A GAME TO TEACH GAMES DESIGN

by

Christopher James Lee

LEE15563252

A dissertation submitted in partial fulfilment of the requirements for the degree of

BSc (Hons) Computer Science

School of Computer Science

University of Lincoln

2018

Acknowledgements

A special thanks to Lewis Cooper, who without his contribution in game sound, textures and models, this project would have taken even longer than it already did. Also thanks to everyone who took part in the study group, you know who you are.

Abstract

Computer games are not solely for entertainment. Serious games are becoming more widely used in the classroom but there are only a few serious games on the subject of games design itself. In this report, a serious game to teach games design is outlined, designed, created and tested. The author finds whether the game is an improvement for revision of a games design principle over the more established revision method of reading over notes.

Background

Video games have been being used for training and educational purposes for many years very successfully from a primary school level (Rosas, et al., 2003), all the way up to highly technical fields in a wide variety of subjects such as medical training (de Lima, et al., 2016) and the military (Lai, et al., 2011). When a game is designed for a primary purpose other than entertainment, it is known as a "serious game". (Djaouti, 2011) However, there have been few serious games which teach game design itself.

In this project, the author will hope to find if it is possible to create a video game which helps university level students to revise and reinforce a game design principle. The game would focus on a specific element or principle of game design. This would encourage the players to experiment and play with it which could reinforce the reasoning for the principle from a player perspective while at the same time helping them to think about it from a designer perspective too. This element of game design will be chosen by looking closely at the syllabus taught at the University of Lincoln and what elements of it translate well to being taught by gameplay. For the purposes of this dissertation the author focuses on principles of the syllabus of years 2 and 3 of the course in Games Computing taught at the University of Lincoln.

The outcomes of the project would not only be the above-mentioned game, but also a study which would find whether or not using the game is a benefit to the learning of the students over traditional teaching and learning methods. If successful, this study could lead to more games being developed to teach and reinforce games design principles in the future.

The rationale of undertaking this project is to help universities Games Computing students locally, and possibly around the world, reinforce their learning and also to look at the role of "serious games" in the context of teaching and revision of games design, with an eye to their future role in teaching and learning and how this might benefit the creation of games that teach other aspects of game design in the future.

Literature review

The book "The Aesthetic of Play" (Upton, 2015) is the basis of all the information taught in the game. More specifically, the section on "playspace heuristics" is the source of entirety of the information given in the game, which is also not by coincidence the information which is taught at the University of Lincoln. Because this information is taught in a Games Design course module at the University of Lincoln, it will allow the author easy access to students who had been taught these principles, which would in turn allow the author to test the effectiveness of the game on students more easily.

Upton breaks down the playspace into 6 individual yet interlinking heuristics. While Upton has many examples of possible games to describe his points on playspace heuristics in this book, to create a game with these examples would take a very long time because they are all different types of games. However, inspiration has been taken from some of the examples found within this book in the final game.

Another useful book is "The Art of Game Design: A Book of Lenses" (Schell, 2014). This book details the fundamentals of game design by making the reader look at their game from different perspectives which the author feels will be very important when building the game. It will come in most useful when evaluating parts of the game, rather than as a tool for selecting a games principle to teach; but it contains many principles such as software engineering, puzzle design and psychology (in the context of games) which will be very useful to the author as a games designer.

The paper "Mixed-methods research: a new approach to evaluating the motivation and satisfaction of university students using advanced visual technologies" (Fonseca, et al., 2015) talks about how university students interact with newer visual technologies and provides a comparison to more traditional physical mediums (in their case, printed plans and physical models, but in this report, reading from a book). It compares the student's motivation while using newer technologies and their satisfaction while using said technologies versus the older mediums such as text books, which is also the comparison medium the study will be on. If the game is satisfying to use, the students will be more likely to continue to play it, and therefore will be more likely to remember the concepts put in the game.

In the study it is planned to investigate how satisfying the created game was to the students, not only as a game but also as a learning tool.

The paper "Introduction to 'New Conceptualizations of Transfer of Learning'" (Goldstone & Day, 2012) talks of the importance of being able to take what is learned in a controlled situation (for example, what game design principle the game teaches the player) and then utilise the knowledge gained from that in an uncontrolled situation (for example, when they are in an exam on it later). If the method of teaching doesn't explore all scenarios well enough, then come the time the student is examined on it, the student may think they were never taught in the first place. This paper suggests that if learning can't be applied to a different situation, it "is almost always unproductive and inefficient".

Another useful paper is "A Model-driven Framework for Educational Game Design" (Roungas, 2016) which is written about a framework for educational games design and, while the author won't use this framework, the "Conceptual Model" outlined in this paper will give a good idea of how I can design the game. The author also supports Roungas' view that a good balance of entertainment and learning is important to making the game memorable and satisfying to use. In the created study it is planned to investigate if people enjoyed the game, as well as if they found it useful as a learning tool, which is where this paper could come in useful.

Design and Development

Game Development

After looking over multiple different possible game design principles[1] to base the game around, the author chose "Playspace Heuristics", as written about in *The Aesthetic of Play* (Upton, 2015). This was because the author felt that the examples found in the book translated best to tangable gameplay concepts. In addition, these examples of Playspace Heuristics could be both easily implemented in a game and would require less time to teach than principles such as "Story-telling", which might require a full length game to provide commentry on. This would be inherently time consuming or require a design which might need complex mechanics and AI to explain and is out of the scope of the limited timespan of this project.

The game was designed as a first person game, as the author felt that this would allow the game to switch between multiple different genres (such as first-person puzzle, first-person shooter) as the game is played, depending on what genre would best explain to the player how a particular concept works. Another advantage of this is due to the popularity of the genre, most Games Computing

[1] It should also be noted that the authors range of possible choices was limited to those taught at the University of Lincoln. This was because this project needs to be able to test how well the game helps students revise the material, the game needed to teach principles they already have been taught about.

students are fimiliar with first person controls, and can therefore understand the core controls of the game easier than if the game was of a a less popular genre which they are less likely to be femiliar with.

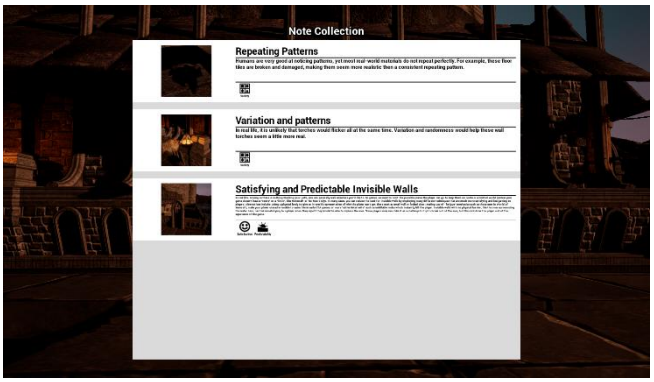

Figure 1: The "note collection" where collected "thoughts" are gathered and can be reviewed later by the player. In this example, the player has collected 3 thoughts.

The majority of the gameplay is centered around the player collecting “thoughts”. These “thoughts” are small pieces of information about the principles of Playspace Heuritics. Playspace Heuristicsappear throughout the game, usually following an example of the implementation of the heuristic in the context of the game. “Thoughts” can appear on small information displays, much like what you might see at a muesum, or can be displayed when looking at an object within the game enviroment (more on both of these later). When the “thought” is collected, it pops down from the top of the screen for a few seconds in a small frame (in a similar style to an “achievement”) and then can be accessed later by the player by looking in the “note collection” (which works similarly to an achievement list, commonly found in other games and game platforms). This means that, if a player wishes, they can look at what they had learnt earlier without having to back-track through the game to the place where they first saw it.

While Schell does state that if game collectables don’t have a general reward other then a higher score, then the player won’t bother to collect them as they don’t help the player advance the level (Schell, 2014, p. 33), the author believes that since the player is also a student, we can hopefully assume they want to better their education and they will try to collect all the collectables, without them needing to be compulsory.

Figure 2: An information display as it appears in game. It is designed to look like something which you might see at an art gallery or museum. Also, in this shot you can see the collected “thought” popping down from the top of the screen. This only happens the first time the player looks at the information display.

Some of the “thoughts” appear as an “information display”, much like that which you would find at a muesum. Initally, playtesters might read the first few, then start skipping them just to play with the various things around the levels. To entice the player to read the information displays more, they glow with light and emit a peaceful, yet noticeable, sound when they haven’t been read. When the lectern is looked at, an auspicious sound effect is played and an achievement-like notification pops down to tell the player that it has been added to their “thought list”. After this change was made, playtesters began to pay more attention to the information displays.

Other “thoughts” appear in an on-screen window, which has a “connecting arm” which connects to the relevant object in game. This “connecting arm” is a line which goes from the bottom of the on-screen window to the side of a square surrounding the object as it appears in screen space. This allows for the player to better understand the reasoning of what the object means in the sense of Playspace Heuristics without the flow of the game being interrupted (which is a flaw in the “information display” approach mentioned earlier). These relevant objects can be part of the environment, gameplay objects or even more abstract objects such as invisible walls.

Figure 3: The on-screen window as seen in game. It is difficult to see in this screenshot, but the black connecting arm is going to a torch which is on screen.

Playspace Heuristics aren’t in completely separate domains from one another and tend to overlap. To show how each heuristic could be related to another, thoughts were made so they could be accociated with some (or all) of the heuristics, if it made sense. These would be displayed on each thought so players could start to see how they were all related. To allow the player to easily distingiush between each of the Playspace Heuristics at a glance, each heuristic was given a unique icon and each thought was given one or more of these icons, depending on which playspace heuristics they were associated with.

