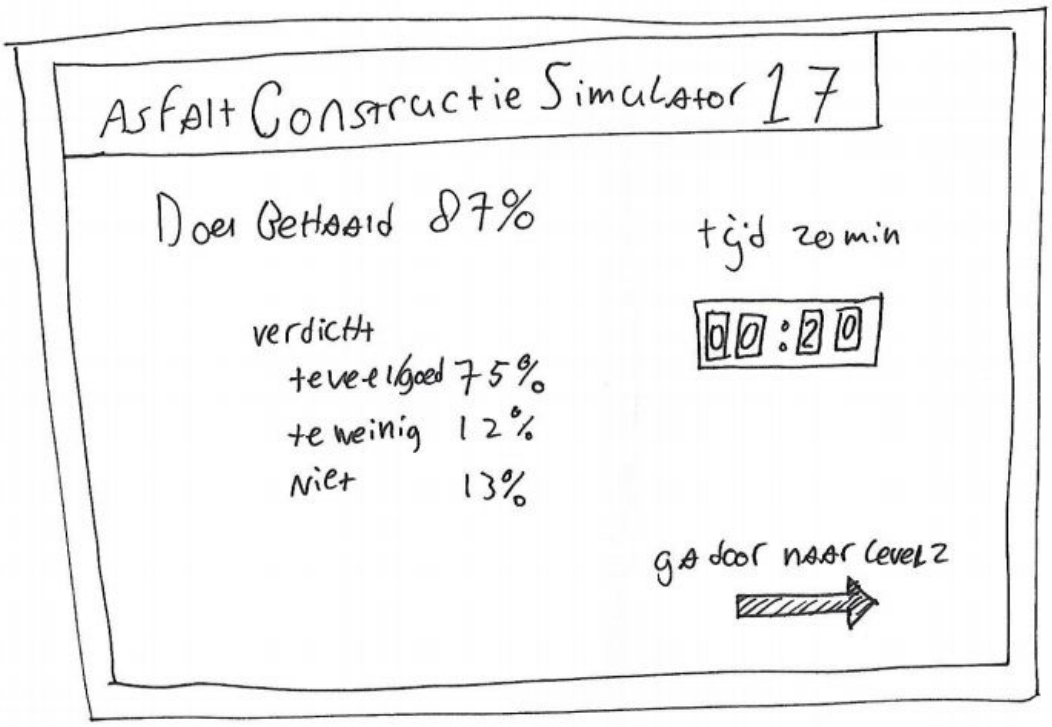
[B] Student drawings from first test





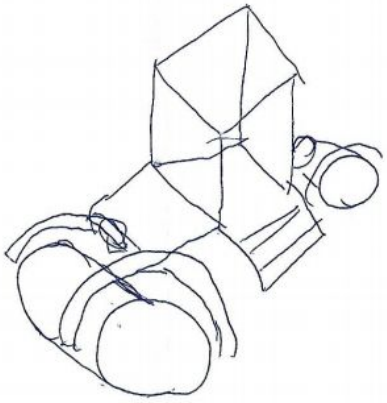

Weergave verdichting
12
1
2
3
4
5
6
7
8
9
10
11
binnen tijd
7
40
20
33
blauw = 7
Rood : 20
Geel : 33
Grys : 40
Gebruikt asfalt 40
Welk asfalt 20ab
Doel Gehaald
Goeie verdichting 8
= 18°C
Welke machines=
1. Wals
2. Vrachtwagen.
3. Vulmachine


verdichting:
tijD:
tonnageS:
KuuBS per m2
aandachtS puNten
18°C

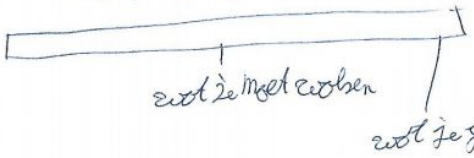


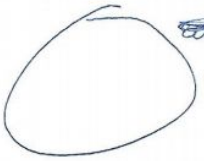
eenigste wat ik zou ik unnen bedenken is het zicht uit de wals / asfaltmachine dat je zeg maar in de cabine zit / en meerdere soorten walsen erin. zoals ~~[illegible]~~ drieral wals banden wals enz.

