H. Content Creation

The Content Creation section allows you to work in teams/pairs/individually to create an online or physical piece of work at your own pace and to your own design.

To be effective these pieces must have

A clear audience in mind

A clear mathematical message to deliver

A clear means of delivering this message to the audience

A clear evaluation strategy

The topic and the means of delivery of the prepared piece is up to you. A useful rule of thumb is that it should take roughly the same time to make and plan as your Masterclass. A submission which does not reflect an appropriate effort is unlikely to score many marks.

(For example: a mathematical poem, however wonderful, will prove difficult to mark unless each of the above bullet points is robustly and comprehensively explored alongside it. To counter this example however, a *set* of poems, forming a coherent work with a clear purpose, alongside clear commentary on the goals, and documented evidence of their use, might be more justifiable, though still difficult to ‘evaluate’)

In all cases we will provide you with mentoring support. Some of these activities will involve working with outside bodies.

Some examples of possible content creation formats are:

a YouTube video

a Website with interactivity (e.g. including a Geogebra applet or Desmos Activity)

Interactive Phone/Tablet App (eg. game)

School Enrichment Resources (a lesson or demo or series of resources)

Material for the Bath Taps online Science Fair

Content for the Maths World UK (MWUK) maths museum

Written article (e.g newspaper, Plus/Chalkdust/Quanta style article)

Podcast (audio recording discussion/interviews/start of series?)

**In the past some of the content created by the Communicating Maths students has been so good that (i) it has been published (ii) we have used it for future resources (with permission).**

Writing up the Content Creation for your report

**Planning (30%)**

Explain the context of the Content Creation

What was your audience? What background did they have?

Description of the **aims and objectives** of your Content Creation and how you planned to achieve them. How were they designed around your audience?

Explain how you/your team went about putting the Content together. How did you work out the different ways of doing things. What ideas did you reject?

Explain any help that you had and how you used this.

**Delivery (30%)**

Make sure that we are able to see/download your Content Creation. We will then mark your output according to how well it achieved your aims and objectives. You do not need to write a full section about the delivery.

**Evaluation (40%)**

Describe your evaluation strategy. How did you gather your data? Was there any other feedback on the day that you found useful?

Summarise any data - use appropriate graphs, making use of both quantitative and qualitative data where appropriate.

Explain how the evaluation reveals whether or not you met your aims and objectives as described in the planning section.

**CRITICAL REFLECTIONS:**

In the light of any evaluation data/feedback, and your experiences:

What went well? How can you tell, and why did it work?

What could be better? How can you tell, and how would you improve these things?

**PLANNING**

What am I creating?

For my content creation, I wanted to create something around the Monty Hall Problem. The Monty Hall Problem is a probability puzzle that was derived from the American TV Gameshow “Let’s make a deal” and was hosted by Monty Hall. The problem was originally posed (and solved) in a letter by Steve Selvin to the American Statistician in 1975 and is as follows:

*“Suppose you're on a game show, and you're given the choice of three doors: Behind one door is a car; behind the others, goats. You pick a door, say No. 1, and the host, who knows what's behind the doors, opens another door, say No. 3, which has a goat. He then says to you, "Do you want to pick door No. 2?" Is it to your advantage to switch your choice?”*

As a hobby of mine, I develop games on the ROBLOX platform. ROBLOX is an online game platform and game creation system developed by ROBLOX Corporation. It allows users to program their own games and play games created by other users. The platform hosts user-created games of multiple genres coded in the programming language Lua.

I figured I could use my pre-existing skillset to create something interactive with the Monty Hall Problem. These work together quite nicely as the problem is all about what decision you want to make (stick or switch doors) so lends itself to the user making their own choices. I also have a small community of users that I could get to test my game and I am also able to advertise my game on the platform.

I am therefore going to create what I will dub an interactive ‘demonstration’ of the Monty Hall problem in the form of a ROBLOX game.

Target Audience

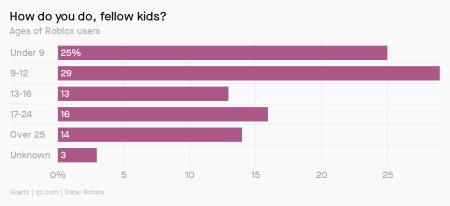
My target audience is 9–15 year-olds with little mathematical knowledge needed. This is quite a large age gap but I went for this as it covers nearly 50% of ROBLOX users. A game can be quite adaptable based on a user’s preferences, so I believe this could turn out quite well. As it will be ROBLOX users, the target audience will also have a good familiarity with video games as well as how the ROBLOX platform functions.