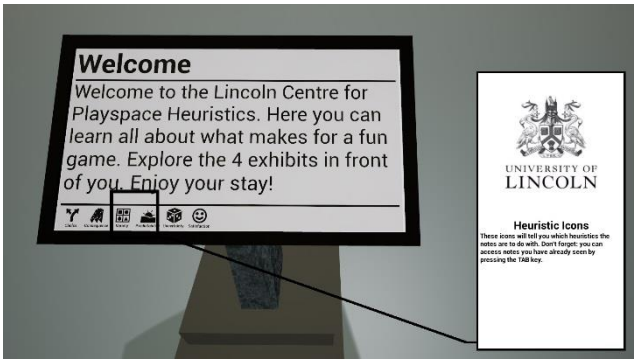

Figure 4: This information display is the first the player will see. It shows how a thought can be associated with one to six heuristic icons, which are displayed at the bottom. This is highlighted to the player by the on-screen thought viewer.

The games environments take inspiration from two places. Firstly from another first-person puzzle game, “Portal” by *Valve Corporation*, and secondly from the white-wall aesthetics of a sterotypical contemporary art gallery. This was chosen as a more simple environments which allows the player to better concentrate on a puzzle, and also speeds up how fast environments can be created for the game, as there are less custom models and texture to be created. This freed-up time to focus on the other parts of the game.

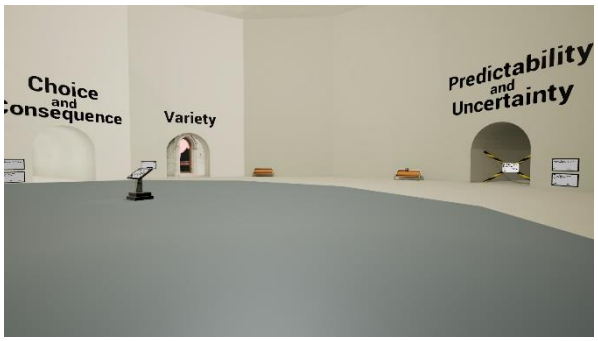

Figure 5: The main hall, where players start the game and pick which of the exhibits they want to explore first.

Another benefit to starting with a simple enviromental design is that it allows for more juxtaposition later; this was used to great effect in a segment in the variety “exhibit” where the environment is completely different, looking more realistic. This is then stressed, emphasized and pointed out as a learning-point about using variety in environments within a game. At the end of this segment, it is

pointed out to the player that, despite the environments being quite different, the way they moved through them - walking in a straight line itself is not very varied, and that as a games designer it would greatly improve a game to vary both environments and also how the player can traverse them. These “forth-wall breaking” self-aware notes are what make up the majority of the “thoughts” which the player collects by playing the game and thus teaches them how Playspace Heuristics can affect their own games design.

Figure 6: The "dock" area. It has a noticeably different aesthetic from the other parts of the game.

The initial idea for the game was that it would be split in to 6 sections called “exhibits”. This name was chosen to make the experience feel like you’re in some sort of museum, which also worked with the above-mentioned art gallery aesthetic. Each section was intended to be named after a single playspace heuristic, but as the project went on it this seemed unrealistic and unachievable as it was realised that there wouldn’t be enough time to create such a large amount of content. Due to the nature of the game, we need to teach the player about games design using a number of unique examples (which in terms of games design is a lot of “mini-games”). This means the game was destined to have a large amount of unique content which would take a lot more time to create and left not much room for non-linear content. But this could be something for the future if the game was to be further developed as a teaching and learning aid.

After it was realised that the game was getting too big to complete within the time limit of a dissertation project, it was decided the number of exhibits would be cut down to 4. This was done by merging some of the playspace heuristics which are often confused for each other. This merger had the added benefit of being able to explain how they were different from one another.

Although none of the created exhibits were fully complete, each did contain enough content to act as a “demo” version of a full game to students.

All of the exhibits revision material was translated to text as well, to be used by the control group participants in the later study. This list of all the “thoughts” found in the game makes up the majority of the information which can be seen extracted from the game in Appendix E: Alternative Revision Resource, with only minor changes to make it more readable outside the context of the game.

The creation of the game is documented in Appendix J: Game development log.

Toolsets and Machine Environments

Unreal Engine 4

To create the game, the game engine “Unreal Engine 4” was used. One major reason Unreal Engine 4 was chosen was that its free license allows the game to be published and distributed without having to pay a licence fee until the revenue exceeds a $3000 per calendar quarter (Epic Games, Inc, n.d.). Since the game was distributed to test participants for free and this game was non-commercial, there was no worry of ever exceeding this amount.

Another major reason for choosing Unreal Engine is that it is known for its large platform compatibility, meaning the game can be easily ported to different platforms should the need arise if it was to continue development.

Unreal Engine supports a wide variety of operating systems, game consoles and mobile devices such as Android or iOS. This could be beneficial in future iterations of the project because mobile devices may promote learning anytime and anywhere, since the student doesn't have to be sitting in front of a computer located in a room or lab (Figueiredo & Bidarra, 2015). Unreal Engine can also deploy to the web as HTML5, allowing the game to be run in a browser window, which eliminates the need for the user to install anything.

That said, the game is currently only built for Windows as the game is only going to be tested in labs which run windows as an operating system, but, if the project was to be expanded on later and published, it might be beneficial to be able to build for some of the above-mentioned systems to appeal to a wider audience.

Another reason Unreal Engine was chosen is its high adoption among developers leading to it having many 3rd party plugins to extend it. One of which is "PortalPlugin" by "FreetimeStudio" (FreetimeStudio, 2018) which is used by a section of the game to move the player from one area to the other. Unreal Engine also has its own marketplace, where game developers can buy and sell art assets, code plugins and editor plugins, which could be used to expand the game in the future if additional art assets are needed.

One final reason Unreal Engine was chosen is that its "Blueprint" visual scripting system allows for rapid prototyping of game logic. This allowed the game to be created faster because Blueprint is a very abstract language, meaning that the focus could be put more on the creation of the game and the mechanics rather than more low-level issues such as memory management and garbage collection. However, Unreal Engine is also fully open source and allows for C++ programming if the programmer finds they need to do a task which is unable to be completed with the Blueprint system. This makes the engine extremely versatile.

The games graphics make use of the Unreal Engine 4's realistic rendering (Epic Games, 2018). This means that the game makes use of "physically-based materials", which have the advantage of allowing even the games more simplistic enviroments to still look highly realistic.

GitHub

To store the project files GitHub was used. Github is a website and hosting service for version control which uses the version control system Git.

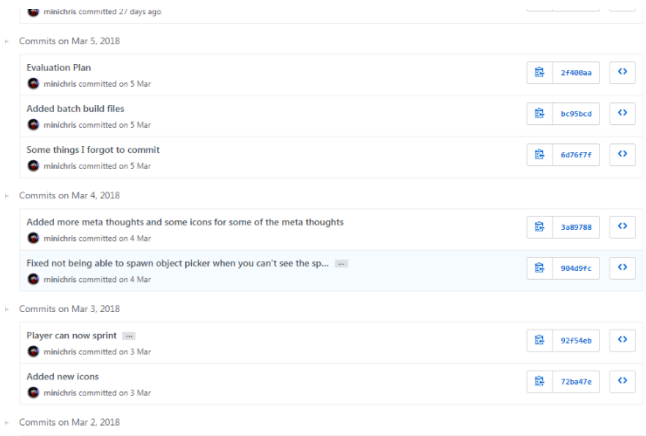

Figure 7: An example of some of the Git commits in the Github.com user interface.

Git allows the project files to not only be backed up externally, but also facilitates going back to an earlier version of the project. This can be useful if a bug crops up and it is unclear when it was introduced, the authors of the Git project can go back to an earlier version which doesn't have the bug to find out what introduced it. Git is especially useful in normal programming projects as it allows for only the changed lines to be committed rather a whole file, meaning two different people can work on a file at once and combine their changes after they are committed to the Git repository. Unfortunately, Git has a flaw; it can do this operation on text files, but not on the binary files (Kenlon, 2016) which are used

by Unreal Engine 4 (called ".uasset" files). Therefore, if someone was working on the files at the same time with other members as a team we would have to be careful to not edit the same file at the same time, and wait for the other person to commit their changes before continuing work. As it is only the author working on the project, this wasn't a concern. Github also allows for bugs about the project to be reported to the developers of the project, wikis to be made about the project and many other useful features. However, for this project the bug reporting system on Github takes too much time to fill out in comparison to Trello's card system (which will be talked about later).

There are other version control services available, such as Gitlab and Bitbucket. Both services offer the benefit of a free private repository (Atlassian, 2018) (GitLab Inc, 2018), whereas Github requires a premium account (Github, 2018), which the author has as a student. However, another important consideration is that an Unreal Engine Git repository can grow to be quite large, and therefore it is important to consider that when choosing a repository service. Github recommends keeping repository sizes to under 1 GB to keep the repository easy to download, but it doesn't have an upper limit (Github, 2018), while Bitbucket has a hard limit of 2GB (Atlassian, 2018) and Gitlab has a hard limit of 10GB (GitLab Inc, 2018). It is unlikely that the repository will exceed 10GB, but it is expected to exceed 2GB, making Bitbucket inappropriate for this sort of project. Due to an aforementioned flaw in Git, where parts of a binary file being changed means the file has to be fully committed, rather than only the changed parts needing to be committed, the project's repository size can substantially exceed the size of just the current project files (as the previous backups are not just the changes to files, but *entire* files). This can mean that an example project which only has 2GB of binary files can end up with 10GB of backup files in Git, if each file is changed 5 times. This is a worst-case example; it is unlikely that each binary file will be changed 5 times - most large files are models and textures, as opposed to more commonly edited files such as class files, which are changed more often as they contain the games logic. However, this shouldn't be overlooked when choosing a version control service – it could be a difficult and time-consuming task to have to change it later down the line.