3D - machines ~~[illegible]~~ [redacted]



gewoon het aantal keer dat je gerold hebt in een tabel want in stad wat je moet moet wolsen
en hoeveel je gerold hebt



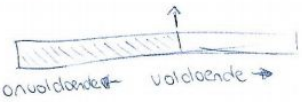


~~wat~~ met Bodentera wat je goed gedaan hebt
en wat niet

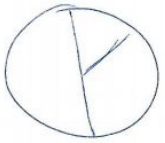
veranderen

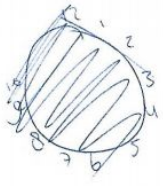
* Botsing
* eindpunten met de main verzetten
* uitleg waarom je een ster niet hebt gehaald

tal keer walsen voldoende is.

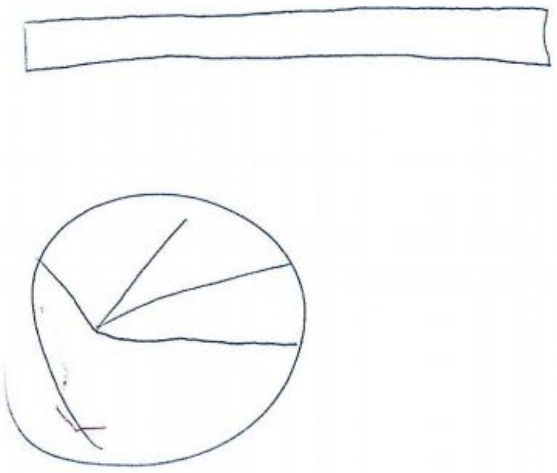


Aantal verdichtingen.





zel kleur
eing tekst
laatjes



[C] Colour study questionnaire

Colour Evaluation

This questionnaire aims to evaluate the use of colour in a digital interactive learning application.

Paving a new asphalt road, requires two kinds of machines: a paver and compactors. The paver lays down hot asphalt. The compactors drive over this newly laid down asphalt to compact it. For this to go right, the asphalt has to cool down to the exact right temperature. Compacting asphalt that is too cold or too hot will not yield a perfect road. Additionally, a compactor should not drive over the same bit of asphalt too many or too few times.

The application allows the user to practice this compaction process. To aid the user, colours will be used to visualise the heat and compaction data.

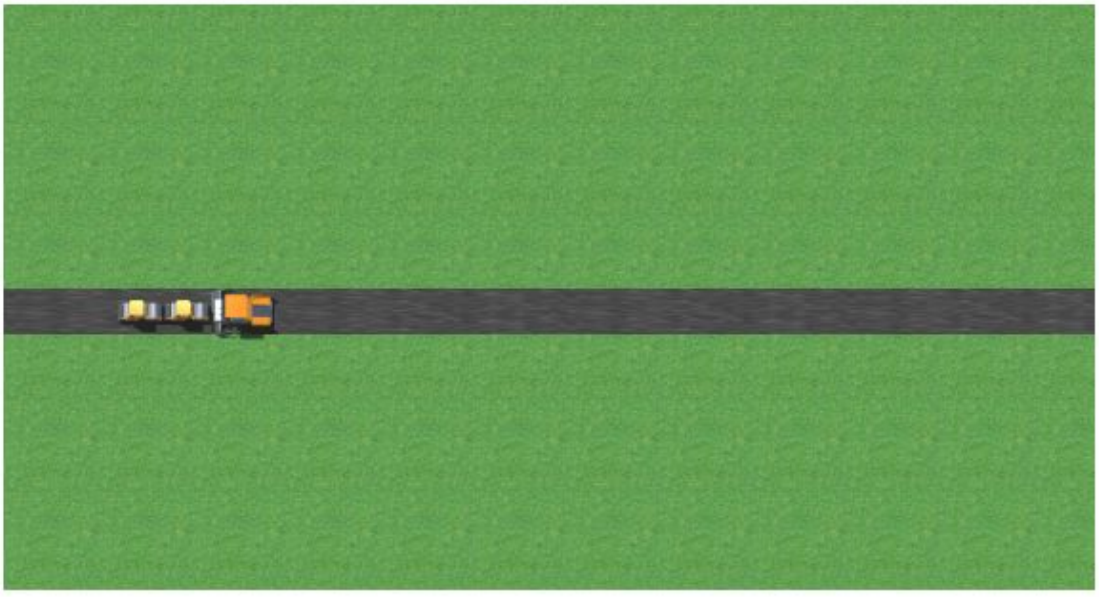
In this questionnaire no answer is considered right or wrong.

VOLGENDE

HEAT

The first questions are about the heat of the asphalt.

Below a picture of the game view is given. A road, a paver and two compactors are shown.



To visualise the temperature of the asphalt, we want to give the asphalt a colour.

