UFCFHQ-45-3 Comprehensive Creative Technology Project Research Documentation

Connor Easterbrook

THE UNIVERSITY OF THE WEST OF ENGLAND

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Student Name:	Connor Easterbrook
Student Number:	18015101
Project Title:	Evolving Video Games with Complementary Geometries: Non-Euclidean Level Design

1. Main research questions

"To what extent does geometry affect a video game's synergy between game genre and level design? How does this affect the video game's creation?"

- What is non-Euclidean geometry?
- What video game engine should I develop my projects in?
- How does non-Euclidean geometry change the dynamics of a video game?
- Does having more options geometrically make level design easier or more complex?
- Are there new considerations to take in mind when working with different geometries?
- What genres are the most compatible with different geometries?
- Would non-Euclidean video games be appealing to a casual audience?

2. Research methodology

2.1. How and why were the research sources chosen?

Deciding the reliability of a research source came down to a four-step checklist that can be seen below. Only if each check confirmed to be true was a research source included in the project's research.

Keyword	Description
Relevance	How relevant is this to the current question? Does it suit the needs?
Accuracy	How accurate is this information? Is it backed up by other references?
Trustworthy	Is the source known for factual information? What is the academic view of the source?
Purpose	For what reason does this source exist? Is it to inform?

Figure 1. Source reliability checklist. From 'CCTP Pre-Production & Research Document'

2.2. Are there any research sources that can be considered to be "secondary research?"

The number of research sources considered to be possibly "secondary research" would be around a quarter of the total research. Even then, It is debatable whether these could be considered "secondary research" as they each contain their own findings and research that has proven invaluable to the project as standalone pieces.

2.3. Could there be a bias in research outcomes?

Whether due to choice or application, there is always a chance that bias could lead to one research source being selected over others. This research bias, if any, would only lead to a project decision that would hold no real bearing over the project's goals, as the project is more practical than theoretical. I do not believe this to be an issue regarding the project's validity, as the question that the overall project aims to answer can only be answered through the deliverable end product. This end product would have been produced through rigorous testing and built upon the experience and knowledge gained from the failed subprojects, meaning that research bias would cause no real effect to the end product.

3. Ethical and professional principle

3.1. Could this project generate any ethical concerns?

It is not believed that this project could generate any ethical concerns as there are no parties involved other than the project creator. In addition to this, the project is not breaching upon any topics that could be deemed offensive to some, nor is it involving any information regarding to an individual.

3.2. Could this project negatively impact individuals?

It is not believed that this project could negatively impact individuals as it is not producing anything that can be considered contradictory to any beliefs. The only aspect that an individual could disagree with would be the stances made on the video game's geometry, genre, and level design combinations. But, the project's deliverables would be based purely on the project creator's opinion and not passed off as factual, so if an individual were to disagree, it would only be a disagreement in opinions.

3.3. Research sources that include media

Referring to research sources sometimes is not as simple as just citing the source and adding it to the bibliography. Sometimes, there are a specific bit of media that might be/is protected by a license. In cases like these, where the license can be found or is unknown, it is essential to receive the author's permission before using the media reference. This piece of media could be in the forms of a figure, table, image, video, etc. If the author can not be contacted then it was decided to find another source with a piece of media that achieves the same thing, again attempting to receive permission. Asking for permission may not be deemed essential due to most licenses allowing for the use of the media in

educational usage but that then leaves an ethical conundrum if the project creator wished to publish their work, or include it in their professional portfolio.

4. Literature review

With the focus on the most relevant reading materials / professional practices relevant to this project, four particular groups encompass most of the theoretical and practical requirements of the project.

4.1. Geometry

Geometric knowledge is essential to appropriately utilize and understand the topic.

[1]Artmann's (2020) book 'The Elements' goes into comprehensive detail regarding the history, significance, and mathematics of Euclidean Geometry. This forms the project's basic geometric understanding.

Non-Euclidean geometry, the basis upon which this project is centred, encompasses all "abnormal" geometries.

[2]Wolfe (2013) discusses what makes non-Euclidean geometry, detailing the most known types. Information from non-Euclidean geometry expands the project's possible work directions.

[3]Henderson (2020) details how a 'non-Euclidean' geometry is simply a geometry that differs from Euclidean geometry. Supporting the notion that non-Euclidean illusions can create a non-Euclidean video game.

 [4]Papadopoulos' (2014) book 'On the works of Euler and his followers on spherical geometry' discusses the history and mathematics of spherical geometry, going into comprehensive detail. Expanding the project's knowledge on spherical geometry.

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[5]Gowers (2002) discusses how spherical geometry violates three of Euclid's postulates whilst remaining "correct" mathematically. Explains how non-Euclidean geometries can go against the norm and remain mathematically correct.

[6]Szecsei's (2004) book 'The Complete Idiot's Guide to Geometry' provides a mathematical breakdown of Spherical Geometry. Useful knowledge for spherical mathematics that may appear within subprojects.

[7]Comment (2016) explains hyperbolic geometry in a readable way, covering history, mathematics and visual theory. Expanding the project's knowledge on hyperbolic geometry.

[8]Sommerville (1914) comprehensively discussed elliptical geometry, its origin, and the mathematics that form it. Allows the project to explore, and take inspiration from, a lesser-known geometry.

4.2. Video game theory

[9]Swink (2008) wrote a book called 'Game Feel: A Game Designer's Guide to Virtual Sensation,' which covers topics like the role of sound, ancillary indicators, the importance of metaphors, perception, and a brief history of video games and their "feel."