A final reason Github was chosen was that this project has the potential to be contributed to by other users beyond its use as being the author's dissertation project. It may be picked up by the University of Lincoln or any other university or college which teaches games design in this way. It seems that almost all developers have Github accounts (some jobs applications may require you to have a Github account (Watson, 2015)), whereas not all developers may have interacted with, or even know of, the less popular Gitlab or Bitbucket. By starting the project on Github, it means the project can be released publicly using Github without any sort of transfer from another service.

Trello

To manage the project, Trello was used to keep a note of features that need implementing and bugs. Trello uses a simplistic board and card-based system, where cards can be added to a list, and a board can have many lists. A benefit to using Trello over Github's built-in bug management system is that it is significantly faster to add cards to Trello than it is to add bug reports to Github. This means the game could be play-

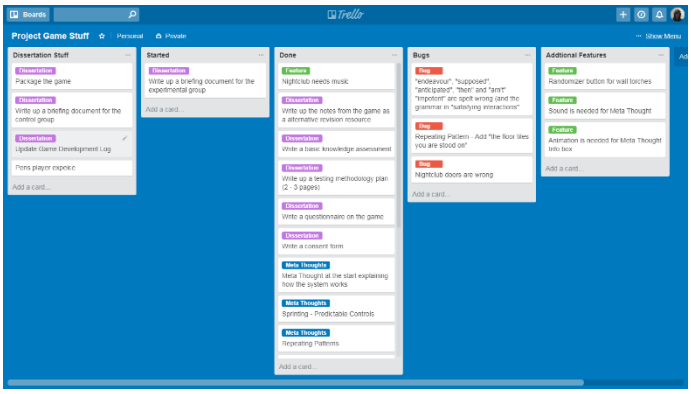

Figure 8: The Trello board used to manage the game project. Note the labels used to separate new game features and ideas from known game bugs.

tested by another person while the author watches and records bugs, rather than gameplay having to be stopped in order to write down bugs, thus spoiling the flow of gameplay for the play-tester.

Research Methodology

Evaluation Plan

Outcome

The outcome is to evaluate the effectiveness of the game as a revision resource, with a particular focus on whether it improves the quantity and quality of information remembered at a later date, and whether it does this better than basic revision through reading.

Plan

Quantitative or Qualitative Research Methods?

In the post-gameplay questionnaire, it is planned to use mostly quantitative research in order to evaluate effectiveness, as this will make the results, which will be used in the evaluation, more objective. This also has the added benefit of making the interpretation of the results less biased; it is much more difficult to argue with hard numbers than it is to interpret the way people have worded their responses to the same questions. However, there will be a section where the study participants will have an opportunity to give any other commentary on the game, which will allow them to express their opinion on the game subjectively if they have any other thoughts which they feel haven't been put across well by the Likert scales in the rest of the questionnaire.

When writing questions for the knowledge assessment, quantitative style questions (true or false; multiple choice) will be used rather than qualitative style questions (such as paragraph or short essay questions) for a multitude of reasons. Firstly, it is significantly easier to write a mark scheme whenever answers are 100% objective. Secondly, it is faster to mark lots of submissions if they use quantitative style questions because the assessment makes use of Google Docs Forms, which has a feature which allows auto-marking with multiple choice questions. Finally, and most importantly, the study participants will be asked to fill in the knowledge assessment 3 times. If qualitative questions were asked, not only would this take a long time since there will be 3 submissions of the knowledge assessment from each participant, but also it would take the participants a significant amount of time to fill it in, which would make the study undesirable to participate in.

Independent and Dependent Variables

The dependent variables of the study are: the improvement of the participant's average score from the knowledge assessment directly after using one of the two revision materials and the improvement of each groups average score from the knowledge assessment a few days after using one of the two revision materials.

The independent variable is the revision materials used. The control group will be given the "alternative revision material", which will hopefully emulate the sort of material a student usually uses to revise (such as looking over old notes and the course module's recommended reading material). The experimental group will be given the game created which will be used as revision material.

Recruitment

To recruit students to participate, the author will ask in both the University of Lincoln's computer science society chat group, and in games design workshops at the University of Lincoln, where second and third year games students will be asked if they are willing to take part in the study as an

optional additional task in their workshop. To encourage students to take part, potential participants will be informed they may learn about Playspace Heuristics.

Second and third year students have been chosen as the test subjects because they have recently been taught playspace heuristics as part of one of their modules. Those who are willing and finish the workshop will be equally distributed between two groups, the control group and the experimental group.

In a perfect world, with a significantly larger number of participants, it would be preferable to use a "between group design" for this study, as it means there would be no participant reuse, meaning it would be more likely for participants to have less knowledge about the subject before using one of the revision materials. There would be a more noticeable change between their knowledge going into the experiment, both directly after using whichever revision material they are assigned, and also when they retake the knowledge assessment after a few days.

However, the author feels that it is more important to achieve a statistically significant amount of people in each group rather than having too little data to draw a conclusion. For this reason, it was decided to use a "*repeated measures design*" where the study participants in the control group would be allowed to be reused in the experimental group and vice versa (Shuttleworth, 2009), therefore requiring less participants to reach the amount needed for statistical significance (Stone, et al., 2015). The author feels this would be unlikely to cause a significant issue with the data as the dependent variables are not concerned with ***how much*** the average participant knows at the end, but how much they know has ***changed***. So, if participants begin the study knowing a small amount and end the study knowing a lot, the net change is the same as if they began with knowing nothing and finish knowing a small amount. An issue with repeated measure designed studies is they can be biased by "order effects", such as participants benefiting from practice or underperforming due to fatigue (McLeod, 2017). For this reason, the groups should be counterbalanced, meaning that one set of participants are started out in the experimental group then move into the control group, and another set of participants start out in the control group and move into the experimental group. This negates order effects as "Although order effects occur for each participant, because they occur equally in both groups, they balance each other out in the results." (McLeod, 2017).

I aim for 20 people in both the control and the experimental group to achieve a statistically significance amount of results.

Preparation

I will need to create the following items:

Packaged Game

The game will be packaged in a ".7z" compressed archive, not only because its gives good compression, meaning file sizes will be smaller, leading to faster downloading from the internet, but also because the lab machines which students will be working on will already have 7zip installed.

Knowledge Assessment (exam)

The exam will be uploaded on to google docs, because the students will be familiar with it, and all the information entered will already be digitized, which is an advantage over a paper exam.

Since the result of the exam doesn't matter to the students, it is unlikely the students would care enough to cheat, so enforcing exam conditions will be unnecessary. A note will be added to the top of the google docs asking them kindly *not* to cheat.

The exam's questions will be focussed solely on the information found within the game and the given alternative revision resource, rather than playspace heuristics in general. This is because the exams are not testing the students' knowledge about playspace heuristics, but how well they retained the knowledge they learned in the game / alternative revision resources, which happen to be on playspace heuristics. Remember, we are trying to find if the game helps with revision of *a* game design principle, not how well it teaches a *specific* game design principle.

The finished knowledge assessment, as taken by the study participants can be found in Appendix B: Knowledge Assessment (screenshots of the Google Docs Form) and the correct answers for it can be found in Appendix A: Knowledge Assessment Plan.

Consent Form

Before the first exam will be a consent form for the students, which will also act as a form gathering basic the participant's email address, which the author will need to know for reasons which are mentioned later.

The finished consent form given to the study participants can be found in Appendix C: Study participant consent form (screenshots of the Google Docs Form).

Questionnaire

This will ask the player what they thought of the game, if they would play it again, would they show it to their friends, etc.

The finished questionnaire can be found in Appendix D: Post-Gameplay Questionnaire (screenshots of the Google Docs Form).

Alternative Revision Resource

Since the aim of the project is trying to find if the game makes for a better revision resource then more traditional media, the author will create a text only version of all the information found within the game as a revision resource which will be given to the control group, rather than the game. This document will also be available on Google Docs.

The finished alternative revision resource can be found in Appendix E: Alternative Revision Resource (PDF file which was uploaded to Google Drive).

Briefing – Experimental Group

This will be a brief document (also found on Google Docs) which will start by asking the participant to complete a consent form followed by a link to that consent form on Google Docs. Then it will ask them to complete a "Knowledge Assessment" which will be an exam found on Google Docs. After they have finished this, they will find a link to the download for the game and instructions outlining how to install the packaged game, how to run it; some very basic information about the game and known bugs that might crop up causing the game to need restarting. After they have finished that they will be asked to fill in the knowledge assessment again.

The finished briefing document given to the control group can be found in Appendix G: Study Participant Briefing Document (Experimental Group).

Briefing – Control Group

This will be a short document (also found on Google Docs) which will start by asking the participant to complete a consent form followed by a link to that consent form on Google Docs. Then it will ask them to complete a "Knowledge Assessment" which will be an exam found on Google Docs.

The finished briefing document given to the control group can be found in Appendix F: Study Participant Briefing Document (Control Group).

Timeline

A day after the initial test, both the control and the experimental group will be sent the same knowledge assessment again by email and will be asked to fill it in again. This is to see how well each group has retained the information provided in each revision material. The email addresses of the students will be obtained from the consent form.