For each scenario given, answer with a colour (e.g. 'yellow' or 'black')

Let us assume the asphalt is too hot to compact. Which colour should it be? *

Jouw antwoord

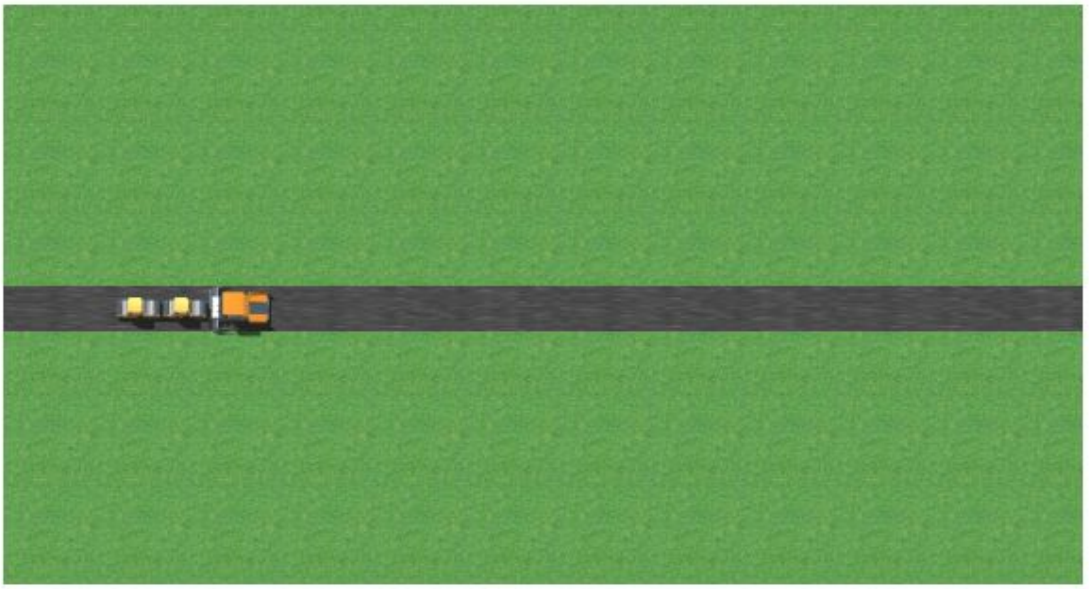
Why did you choose this colour? *

Jouw antwoord

VORIGE VOLGENDE

HEAT

Below a picture of the game view is given. A road, a paver and two compactors are shown.



Let us assume the asphalt has cooled down and is now too cold to compact. Which colour should it be? *

Jouw antwoord

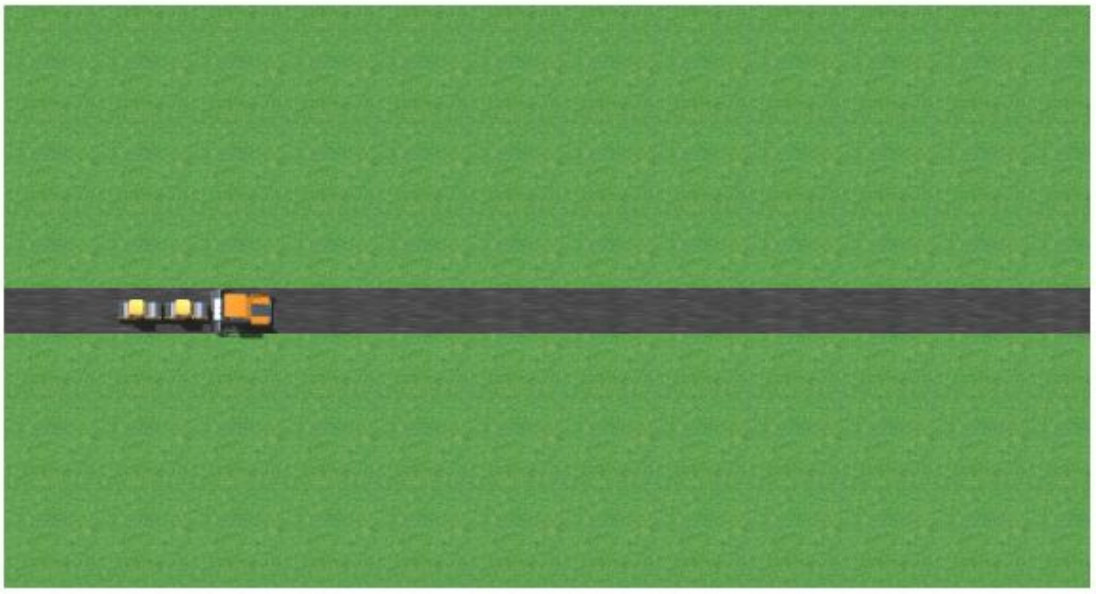
Why did you choose this colour? *

Jouw antwoord

VORIGE VOLGENDE

HEAT

Below a picture of the game view is given. A road, a paver and two compactors are shown.