4.3. Video game development

The core concept of a game development project is described by [10]Laramée (2007, p.191), as "creating what the game is going to be out of thin air". Also discussing the conception, production, development, and marketing of video games in thorough detail. This is useful for creating a marketable deliverable.

[11]Greenberg et al. (2008) detail the statistics and correlations of video game preference with

gender and age. The blind study showcases the ideal development routes to take depending on the target audience, boosting the project's marketability.

[12]Limelight (2021) delves into comprehensive detail on the present video game industry and discusses just what specific audiences want from their video games, and their average video game playtime. This source is of great help to understand the current climate of the video games industry.

4.4. Coding

Research material that focuses on practical use would be found more commonly in related projects with open-source code, than in a published piece of literature. With this in mind, it was decided to focus on projects by [13, 14]Lague (Lague (2020) and Lague (2016)) as they both involve non-Euclidean work within Unity and serve as a good reference of these geometries in use. Specifically, one of which focuses on spherical geometry, while the other focuses on portals that can be used in a hyperbolic context.

5. Research findings

This section will discuss the summarised version of relevant findings from the given research sources.

[1]Artmann (2020) allowed for individuals who are not mathematicians to clearly understand Euclid's postulates and understand beyond a basic level what distinguishes Euclidean geometry. This is useful to establish the true bounds of Euclidean geometry.

It was found that [2]Wolfe (2013) taught individuals about popular non-Euclidean geometries, breaking them down in a way that formed a detailed understanding of the theory. This theory could then be projected onto shapes within the

given geometry and understood. An example of this would be how a hyperbolic square can lead to an infinite number of rooms if an individual continued to go through the right side.

[3]Henderson (2020) offered his understanding that so long as an appropriate postulate of Euclidean geometry is altered, the new geometry can be considered non-Euclidean as it is not a duplicate of Euclidean geometry. Meaning, a video game level can be completely Euclidean but if a core component breaches the standardised understanding of geometry, it can be considered a non-Euclidean video game.

[4]Papadopoulos (2014) offers to teach about the mathematical basis of spherical geometry and its real-world applications. This is useful as the information given can significantly aid a video game based on a spherical object, or spherical geometry.

[5]Gowers' (2002) understanding of the mathematics behind geometric systems allowed him to break down his knowledge of spherical geometry in a teachable way. From this, it was found out how non-Euclidean geometries remain mathematically correct, even though they contradict Euclidean geometry.

The breakdown of spherical triangles was learned from [6]Szecsei's (2004) work, expanding spherical geometry-based knowledge. Specifically, how to correctly draw triangles on a spherical object, and that the interior angles would total to a value less than one-hundred and eighty degrees.

[7]Comment's (2016) written overview of hyperbolic geometry teaches about hyperbolic triangles and the understanding of hyperbolic shapes. The readability of the research source aids hyperbolic understanding as it was written at a student level. The knowledge gained will be utilised in

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regards to three-dimensional hyperbolic level design.

[8]Sommerville's (1914) breakdown of elliptical geometry, while not directly useful to the project as elliptical geometry was excluded, still provided some teachings on non-Euclidean theory. Particularly, possible directions in a spherical geometry-based video game can be skewed with elliptical elements to create a unique geometry.

[9]Swink (2008) was a great learning material on how to make a game feel good to play for players, creating a sense of immersion while not having the game feel real. Specifically, the discussion around sound implementation within video games offered a lot to the project, with the main subproject having a good amount of sound design.

[10]Laramée's (2007) book, as a whole, was a great learning experience as it discussed the step-by-step process of video game project development, aiding in the creation of the project's planning process. The detailed information within each chapter certainly provided a level of understanding of what the checklist for each stage of a project should be.

The investigation on the correlation between age and video game genre preference conducted by [11]Greenberg et al. (2008) guided the target age

rating for the project's planned subprojects, making them possibly marketable if they were developed to completion.

[12]Limelight's (2021) investigations on video game preferences by biological gender provided some insight on which items within video games can be assumed as appealing to both. This will aid the subproject's possible marketability.

[13, 14]Lague (Lague (2020) and Lague (2016)) is a great source of coding information as he is both knowledgeable and informative. The two referenced projects are of great help to the project as they teach how to create the base-level implementations of spherical geometry and hyperbolic portals.

6. Future impact

The findings from the given research sources will shape the development process of the project. With findings on geometry, game theory, game development and coding, there should be no unexpected developments within the project that can not be solved. When making subprojects, the planning will take the theoretical sources into account, while the development will utilise the practical sources within the Unity video game engine.

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8.1. Video Game Examples

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Appendix A: 'UFCFHQ-45-3 Comprehensive Creative Technology Project Progress Log'

https://docs.google.com/spreadsheets/d/1EVGBOq-YrGyDMFHJVMCJBbnYe0GHdW2nl4tSVSQ25Vk/edit?usp=sharing

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Appendix B: 'UFCFHQ-45-3 Comprehensive Creative Technology Project Production Document'

https://docs.google.com/document/d/1QKFpfexko2oj9idszsvQII9qJ78Dq0HH2ord7JreA90/edit?usp=sharing

Appendix C: 'UFCFHQ-45-3 Comprehensive Creative Technology Project Pre-Production & Research Document'

https://docs.google.com/document/d/10XsEr6aNCmh6YeVFqMFQSdVdJT6rvR-61TTznkQoS7s/edit?usp=sharing

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