Outcome Interpretation

	Test results improve directly after playing	Test results don't improve directly after playing
Test results are still improved after a day	If the students keep the knowledge and it stays with them for a day, there is a strong argument for the game being able to help with revision.	This is still beneficial to the student, but the author doesn't expect this result.
Test results are not still improved after a day	If the participants improve their result after the first test, but then they are back to how they were before, then we could argue that, while they did know all the answers after playing, they failed to retain the knowledge for a long term.	If the participants don't improve their result after any of the tests, then we can conclude that the game doesn't help with the revision of playspace heuristics.

Results

Knowledge Assessment scores

	Control Group Average Score	Experimental Group Average Score
Before using revision material	4.8 (5 respondents)	4.666 (3 respondents)
After using revision material	6.8 (5 respondents)	6.75 (4 respondents)
A day after using the revision material	6.333 (3 respondents)	8 (1 respondent)

In the above table, "revision material" refers to the game for the experimental group and the provided alternative revision resource (which can be found in Appendix E: Alternative Revision Resource) for the control group. The full data for these scores can be found in Appendix H: Knowledge Assessment Results and Appendix I: Knowledge Assessment Results (Experimental Group)).

Knowledge Assessment Average Improvement

Because the author could determine (via an approach mentioned later in this report, and in the relevant appendices) each participant's knowledge assessment scores before revision and after revision, we can find out each individual's average improvement. This data can also be found in Appendix H: Knowledge Assessment Results and Appendix I: Knowledge Assessment Results (Experimental Group). To calculate the improvement is as simple as:

$$Individuals\ Improvement = After\ revision\ score - Before\ revision\ score$$

Group	Mean Individual Improvement
Control Group	1.8
Experimental Group	1.333

Analysis of Results

Knowledge Assessment

The results seem somewhat inconclusive as there isn't a significant difference in either group. However, it would be reasonable from the knowledge assessment to suggest that the control group did do better in general then the experimental group, at least in improvement. This certainly doesn't support a hypothesis that a game is necessarily a better way to teach games design.

Post-Gameplay Questionnaire

The raw results of the post-gameplay questionnaire can be found in Appendix K: Post gameplay questionnaire results.

Most study participants agreed with the statement "I enjoyed playing the game." with scores such as five and six, with one outlying result of ten suggesting that this person thought that the game was great. All respondents (3) strongly agreed with the statement "I felt the game will help the player better answer the knowledge assessment questions". This, with answers to the previous question, is a strong sign that even if the game isn't great on its own, students would play it to supplement any other revision.

Most participants slightly disagreed with the statement "I feel like I would play the game again." which might suggest that they feel they get all the knowledge they need from only one play-through, or that there isn't much replayability (the demo doesn't have much replayability in mind).

All participants strongly agreed with the statement "I think I would like the game more if it was in a more finished state." This is a tell tail sign that that, not only the demo is clearly unfinished, but also, that there is a lot of interest for this style of learning.

All participants also moderately or strongly agreed with the statement "I feel like if this game was more finished, I would use it to supplement my own revision." This suggests again that they are very interested in this interactive style of learning and revising.

The only valuable optional feedback comment is "I think it needs to implement more 'show not tell', there was good examples already but there was still a lot of looking at boards with lots of text". This would suggest a fully finished game should try to have more "mini-games" and interactive examples as well as "thoughts", which are more passive way of learning.

Project Conclusion

Before making any sort of conclusion, it should be noted that, some participants were recruited who did not meet the initial participant recruitment requirements[2] due to lack of participants who met these requirements willing to take part in the study (this is discussed in more detail in the reflection part of this report). These participants who didn't meet the criteria were used in both the control group and experimental group. The change from exclusively University of Lincoln 2nd and 3rd year

[2] Initially the requirement was that the participant was a second or third year Games Computing student from the University of Lincoln.

Games Computing students to students with a general competence in computing[3] should not make the testing any more biased.

It does, however, make it less accurate useful to the original outcome of "to evaluate the effectiveness of the game as a revision resource, with a particular focus on whether it improves the quantity and quality of information remembered at a later date, and whether it does this better than basic revision through reading." , as the testing is changed from being about how well it reminded the participants of information they had already learnt, to being the first time they have ever seen the information, and therefore it being the first time they had learnt it[4]. Therefore, the following evaluation will be using the data to answer the outcome on effectiveness of learning, rather than revision.

As found in the analysis of results, if the method used to evaluate the taught material is an exam, it might be better to stick with more standard approaches for teaching some fundamental game design principles. However, many participants' responses in the post-gameplay questionnaire did seem to suggest that there is interest in this style of learning and most would make use of this game to revise and study on top of more traditional revision techniques.

However, a better question to ask might be "is it practical to create a game to teach games design?". The author personally thinks it is highly impractical for many reasons: this game was only ever designed to cover "playspace heuristics", which is a very small part of the overall university module it is contained in, and that module covers only a small part of games design itself. The development of the game ended with only a small amount of coverage of playspace heuristics being fully implemented with a significant portion left to do. This would seem to show that it is extremely impractical for a single person to create a game of this size, linearity and complexity.

Only the author worked on the games design and programming, and the majority of the art was created by the author with the exception being some free game assets on the internet, and some art assets from more artistically-inclined colleges. This, the author believes, is the main reason the game was not brought to proper completion. Due to the time requirement of designing and developing a game, it might be impractical for a lecturer creating revision materials for a module to create a related game rather than a more conventional set of revision materials such as a reading list and it is suggested that many "teachers do not have advanced technological skills to create or adapt their own educational games" (Melero & Hernandez-Leo, 2014).

In conclusion, it is *possible* but statistically it doesn't seem to be worth the time, effort, skill requirement for one person to undertake such a large endeavour.

Reflective Analysis

During the creation of this project, the game's design, programming and art was all created by one person. Realistically if a university did want to take forward this approach as a viable method of creating revision materials, then it is presumed they would have a large team to create the game, rather than just one person, which could potentially greatly increase the scope and quality of the final game. It is not unrealistic to think that a lot of time and effort is required in the creation of the art assets and basic gameplay mechanics could have be reduced by buying assets from an online

[3] All of these students had played a video game of a similar nature before and were competent in using computer systems and are known by the author to be fairly technologically capable.

[4] Arguably, this doesn't make a lot of difference as it is completely possible that the second or third year students that would have been recruited may not have learnt this information in their regular education, for example if they didn't attend the session where it was first taught.

marketplace (such as the Unreal Marketplace or the Unity Asset Store) or even outsourcing to a larger game publisher, if the project was big enough. I believe being able to buy assets from the store would have significantly increased the speed at which the game could have been created, as would have having a development team of skilled designers and programmers but this, in turn, would have also made the project significantly more expensive to produce.

I chose to make a game about Brian Upton's playspace heuristics because these are taught in the games design course at the University of Lincoln. While Brain Upton is respected in his field for both his writings about game design and his creations in the field of game design, his work in playspace heuristics is not the only contribution regarding playspace heuristics in games design. There are many other authors who have written their thoughts on playspace heuristics, but my game has grown from how Brain Upton writes about them in his book *The Aesthetic of Play*. I did minimal research to find out if Brain Upton's variety of playspace heuristics were taught at any other universities. This being such a small area of games design will more than likely limit the audience for the game. Had I had more time, I might have included other authors' versions of playspace heuristics which could give the game a wider audience of students who could learn from the game. Also, if I had picked a more general game design topic this would have been the case, but both these suggestions would have caused the project to overrun and also become overly complex.

When designing my research methodology, I decided to keep all knowledge assessment results anonymous, as not to deter any students who may worry about being judged for their knowledge (or lack thereof). I could match pre-revision assessment and post-revision assessment results of the same person because I only set-off a new study participant after the previous one had finished, which allowed me to correlate the submission timestamps. A day after completing the post-revision assessment, the email addresses collected in the study participant's consent forms were used to send them an email asking them to complete a final third knowledge assessment to gauge how well they retained the knowledge they have revised the previous day. However, some participants failed to respond to this email, leaving me with a smaller sample size for this data than the rest of the study. Others responded late, which arguably makes the data less reliable as they have had more time to forget more things. Because it was an email which was not treated with urgency, I was unable to match an individual participant's initial, "before revision" and "after revision" results to that individual's "after a day" result. For this reason, averages of the entire surveyed group scores had to be compared when comparing anything to the "after a day" result, as opposed to being able to calculate and compare individual scores. If I was to repeat this study, I could either: require study participants write their name (or another identifying reference number such as student ID) at the top of each knowledge assessment; assign each new participant a random number when they complete the first knowledge assessment (before revision), which they then enter as an ID for the second (after revision) and third (after a day) knowledge assessments. By doing this, I would be able to calculate exactly how much knowledge each particular study participant retained after a day, whereas without it I can only see how much my participants improved as an average of a group.

An issue which arose when preforming my study was that, according to my evaluation plan, I would require 40 University of Lincoln 2nd and 3rd year Games Computing students. At the time of creation of this plan I did think this was at least somewhat feasible but, as my time to complete the project dwindled, I realised that the amount I had managed to recruit (1) was not enough for any sort of statistical significance. For this reason, some students were found who did not meet the above requirements but were willing to participate. All of these students had played a video game of a similar nature before and were competent in using computer systems. These students were used in both the control group and experimental group, meaning they were not a variable, but a constant.

The change from exclusively University of Lincoln 2nd and 3rd year Games Computing students to students with a general competence in computing should not make the testing any more biased. It does, however, make it less accurate, as the testing is changes from being about how well it reminded them of information they had already learnt, to potentially being the first time they have ever seen the information, and therefore it being the first time they had learnt it. As mentioned before, if I was to repeat this study, I would offer a stronger incentive for participating in the study as a method to get more targeted study participants and I would consider an incentive to get participants to follow through with the study to the end, such as possibly offering a payment or reward which they only receive after completing this final knowledge assessment. This is because some participants forgot or couldn't be bothering to reply to the final email.