Let us assume the asphalt is exactly the right temperature to compact. Which colour should it be? *

Jouw antwoord

Why did you choose this colour? *

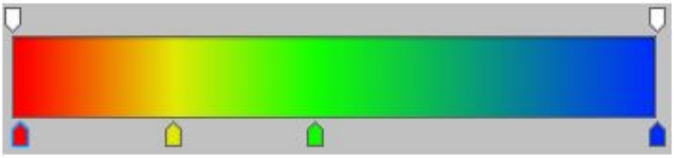
Jouw antwoord

VORIGE VOLGENDE

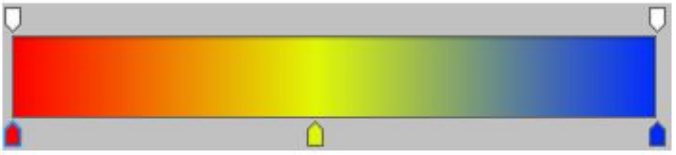
Heat

Some possible colour gradients for the visualisation of the temperature of the asphalt have already been made. They are shown below. The left of each gradient shows the colour used to visualise asphalt that is too hot. On the right the colour is given to indicate that the asphalt is too cold.

Gradient 1



Gradient 2



Gradient 3

Which gradient would be most helpful for you? *

- ◯ Gradient 1
- ◯ Gradient 2
- ◯ Gradient 3

Motivate your answer. *

Jouw antwoord

VORIGE VOLGENDE

Colour Evaluation

The following images are about the amount of compaction.

Once the asphalt is the right temperature, the compactors will drive over the asphalt to compact it. This needs to be done carefully, as driving over given part of the asphalt too little or too much will both yield undesirable results.

We assume the asphalt has three compaction states: not compacted, compacted the right amount and finally compacted too much. Each state needs to be represented by a colour.

Remember, there are no wrong or right answers.

VORIGE VOLGENDE

COMPACTION

The following questions are about the degree of compaction of the asphalt. For each picture, choose the scenario which best fit's the picture. It is possible to answer with the same scenario multiple times. It is possible to answer with a custom response if you feel none of the scenario's fit with with the picture.

What does the green colour indicate here? *

- ◯ The right amount of compaction
- ◯ Not compacted
- ◯ Too much compaction
- ◯ Anders: _____

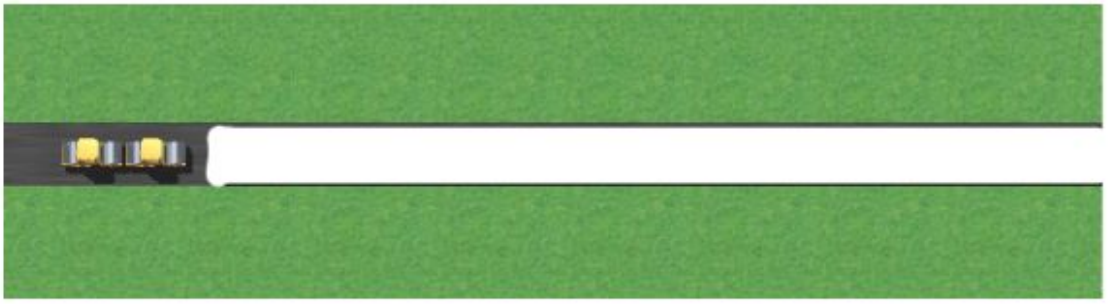
What does the black colour indicate here? *

- ◯ The right amount of compaction
- ◯ Not compacted
- ◯ Too much compaction
- ◯ Anders: _____

What does the blue colour indicate here? *

- ◯ The right amount of compaction
- ◯ Not compacted
- ◯ Too much compaction
- ◯ Anders: _____

What does the white colour indicate here? *



- ◯ The right amount of compaction
- ◯ Too much compaction
- ◯ Not compacted
- ◯ Anders: _____

What does the red colour indicate here? *

- ◯ Too much compaction
- ◯ The right amount of compaction
- ◯ Not compacted
- ◯ Anders: _____

What does the yellow colour indicate here? *

- ◯ Not compacted
- ◯ Too much compaction
- ◯ The right amount of compaction
- ◯ Anders: _____

What does the orange colour indicate here? *

- ◯ Not compacted
- ◯ The right amount of compaction
- ◯ Too much compaction
- ◯ Anders: _____

Do you have any further comments? If so, please write them down here.