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Appendix

Appendix A: Knowledge Assessment Plan

(Correct answers are in red.)

Knowledge Assessment

Please close the game or the alternative revision material if you have it open before attempting this.

What stage are you in the study?

- I haven't either played the game or read the alternative revision material yet.
- I have just finished either playing the game or reading the alternative revision material.
- It has been a day since I last either played the game or read the alternative revision material.

"_____" means that outcomes aren't predetermined.

- Choice
- Consequence
- Predictability
- Variety
- Uncertainty
- Satisfaction

"_____" means that desirable actions are attainable.

- Choice
- Consequence
- Predictability
- Variety
- Uncertainty
- Satisfaction

When a player is thinking on what they are about to do before they do it, what are they exploring?

- Choice
- Consequence
- All of the above
- Neither of the above

Having annoyingly placed invisible walls is an example of poor implementation of which two playspace heuristics?

- Choice
- Consequence
- Predictability
- Variety
- Uncertainty
- Satisfaction

"_____" means that horizons aren't repeated.

- Choice
- Variety
- All of the above
- Other (lets users enter their own words)

If you want your player to always know how far a character should be able to jump, then game controls should "_____"

- have consequence
- be predictable
- be not uncertain

The outcome of a choice is what?

- An action
- A consequence
- A certainty
- Meaningless

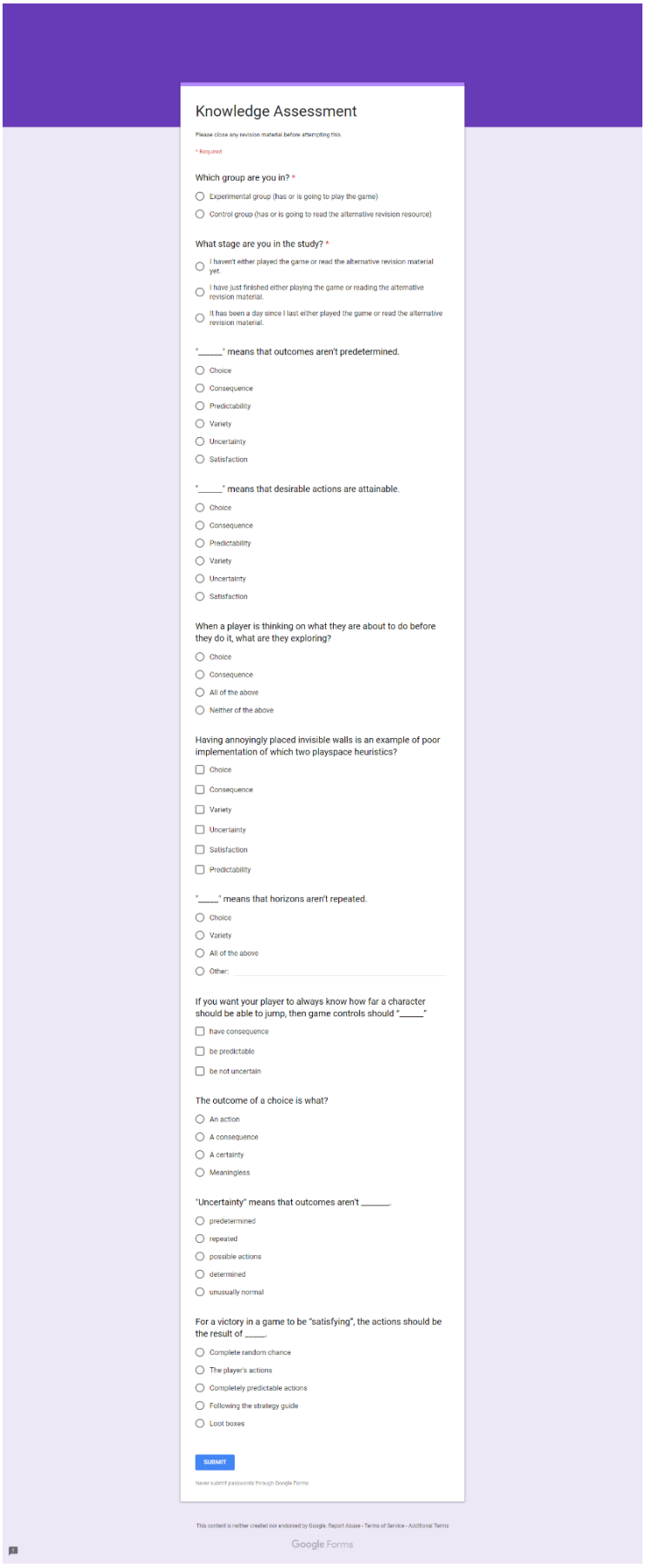
"Uncertainty" means that outcomes aren't _____.

- predetermined
- repeated
- possible actions
- determined
- unusually normal

For a victory in a game to be "satisfying", the actions should be the result of _____.

- Complete random chance
- The player's actions
- Completely predictable actions
- Following the strategy guide
- Loot boxes

Appendix B: Knowledge Assessment



Knowledge Assessment

Please close any revision material before attempting this.

* Required

Which group are you in? *

- Experimental group (has or is going to play the game)
- Control group (has or is going to read the alternative revision resource)

What stage are you in the study? *

- I haven't either played the game or read the alternative revision material yet.
- I have just finished either playing the game or reading the alternative revision material.
- It has been a day since I last either played the game or read the alternative revision material.

"_____" means that outcomes aren't predetermined.

- Choice
- Consequence
- Predictability
- Variety
- Uncertainty
- Satisfaction

"_____" means that desirable actions are attainable.

- Choice
- Consequence
- Predictability
- Variety
- Uncertainty
- Satisfaction

When a player is thinking on what they are about to do before they do it, what are they exploring?

- Choice
- Consequence
- All of the above
- Neither of the above

Having annoyingly placed invisible walls is an example of poor implementation of which two playspace heuristics?

- Choice
- Consequence
- Variety
- Uncertainty
- Satisfaction
- Predictability

"____" means that horizons aren't repeated.

- Choice
- Variety
- All of the above
- Other: _____

If you want your player to always know how far a character should be able to jump, then game controls should "_____"

- have consequence
- be predictable
- be not uncertain

The outcome of a choice is what?

- An action
- A consequence
- A certainty
- Meaningless

"Uncertainty" means that outcomes aren't _____.

- predetermined
- repeated
- possible actions
- determined
- unusually normal

For a victory in a game to be "satisfying", the actions should be the result of _____.

- Complete random chance
- The player's actions
- Completely predictable actions
- Following the strategy guide
- Loot boxes

SUBMIT

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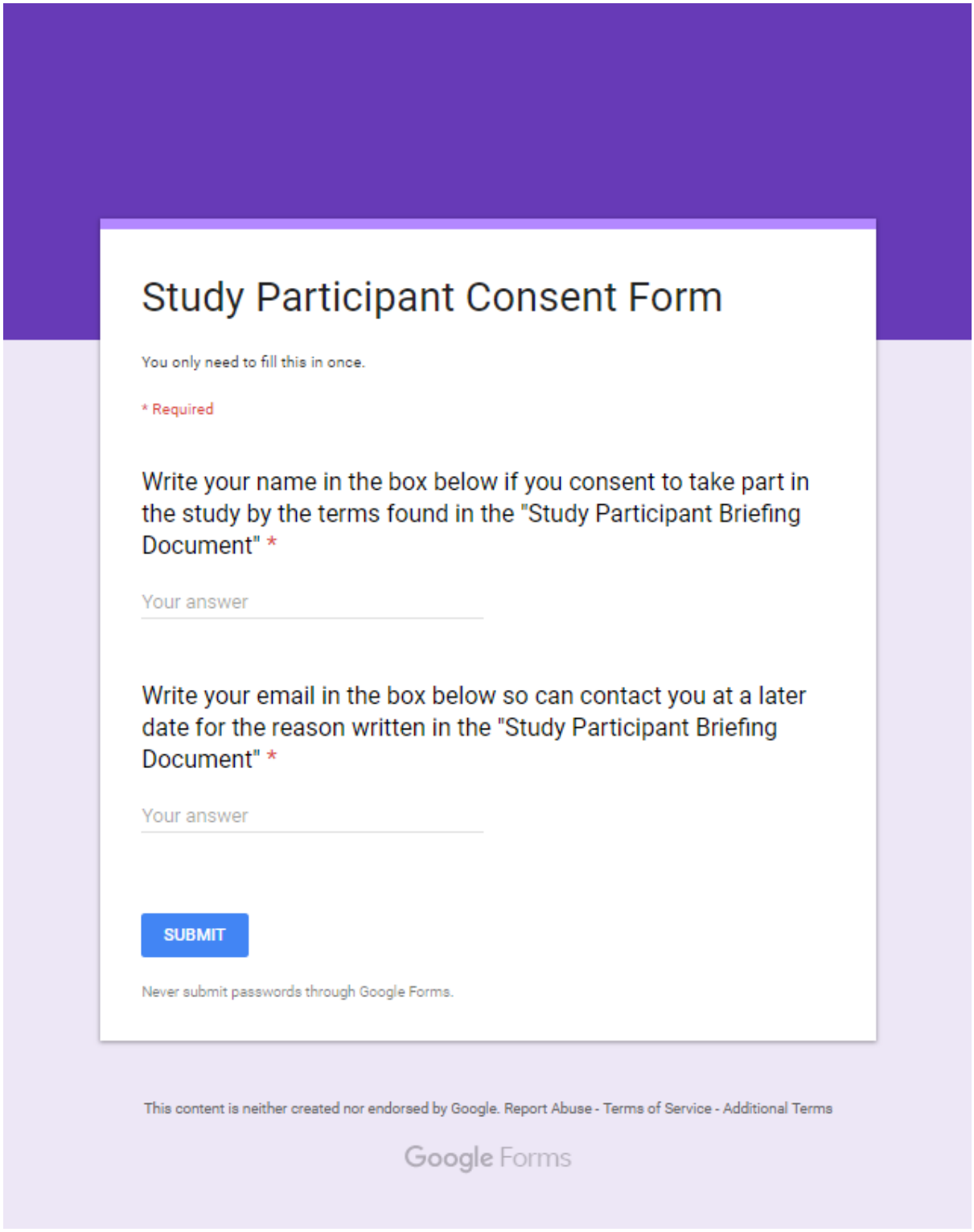
Appendix C: Study participant consent form



Study Participant Consent Form

You only need to fill this in once.