Jouw antwoord

VORIGE VOLGENDE

Colour Evaluation

Thank you.

Thank you for participating. If you want to know more about this research, contact Selwyn Nijpels on s.t.nijpels@student.utwente.nl

VORIGE VERZENDEN

Verzend nooit wachtwoorden via Google Formulieren.

[D] Ethical review

Reflection II
Review of ethical issues in serious game development and implementation

By Selwyn Nijpels
s1580329
Creative Technology

Table of contents

Introduction 3

Project description 4

Stakeholders 5

Ethical issues in stakeholder relationships 7

Ethical issues in serious game implementation and adoption 10

Conclusion 12

1. Introduction

In this paper the ethical issues with regards to serious games and their development and implementation are reviewed. My bachelor thesis provides context for this review. In this project I worked on a serious game that is to be implemented in a curriculum on two schools. In this paper the ethical issues of this project and serious games in general are identified. First, stakeholders and their relationships with regards to serious games are determined and explored. Second, the ethical issues of this relationships are discussed. Thirdly, general issues that should be considered are reviewed. Finally, a conclusion is formulated.

3. Project description

This project was provided to me by the University of Twente. It is a continuation of a project started by a student one year higher than myself. The description of the project as provided by the University is as follows (original Dutch version):

Doel van dit project is het ontwikkelen van een cursus rondom een serious game voor voor gebruik bij het opleiden van een 2e /3e jaars mbo niveau 3 student "machinist en balkman asfaltspreidmachine en walsmachinist" en 2e jaars mbo niveau 3 student "vakman grond weg en waterbouw". Hiervoor moet onderzoek worden gedaan naar het geven van feedback en de meest effectieve manier van leren met behulp van deze serious game. Daarnaast moet er een 'level-editor' ontwikkeld worden die kan worden gebruikt door de docenten voor het creëren van nieuwe content.

1. Inzicht in uitvoeringsproces bij het aanleggen van een weg
2. inzicht in factoren die invloed hebben op het uitvoeringsproces
3. strategie kunnen uittesten en beargumenteren waarom de strategie goed is
4. reflecteren op strategieën en factoren die invloed hebben op de dichtheid van asfalt

Below this description is summarized in English and also expanded upon with the most recent developments and changes in scope and focus.

The project that serves as the subject for this report is about a serious game that is to be used in a newly developed MBO (Vocational Education) minor course at ROC Twente and Soma College in Harderwijk. The game teaches users about the asphalt road paving process. My graduation project is about the implementation of and use of the above described game. The game in question has already been partially built by a previous graduation candidate. My job is to further improve the game, so it can be used and implemented in an educational environment. This includes improving to game such that learning goals can be achieved, adding or completing features to satisfy both the students and the teachers and evaluating these changes. Besides, a content creation system, that the teacher can use to provide adaptive content in the game, was developed.

The learning goals are:

1. insight into the execution process when paving a road
2. insight into all factors that influence this execution process
3. testing strategies and substantiate why a strategy is good
4. reflecting on the strategies and factors that influence the compaction of the asphalt

3. Stakeholders

This project has many stakeholders. Serious games are used in many educational environments, and by extension this involves a number of important stakeholders. In table 3.1 all stakeholders are identified, and a description of their role is given.

Table 3.1	
Stakeholder	**Role**
Students	The students are in essence the end users of the serious game. They will use the game for their education. It is of importance for them that the game can be used properly, provides them with learning facilities and knowledge and has added value over the current method. In the case of this project, they are also involved in the development of the game. This means that they have influence on the quality of the project.
Teachers	Teachers, like the students, are users of the serious game, but on a different level. For them, the game needs to contain the necessary knowledge, but also provide tools to monitor and overview the students performances. For them it is of great importance that the game does not get in the way of learning, but rather enhances it.
Schools/school management	The schools where the game is to be used, ROC and SOMA in this case, are effectively clients of the game developers and/or publishers. Their stake is partly similar to that of the students and teachers; the game needs to be able to provide the necessary knowledge, and enhance the learning process. On the other hand, cost should not be too high and problems with the game should be easily solvable. Either the game should allow for technical changes by school staff of the developer/publisher should provide service after purchase.
Developers	The developer of this serious game is me. In this particular project I have little to no stake in the games implementation in educational environments. For me it is of importance that the game is sufficiently developed to finish my project. Even though the game will be implemented, partly as a result of my effort during the project, I will not receive no financial compensation for this. For the scope and relevance of this paper, I will therefore also assume a scenario where the development is commissioned by schools or businesses.

Businesses/ Commissioners	In a scenario where serious games are developed, it is likely that external businesses are involved. In the case of this project, multiple companies are involved, such as Strukton and Heijmans. These companies, and many other, and the University are part of the ASPARI group. ASPARI is the commissioner of this project. For this paper it is assumed that businesses will be involved when a serious game is developed. To cover the cost of the development of a serious game, assuming it is commercial, businesses are the most relevant funders. Schools usually do not have the resources to commision such a project by themselves.

4. Ethical issues in stakeholder relationships

In a scenario where a serious game is first developed, evaluated and then implemented and used in education, all the different stakeholders have professional and cooperative relationships with each other. In order to make this system of relations tangible, a figure was created. In figure 4.1 the relationships of the stakeholders are represented with arrows. An arrow going in only one direction means the relation is one sided, meaning one stakeholder influences the other but not the other way around. An bidirectional arrow means there is an active influence of the stakeholder on each other. In Table 4.2 the ethical issues of each relevant relationship are discussed, for both my specific project, if applicable, and in general.

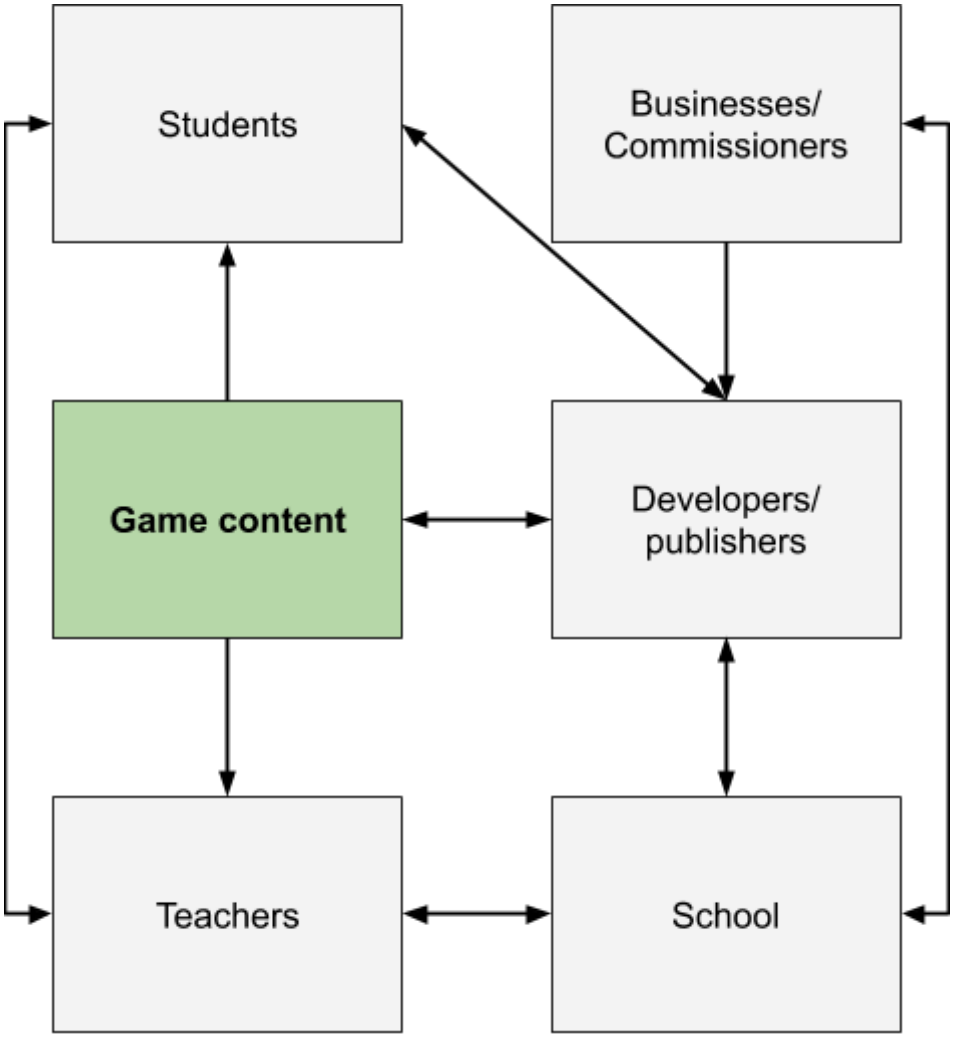


Figure 4.1: relationships between stakeholders.