* Required

Write your name in the box below if you consent to take part in the study by the terms found in the "Study Participant Briefing Document" *

Your answer

Write your email in the box below so can contact you at a later date for the reason written in the "Study Participant Briefing Document" *

Your answer

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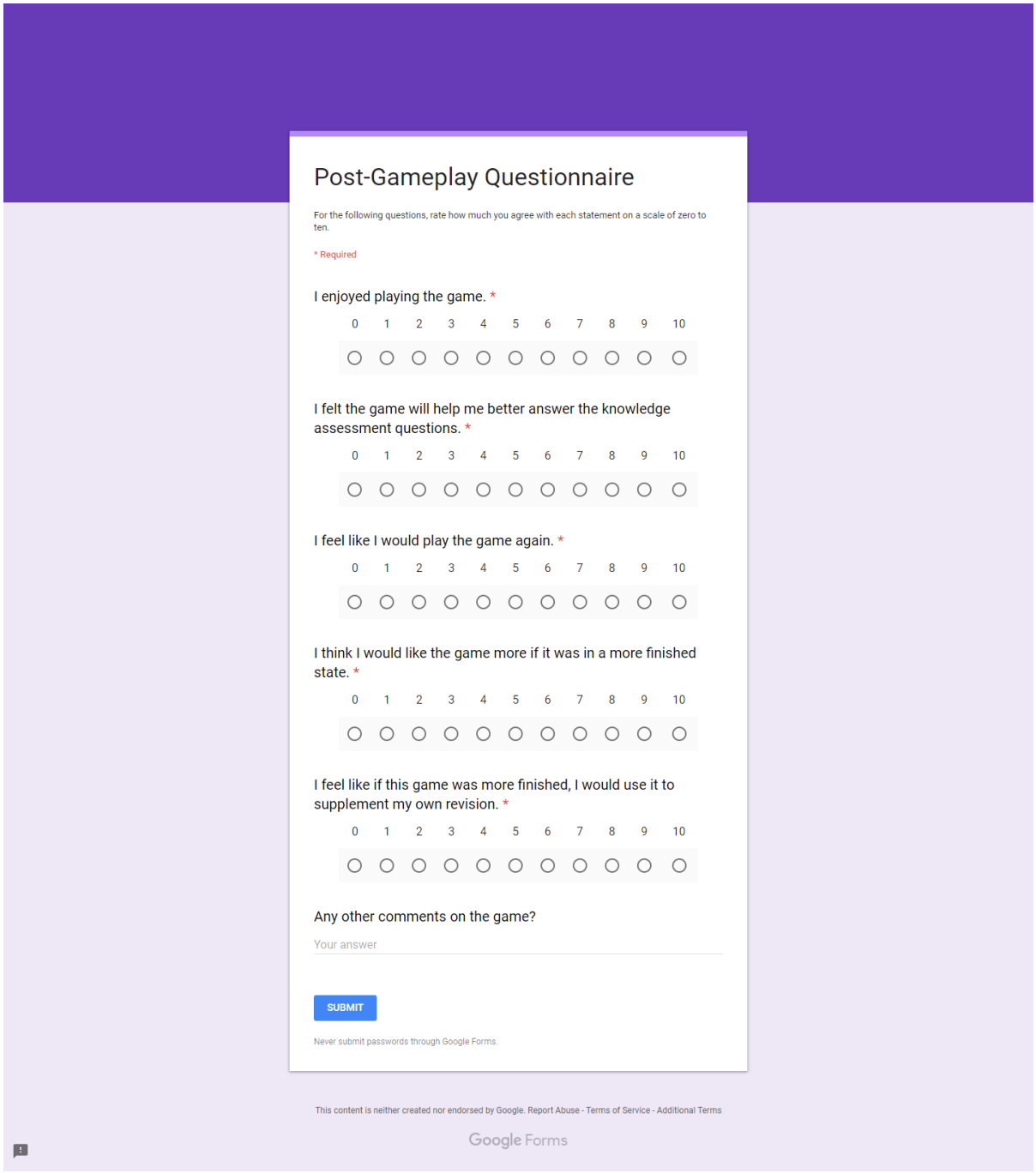
Appendix D: Post-Gameplay Questionnaire



Post-Gameplay Questionnaire

For the following questions, rate how much you agree with each statement on a scale of zero to ten.

* Required

I enjoyed playing the game. *

0 1 2 3 4 5 6 7 8 9 10

I felt the game will help me better answer the knowledge assessment questions. *

0 1 2 3 4 5 6 7 8 9 10

I feel like I would play the game again. *

0 1 2 3 4 5 6 7 8 9 10

I think I would like the game more if it was in a more finished state. *

0 1 2 3 4 5 6 7 8 9 10

I feel like if this game was more finished, I would use it to supplement my own revision. *

0 1 2 3 4 5 6 7 8 9 10

Any other comments on the game?

Your answer

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Appendix E: Alternative Revision Resource

Alternative Revision Resource

This revision resource should contain all the information you would learn by playing the game, but in a text form. Most of these are copied directly out the game and reference objects found in the game.

Choice

To have "choice" is to offer a range of possible actions.

Importance of Choice

It is important that a game has choice, even if it is menial, to make the player feel like they have a purpose in the game world. Because of this, a game can develop a connection with a player on a deeper level because the player is both observing, and acting.

Non-Meaningful

Forcing the player to make a seemingly unmeaningful choice can be a pointless (yet quirky) endeavour at best, and at worst may leave them feeling their time has been wasted. If you do want to make a game with a lot of meaningless choices / customisation in it, perhaps give the player the option to skip them or make them optional.

Meaningfulness

Of course, there are situations where a choice which has no meaning in the grand scheme of the game is a good choice to give; for example, asking the player what colour they would like the carpet in their house, or what fruit should be in the fruit bowl. Giving players these choices can help the places which are supposed to be home to them are as personal to them as their real home.

Replayability

Games, as an interactive medium are in a special in that unlike a book when reread or a movie when rewatched, a game when replayed can be different. Part of the differences between playthroughs can be choice (the part being randomness, or uncertainty). For example, having choices lock-out other story branches extends the life of the game and keeps the player coming back to experience the game differently.

Choice or Consequence?

When a player is exploring meaningful choices, they are reflecting on what they are about to do before they do it and thinking it through. Much like how I just made you decide whether to take the left route or the right route, you knew the outcome of the decision beforehand. In the next example, you won't know the consequences, you will just have to make the choice.

Consequence

"Consequence" means that actions have outcomes.

Choices with unknown consequences

Sometimes, the player will need to make a choice (consciously or otherwise) which will have unforeseen consequences. These choices may seem meaningless at the time, but can have big repercussions later. This is similar to the butterfly effect, where even a small change in the initial conditions can result in a large difference down the line. When a game is exploring meaningful consequences, they usually don’t let the player know the decision that will create these

consequences beforehand: much like in real life, you don't know the outcome of all actions before taking them.

Predictability

"Predictability" means outcomes can be anticipated.

Satisfying and Predictable Invisible Walls

In real life, as long as there is nothing blocking your path, you can generally walk anywhere you'd like to. In games, we need to limit the possible places the player can go to keep them on route in a limited world (unless your game doesn't have a "route" or a "limit", like Minecraft or No Man's Sky). In many cases, you can reduce the need for invisible walls by employing many different techniques that are much more satisfying and less jarring to players. Alternatives include: Using a physical body to give an in-world representation of why the player can't get there such as small wall or locked door; making use of "fatigue" mechanics such as those seen in World of Warcraft; make your player character unable to swim like in early GTA games; or more "active deterrents" such as unkillable mobs which instantly kill the player. Invisible walls with no physical barrier, like the ones surrounding the water here, can feel unsatisfying to a player when they expect they would be able to explore the area. Some players may even take it as a challenge to try to break out of the area, but this will draw the player out of the experience of the game.

Predictable Controls

Most developers aim for their games to be easy to pick up, but hard to master. One way to reduce the amount of time it takes a player to pick up the game is to map the controls in a way which is recognisable to the player. This seems obvious – everyone knows WASD is for movement, mouse is for looking around, space is for jumping and hold shift to sprint. However, some developers stray from this norm, which is perfectly acceptable if the circumstances dictate it. However, if you bind sprint to "Alt" by default, like The Elder Scrolls: Skyrim did, expect me to complete the game without ever knowing I could sprint.

Satisfaction

"Satisfaction" means that desirable actions are attainable.