Table 4.2	
Businesses/ commisionners → Developers/ publishers	In this project the relation between the commissioners and developer is fairly simple. This is due to the fact that the University acted as a mediator between the two stakeholders. I have been in contact with the developers irregularly, only to briefly discuss progress. The commissioner provided the outline and goal of the project, and the University handled the the execution of the project. This in itself does present an ethical issue.I was not motivated directly to produce the best possible game for the students, but rather for myself, for the outcome of my own project. Consequently, not being financially motivated does bring problems of its own, especially when I have a different primary goals then the commissioner. In a scenario where a serious game not commissioned via a University, there is a very important relationship between the business who commissioned the project and the developers. Since the funding is likely to come from these business they may have significant influence on the content of the game and how certain elements are presented. Taking my project as an example, the game simulates real world scenarios with real world materials and tools. There are different types of asphalt that could be produced by different companies. If a company decides to fund a project like a serious game, they could influence or even strongarm the developers to make their product look intentionally better. This is especially true for serious games with such practical and direct use cases. The students are likely to work very close to the businesses that had a say in the games content. Likewise, a game for medical training could put a certain medicine in positive light as a result of business influence.
Developers/ publishers ↔ Students	In the case of my project the students were involved in the design of a part of the game. They were asked to provide input on the layout, design and content of a feedback screen. The screen would display their performance on the level they played. They were also asked to fill out a questionnaire regarding their stance on the game. This was done twice, with two different versions of the game. In one version changes were made compared to the other version. While involving the students in the development of the game, it is important to keep in mind what their goals might be. A change that was made to the game that is based on previous work and research, might not be popular amongst the students. Their goal could be to make the game more fun, while a change made to improve learning effectiveness could contradict this in their eyes. It is therefore important to weigh the input of the students against that of literature and research. However, what balance is best? How much influence should the students have?
Developers/ publishers ↔ School	Once a school decides to invest in the implementation of a serious game, they take a high risk. Using a book for a certain subject is a

	low risk scenario. If the book is regarded to be obsolete or no longer up to the standards of the school, they can simply switch to another book. For a serious game this is more complicated. The investment in the game is not only financial, but there is also a knowledge and time investment. Teachers have to learn how to use game. Computers have to be prepared. Once this investment is done, switching would require considerable resources. There is also the matter of upkeep or maintenance. If faults are found or data is no longer up to date, the school relies on the developer or publisher to do so. This puts the developer or publisher is a strong bargaining position. The alternative is to educate school staff to tackle these technical challenges themselves, but this further increases the investment put into that game, increasing the risk. The relationship between the publisher or developer and the school is therefore very delicate. Should governments intervene? Should it stay a free market to stimulate competition and perhaps drive innovation? This could of course potentially be beneficial to the learning process.
Teacher ↔ School	Once a school decides to implement a serious game in their curriculum, teachers will have to adapt. Some might not be a fan of the game or of serious games at all. This could raise issues. Since the school has significant investment in the game, they might take certain actions to make sure teachers use the game. Teachers that refuse might have less chance to retain their job or even find a new one. Who is to say the game improves the learning experience of the students compared to the 'traditional' method of the teacher?
Businesses/ commissioners ↔ schools	In practical field such as the road paving industry, schools and businesses could have a very close and important relationship. If the businesses commision the development of the game, they have something to gain from this. The most prevalent aspect is recruitment. If the game contributes to better learning, they might eventually benefit by hiring the students that used that game. The school is stakeholder in this hiring process, as job guarantees are a big factor in attracting new students. Consequently, once a school decides to implement a certain game, the business that commissioned it would want the school to use it as long as possible. Moreover, in their relationship with the developer they could even steer the content such that they are effectively advertising their company. Student would then be more likely to want to work there. Since the school benefits from this as well, who makes sure the content is still objective?

5. Ethical issues in serious game implementation and adoption

In this chapter the ethical issues with regards to the general implementation, aside from stakeholder relations, and widespread adoption are discussed. In table 5.1 each issue is identified and elaborated on.