Satisfying Choices

Having too much or too little choice can also limit the amount of satisfaction that a game can give. For example, a game giving little choice can become boring, while a game giving lots of choice can become confusing. However, a game can be boring and still satisfying, such as when a player replays an old favourite, they may find themselves making few meaningful decisions, but finding enjoyment in it nevertheless. Also, a game can be confusing and still satisfying; when a player encounters a new game, they won't have constructed an idea of what the limits of potential actions are, without any idea of the consequence of these choices. If the stumbling leads to some positive outcomes, they may still feel satisfied by the experience.

Satisfying Games

For a game to be satisfying, desirable outcomes should be attainable. This doesn't necessarily mean an easy game is satisfying, because we must also have the impression that the "victory is the result of our own skill and not just random chance", as Brian Upton writes it in his book "The Aesthetic of Play". It should be noted that in playspace heuristics, it is thought that the opposite of "satisfaction" is "frustration".

Satisfying Interactions

It is very important to remember that in playspace heuristics, the opposite of “satisfaction” is “frustration”, not “unsatisfying”. However, things can feel frustrating if there is no noticeable consequence on the game world for doing it. For example, when you look at (and hopefully read) these notes, a sound plays, the lighting of this stand changes colour and you get a sort of collectable / achievement. This feels significantly more of an accomplishment then if nothing happened at all. All games make use of sound and particle effects to make things feel satisfying, so when you test your game in development and it doesn’t feel to satisfying, try fine-tuning these features.

Uncertainty

"Uncertainty" means that outcomes aren’t predetermined.

Variety

"Variety" means that horizons aren’t repeated.

Variation and patterns

In real life, it is unlikely that torches would flicker all at the same time. Variation and randomness would help these wall torches seem a little more real.

Repeating Patterns

Humans are very good at noticing patterns, yet most real-world materials do not repeat perfectly. For example, these floor tiles are broken and damaged, making them seem more realistic then a consistent repeating pattern.

Easy Variation

Custom broken floor tiles and per instance torch randomisation seem too time consuming? There are quick tricks to variation too! For example, did you notice these mountains in the background are just the same mountain rotated or rescaled? Took less than a minute, and is probably good enough that most people wouldn't know. Except you, now. Hmm.

Variety in Environments

Changing up the environment is another example of variety in games. If the entirety of the game looks pretty much the same, it will not only make the player feel like they aren’t going anywhere (which is fine, if that is the feeling you’re going for) but in larger games it is important that areas feel different to make them memorable.

Appendix F: Study Participant Briefing Document (Control Group)

Control Group

Study Participant Briefing Document

Hello, thank you for taking the time to see if you want to help me by being part of the control group or experimentation group of my dissertation project! The following document should help me explain what I would like you to do and if you're interested, what I'm trying to find out.

Who am I?

I am Christopher Lee, a third year doing his dissertation project which is titled "A Game to Teach Games Design". I can be contacted via my email "15563252@students.lincoln.ac.uk". My supervisor is Jussi Holopainen.

What I'm trying to find out:

My dissertation is trying to find out **if it is possible to create a game which helps with the revision of a games design principle** (and also if it is practical). To do this, I have created a game, which teaches the "playspace heuristics" as described by Brain Upton (the designer of Rainbow Six and Ghost Recon) in his book "The Aesthetics of Play". These might have been taught to you during your time on the Games Design course at the University of Lincoln.

Benefits / Risk of participating:

A benefit is you might learn or relearn something about playspace heuristics. There is no risk other then I waste your time a little. The tests will take 5 – 10 min each and the playing of the game takes as long as you want, but will probably take no longer than 15 minutes. In total, it will probably take 15 – 30 minutes. The most personal information I will have from you is your name and email address, which will be destroyed at the end of the project. All other data will be anonymous, even to me. You have the right to withdraw from the study at any time and for any reason. This research project has been reviewed and approved by the university ethics committee.

What I want you to do:

Consent Form

Firstly, you need to sign the consent form if you haven't already. It will only ask for your name (as a signature to verify your consent to take part in this study) and your email address (so I can send you the knowledge assessment again in a week to test if your knowledge of the has been retained). The consent form can be found on Google Docs here:

https://docs.google.com/forms/d/e/1FAIpQLSdOsrn4iuqfSgPdmUo1ClL52JjzNoSX68XM6ZxXp_9gwgdLKw/viewform

Knowledge Assessment

Next, I will need you complete the knowledge assessment. This is a short "exam" just to find out how much you know before you play the game I have created. Please select "I haven't either played the game or read the alternative revision material yet." for the answer to the first question. This can be found here:
https://docs.google.com/forms/d/e/1FAIpQLSeHk6pB5jClfxU4Z66CGod38AGH9HazvTWrBQP08uOjZ2ty-Q/viewform

Control Group

Alternative Revision Resource

Next read this alternative revision resource. It's a text file that should tell you everything you would find out by playing my game.

https://drive.google.com/open?id=1Mi0IYUZCfYvHRgVMOye-pie2cVqfWlCK

Second Knowledge Assessment

Next, I will need you complete the knowledge assessment again. Please select "I have just finished either playing the game or reading the alternative revision material." for the answer to the first question. This can be found here:

https://docs.google.com/forms/d/e/1FAIpQLSeHk6pB5jCIfxU4Z66CGod38AGH9HazvTWrBQP08uOjZ2ty-Q/viewform

Third Knowledge Assessment

After a day, I will contact you with the email address supplied in your consent form. This will just be a link to do the knowledge assessment again. This time you will need to select "It has been a day since I last either played the game or read the alternative revision material." If you don't receive the email, the link can be found here:

https://docs.google.com/forms/d/e/1FAIpQLSeHk6pB5jCIfxU4Z66CGod38AGH9HazvTWrBQP08uOjZ2ty-Q/viewform

Thank you for participating in my dissertation project!

Appendix G: Study Participant Briefing Document (Experimental Group)

Experimental Group

Study Participant Briefing Document

Hello, thank you for taking the time to see if you want to help me by being part of the control group or experimentation group of my dissertation project! The following document should help me explain what I would like you to do and if you're interested, what I'm trying to find out.

Who am I?

I am Christopher Lee, a third year doing his dissertation project which is titled "A Game to Teach Games Design". I can be contacted via my email "15563252@students.lincoln.ac.uk". My supervisor is Jussi Holopainen.

What I'm trying to find out:

My dissertation is trying to find out **if it is possible to create a game which helps with the revision of a games design principle** (and also if it is practical). To do this, I have created a game, which teaches the "playspace heuristics" as described by Brain Upton (the designer of Rainbow Six and Ghost Recon) in his book "The Aesthetics of Play". These might have been taught to you during your time on the Games Design course at the University of Lincoln.

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A benefit is you might learn or relearn something about playspace heuristics. There is no risk other then I waste your time a little. The tests will take 5 – 10 min each and the playing of the game takes as long as you want, but will probably take no longer than 15 minutes. In total, it will probably take 15 – 30 minutes. The most personal information I will have from you is your name and email address, which will be destroyed at the end of the project. All other data will be anonymous, even to me. You have the right to withdraw from the study at any time and for any reason. This research project has been reviewed and approved by the university ethics committee.

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Knowledge Assessment

Next, I will need you complete the knowledge assessment. This is a short "exam" just to find out how much you know before you play the game I have created. Please select "I haven't either played the game or read the alternative revision material yet." for the answer to the first question. This can be found here:

https://docs.google.com/forms/d/e/1FAIpQLSeHk6pB5jCIfxU4Z66CGod38AGH9HazvTWrBQP08uOjZ2ty-Q/viewform

Experimental Group

Play the game

Now you can play the game. Please note, it can be very buggy and is nowhere near complete. Occasionally, you may be teleported into nowhere. If this happens, restart the game. If you come across a sign telling you that "this is the end of this part of the demo" (such as the one pictured below) try going down one of the other paths in the main room until you experience them all.

This can be found here: https://drive.google.com/open?id=1xh0qtCWxlzCsyzhCEtjR7bVEwLwYG8eN

Post-Gameplay Questionnaire

This will ask you about your experience with the game. It can be found here:

https://docs.google.com/forms/d/e/1FAIpQLSdW3C91HM88PRLb5gZuhTmJ6sr6K7eWEh7de3MWDgIj6sQ27g/viewform?usp=pp_url&entry.302611429

Second Knowledge Assessment

Next, I will need you complete the knowledge assessment again. Please select "I have just finished either playing the game or reading the alternative revision material." for the answer to the first question. This can be found here:

https://docs.google.com/forms/d/e/1FAIpQLSeHk6pB5jCIfxU4Z66CGod38AGH9HazvTWrBQP08uOjZ2ty-Q/viewform

Third Knowledge Assessment

After a day, I will contact you with the email address supplied in your consent form. This will just be a link to do the knowledge assessment again. This time you will need to select "It has been a day since I last either played the game or read the alternative revision material." If you don't receive the email, the link can be found here:

https://docs.google.com/forms/d/e/1FAIpQLSeHk6pB5jCIfxU4Z66CGod38AGH9HazvTWrBQP08uOjZ2ty-Q/viewform

Thank you for participating in my dissertation project!

Appendix H: Knowledge Assessment Results (Control Group)

Note: IDs were added to make this, and the following table, more readable. It was possible to assign IDs to each participant as there was only ever one participant actually doing the study at a time, which can be seen by the timestamps.

Timestamp	Score	Stage	ID
4/7/2018 20:41:26	3 / 9	Before Revision	Anon 1
4/7/2018 21:11:16	7 / 9	After Revision	Anon 1
4/7/2018 21:12:32	5 / 9	Before Revision	Anon 2
4/7/2018 21:20:23	5 / 9	After Revision	Anon 2
4/8/2018 18:19:54	6 / 9	Before Revision	Anon 3
4/8/2018 18:22:40	6 / 9	After Revision	Anon 3
4/9/2018 14:31:50	3 / 9	Before Revision	Anon 4
4/9/2018 14:39:39	7 / 9	After Revision	Anon 4
4/9/2018 18:05:21	7 / 9	Before Revision	Anon 5
4/9/2018 18:10:55	8 / 9	After Revision	Anon 5

ID	After Revision Improvement (Score)
Anon 1	4
Anon 2	0
Anon 3	0
Anon 4	4
Anon 5	1
Mean Individual Improvement	**1.8**

Due to slowness / lack of response from the participants for the final knowledge score (probably due to them being given by emails), it is impossible to match each participant to their final knowledge assessment score. Most of the responses that *did* arrive for the final knowledge assessment were more than a day after they had completed the previous one, which should be considered when considering the validity of this data.

Timestamp	Score
4/10/2018 17:53:10	8 / 9
4/16/2018 16:23:17	6 / 9
4/16/2018 16:57:02	5 / 9

Appendix I: Knowledge Assessment Results (Experimental Group)

Note: IDs were added to make this, and the following table, more readable. It was possible to assign IDs to each participant as there was only ever one participant actually doing the study at a time, which can be seen by the timestamps.

Timestamp	Score	Stage	ID
5/2/2018 1:50:50	7 / 9	Before Revision	Anon 6
5/2/2018 2:19:10	7 / 9	After Revision	Anon 6
5/5/2018 10:19:57	9 / 9	After Revision	Anon 7
5/5/2018 15:10:51	3 / 9	Before Revision	Anon 8
5/5/2018 15:21:57	5 / 9	After Revision	Anon 8
5/5/2018 15:25:49	4 / 9	Before Revision	Anon 9
5/5/2018 15:41:46	6 / 9	After Revision	Anon 9

Also note: Anon 2 forgot to take the pre-revision knowledge assessment. There results won't be counted. This is a disadvantage of allowing study participants to participate unsupervised.

ID	After Revision Improvement (Score)
Anon 6	0
Anon 7	N/A
Anon 8	2
Anon 9	2
Mean Individual Improvement	**1.333**

Due to slowness / lack of response from the participants for the final knowledge score (probably due to them being given by emails), it is impossible to match each participant to their final knowledge assessment score. There was only one responses for the final knowledge assessment in this group.

Timestamp	Score
5/4/2018 7:43:11	8 / 9

Appendix J: Game development log

Game Development Log

28/11/17

- I chose “Playspace Heuristics” as the gameplay principle to teach. This is because I feel it could be best translated to a game and there are few enough of them that I would have enough time to fit them into a game.

12/12/17

- Work begins on the game in Unreal Engine 4. This is chosen because of:
    - my familiarity with it
    - large community support with lots of tutorials making it easier to learn how to do more specific things
    - large compatibility, meaning the game can be easily ported to different platforms
    - its free license allows me to publish and distribute the game
- I created the main room, based on some sketches of ideas I created earlier. I created a lectern with a customisable screen on it which could be used to display information about how the game works to the user as they spawn in this room, and later as a method to help the player understand what I’m trying to teach them through the gameplay.
- I decided that the segments of the game for each of the “Playspace Heuristics” will be called “exhibits” to make the experience feel like you’re in some sort of weird museum.
- I decided to go for a simplistic design for the main parts of the museum, not only because it saves on the amount of artwork that needs to be created, but also allows for more juxtaposition later in a segment in one of the Variety exhibits (mentioned below).
- This segment will consist of the player walking through a variety of completely different environments, and then it will be pointed out to the player that despite the environments being quite different, the way they moved through them (walking in a straight line) itself is quite boring, and it can be good for the designer to vary both environments and also how they can traverse them.
- I added the free “StarterContent” pack from Unreal Engine 4 to make use of its premade models, materials and textures.
- I added the free “InfinityBladeGrassLands” Pack from the UE4 Marketplace to make use of its premade models and materials in the segment discussed above.
- I made a lectern model and associated materials.

16/01/18

- Looking at the way the map is currently designed, I think it would be best to secretly teleport the player between segments. This is also beneficial because it means I can restructure the order which the exhibits are played at any point in development (the same reason it was used in Portal 2’s development, apparently).
- I chose to include FreetimeStudio’s portal plugin which can be found here https://github.com/FreetimeStudio/PortalPlugin. It is used under the MIT licence.
- Started on the dock area of the Variety exhibit including a dock area.

17/01/18

- I think that each of the playspace heuristics should have their own icon / logo. This will make them hopefully easier to remember, and they could act as a logo / common theme

throughout the game, appearing on the lecterns in the game and above each route. These will be:
    - Choice – A "split arrow" signifying multiple paths
    - Variety – A grid of different shapes
    - Consequence – Dominos toppling
    - Predictability – Sun rising, something which is said to be predictable
    - Uncertainty – A question mark
    - Satisfaction – A smiling face showing happiness
- I think the lecterns should have some sort of effect which attracts the player's attention to them more than just the lit-up screen. It is currently very easy to miss one in the dock area of the variety exhibit.
- I may some sort of tracker for all of the currently found tips. This may incentivise players to try to find all of the tips in the game.
- I fixed the portal going from the main room to the dock area and it is now fairly seamless. This was done by integrating bits from the Simple Portals tutorial.[5]
- I think the next zone the player should go to after the dock area should be a cyberpunk city sort of theme, so I can talk about variety of setting / location. I downloaded:
    - "Sci-fi gate Game ready Free VR / AR / low-poly 3D model" by "onur özen"[6]
    - "Roller Shutters rigged animated Free VR / AR / low-poly 3D model" by "dennish2010"[7]
    - "Rusted Iron PBR Metal Material" by Free PBR Materials[8]

18/01/18

- To make the player want to read all the lecterns, they now glow a different colour and emit a particle effect when they haven't been read and fade out when the lectern is looked at / read. They also make a noise to attract the player to them, as well as make a noise when they are read. These sounds (the looping sound and the read sound) are used with the permission of their creator, Lewis Cooper. He also allowed me to use the 3 sliding door sounds.
- I got the icons for "Choice" and "Uncertainty" from Icons8.com.
- I implemented a push-button, and a system for the player to push buttons. The pushing button icon also came from Icons8.com.
- I started work on the choice area. The player will need to:
    - Choose between an apple and a banana which will show that choices should be meaningful, both in the sense the player should care about them, and also that the outcome is meaningful (the player goes to the same place no matter which these choose).

19/01/18

- I merged the choice and the consequence area because I feel these are best taught at the same time, I may end up doing this to the predictability / uncertainty areas too.
- I adjusted the lecterns as the original design lacked enough room to have the amount of information I'm currently adding to them on the screen.

[5] https://wiki.unrealengine.com/Simple_Portals
[6] https://www.cgtrader.com/free-3d-models/exterior/sci-fi/scifi-gate-game-ready
[7] https://www.cgtrader.com/free-3d-models/architectural/door/roller-shutters-rigged-animated
[8] https://freepbr.com/materials/rusted-iron-pbr-metal-material/

- Some of the lecterns I wrote in the choice and consequence section were inspired by this video: https://www.youtube.com/watch?v=7iklM_djBeY

22/01/18

- Added a thought unlocked popup, like an achievement popup
- Added a basic thought / achievement viewer (on TAB key)

30/01/18

- More fixes to portals

31/01/18

- Wrote about satisfaction
- Started work on satisfaction area
- Added a basic pause menu

03/02/18

- Tweaked the game building procedure to reduce the size of the game from about 1.5GB to 1GB.

04/02/18

- Built a system to associate gameplay heuristics with thoughts.

11/02/18

- Removed the first-person character animations from the example which were not being used.
- Added pickup-able apples to the predictability section.

12/02/18

- Predictability apples can now be picked up, change colour and also jump off the table.

19/02/18

- Fixed sliding doors to make them less noisy.
- Game should only cook assets that exist in a map now, which reduced the total size down from about 1GB to 400MB.
- Added a placeholder texture.

20/02/18

- Started work on a “small thought viewer” which will be a way of displaying information to the player without them having to look at a lectern.

21/02/18

- Added a UMG widget for the small thought viewer.

22/02/18

- Finished the small though viewer.

23/02/18

- "Achievement" widget will now clear off any existing heuristics before adding new ones.
- Added an example small thought.

24/02/18

- Fixed a z-clipping issue in the port area and wall torches not flickering as well as many other minor bugs.

25/02/18

- Added animations to the small thought system.
- Fixed a bug with the sliding doors.
- Updated the glass texture to refract sensibly.

02/03/18

- Added first batch of Icons8 and icons by Mumble.

03/03/18

- Players can now sprint.
- Added new icons.

04/03/18

- Added more meta thoughts and some icons for some of the meta thoughts.
- Fixed the problem of not being able to spawn the object picker when you can't see the spawn.

05/03/18

- Added batch building files so the game can be built more reliably.

06/04/18

- Added some music and final touch-ups on the game.
- Built the game for play-through with study participants.

Appendix K: Post gameplay questionnaire results

Timestamp	I enjoyed playing the game.	I felt the game will help me better answer the knowledge assessment questions.	I feel like I would play the game again.	I think I would like the game more if it was in a more finished state.	I feel like if this game was more finished, I would use it to supplement my own revision.	Any other comments on the game?
5/2/2018 2:15:49	5	7	4	9	10	no
5/5/2018 15:39:27	10	8	6	8	8	
5/6/2018 9:00:27	6	6	4	10	7	I think it needs to implement more ‘show not tell’, there was good examples already but there was still a lot of looking at boards with lots of text