Table 5.1	
Role and status of teachers	Right now, teachers teach content. They learn students new things. Depending on the school, year, and class they have guiding and maybe even raising role. The use of serious game could potentially change this situation significantly. Assume serious games will get a prominent position in the curriculum. The game will provide the student with content and the student will learn by playing the game. Possibly, the game will even provide the grade and determine a pass or fail. The role of the teacher would change as a result of this. Instead of teaching the students they are guiding and assisting them, because the game now takes center stage in the learning process. If even the grading is taken out of teachers hands, this could be seen as detrimental to their status. How much control should the game take away from the teacher? How large should presence in education be? By extension, do teachers still need to possess knowledge? Effectively the developers become the teachers. In such a scenario, how do we maintain and check the knowledge that is being transferred?
Grading	The grading through serious game presents a number of issues by itself. If the game determines who passes and who fails, then effectively the developer and maybe even the commissioner determines it. The game now decides what is good and what is bad. If the game provides the grade, and this grade is considered to be determinant of pass or fail situations, can someone who plays the game independent of a study achieve the same educational status? Why would a company only hire people who completed a study, when anyone who can achieve a good grade in the game should be able to do the job? Where do we draw the line? Do diplomas and certificates still mean something?
Scoring	One the features often used in games, serious or entertaining, is scoring. Players can score points, gain experience and level up. In games for entertainment this is stimulating and considered fun. Serious games however, do not have entertainment as their primary purpose. While such a scoring system could make the game more appealing, it does add competitive elements to an educational tool. The effect of this on students could be beneficial but also detrimental. Lesser performing students being confronted with their performance might lose hope and be less motivated.

	On the other hand, students might constantly be stimulated to perform better. A balance should be found to avoid the aforementioned fall off of students. Should scoring and competitive elements be implemented at all? What role should the teacher have in this matter?
Ease of use	Serious games are played on computers or other electronic devices. For many this is not a problem. However, unlike reading and writing, the use and affinity with computers is not consistently taught at school. If a serious game is implemented in a curriculum and used intensively, students with high affinity with computers and games might be at an advantage. In combination with the aforementioned scoring and grading involved, this could lead to unfair performance comparisons. Perhaps the developers are responsible to design their games such that this effect can be kept at a minimum. However, who will check this? Should students who are less proficient with computers receive compensation, similar to students who suffer from dyslexia?
Privacy	Like many IT systems, the widespread use of serious games does raise privacy concerns. Student grades are already stores digitally, but a game could store a lot more data than just grades. Both entertainment and serious games comes ever closer to simulating real life. This means that students could be confronted with real life-like scenarios in the game. Their behaviour in that scenario could be important for future employers, who might have even commissioned the game. If data about the students' performance and behaviour in these scenario is stored, they could later be confronted with it. It could even be used against them. Should this kind of data be allowed to be stored? Who is responsible for the data, the school or the game developer?

6. Conclusion

After reviewing and organising all the possible ethical issues with serious games, I have gained new insights in the dangers but also potential of my own serious game. At the moment, the game from my project is not yet implemented. There are however serious plans to do so. Before the analysis and discussion of the issues in this paper, this implementation seemed harmless. Conversely, I did not properly consider the risks and ethical implications of such an implementation. Especially when I am the developer. My personal influence on the game is significant. I decide how the students learn. This is a big responsibility. A fault in the game could impact the learning experience of many students. Before, I did not consider my ties to this implementation. Once implemented, the school relies on me for support if issues arise. This has emphasised for me the importance of transferring my knowledge and all the games assets to someone who can carry it forward. In retrospect, I would have given the ease of use factor of the game more attention. During my project it was not a priority to make the game as easy to use as possible. Considering the consequences, perhaps is should have been. I am happy that I decided to not enable any data recording features in the game. Monitoring student performance is harder as a result, but it also prevents any harmful use of the data. If the university decides to follow up this project and assign it to another student, my hope is that this person takes the ethical issues and implications seriously. Perhaps the next project should be entirely focussed on navigating these issues and preparing the game for larger scale implementation.

Widening the scope, serious games in general clearly raise a lot of questions. The answers to these questions are of great relevance to the stakeholders. This means that it would be best that independent parties are involved to provide these answers. Government involvement could for example go a long way towards tackling these issues. Given the government in many countries already has a significant influence on education, this seems like a logical step. However, this creates problems of its own. In any sector where commercial parties are involved, interference could hamper competition and therefore innovation. Clearly, the answers to these questions are not clear cut, and finding the method to answer them is neither. My hope is that serious games will be taken seriously. Not only because I do believe in the many benefit, but also because the ethical issues they come with should be properly and carefully considered.