Figure A representation of the ROBLOX userbase

Aims & Objectives

Aim: To delve into the Monty Hall problem and give users an understanding of how it works and how best to approach it intuitively and mathematically.

Objective 1) To teach users the best strategy for the Monty Hall problem

Objective 2) To give users the intuition for why the best strategy should be chosen

Objective 3) For users to understand the maths behind choosing the best strategy

I must meet objective 1, should meet objective 2 and could meet objective 3. As I have got a wide range of ages, some objectives are going to be easier to meet for the whole audience than others. I’d like to make sure everyone leaves the demonstration having an understanding of the problem and what is the best choice to make – this may be enough to inspire users to do their own research. Most players, I would hope, would be able to grasp the intuition behind the best strategy and I hope to achieve this by being very interactive and giving multiple examples that all point towards the same way of thinking. Ideally, a big proportion of my audience would be able to grapple with the maths and see the problem from a probabilistic point of view – albeit a simple one. This could allow them to see a similar problem and apply what they have learnt to come up with their own solution.

Research

I firstly wanted to do a bit of research into the mathematics behind the problem itself. I wanted to see the different ways people approach the problem and come to a solution.

Table

Description automatically generated with medium confidenceI found the Wikipedia article on the subject to be quite useful! It made clear there are multiple ways of looking at this problem; via explanation, by simulation or using a rigorous mathematical proof. There is a section detailing that Paul Erdős struggled to grasp the Monty Hall problem until he was shown a large computer simulation. A good way of looking at the problem can be seen below (Figure 2)

Figure A layout of all possible outcomes

I then focused my research on pre-existing pieces of mathematical content on the Monty Hall Problem.

**Monty Hall Problem and Variations: Intuitive Solutions by Dan Jacob Wallace (2018)**

This is a written article that looks at the Monty Hall problem from 6 different angles. Dan initially goes through the classic Monty Hall problem as posed by Steve Selvin, then starts analysing how the winning strategy changes when things are altered slightly. One version is 1,000,000 doors instead of 3 (revealing 999,998 goats instead of 1), another version has Monty forget where the car is. The final adaptation looked at, Monty has a tell so it isn’t just guess work on the doors. Dan goes into a lot of detail with the maths on each case and it is fascinating how seemingly small changes make a big impact on the probabilities.

**Monty Hall Problem – Numberphile /w Lisa Goldberg (2014)**

Text

Description automatically generatedNumberphile has a video on the Monty Hall problem! It gives a brief overview of the history and the problem then delves into why switching is the best strategy by looking at the probabilities of choosing a goat vs the car. It uses red/green colours to help differentiate the doors which I found useful. In the latter part of the video, Lisa looks at a 100-door version where 98 goats get revealed (1 car and 99 goats). This still results in the stick or switch decision to be made and as it skews the probabilities so much, it makes a clear argument as to why switching is the intuitive choice. The graphics – being able to see all the doors – was useful in aiding my understanding.

Figure A screengrab from the Numberphile video of the 100 door example

**The Monty Hall Problem – D!NG /w Michael Stevens (VSauce) (2019)**

Michael has a video on the problem too that is 3 times as long as the one over on Numberphile. He poses the problem with the history behind it and makes sure to give a thorough explanation of the rules. Michael notes that a misunderstanding of the solution, for a lot of people, comes from a lack of understanding of the rules. He runs the narrative briefly of seeing it from a fresh perspective – talking about going with your gut, how there’s a 50/50 chance.. Once switching has been said to be the best strategy, it is reiterated this isn’t how to always win – it is how you have the greatest chance of winning. The probabilities are looked at to explain this. Next, Michael takes a new spin on the problem by looking at a sack with 3 marbles. There are 2 black marbles and 1 red marble. You take one marble from the bag (without looking), then the host takes out a black marble from the bag (there will always be 1 or 2 black marbles in the bag at this stage). Do you stick with your original marble or switch? This is a simpler way of looking at the problem and mirrors the table of outcomes from the Wikipedia article.

**The Monty Hall Problem | Brooklyn Nine-Nine**

This was simply a clip from the TV show Brooklyn Nine-Nine, where the solution to the Monty Hall problem causes a row between husband and husband. One believes switching or sticking doesn’t matter (50/50 chance) and the other is correct in thinking switching will get you the car 2/3 of the time. This clip was useful as it taught me about common misconceptions with the problem – and showed how wound up people can get about it!

What I learned from my research

The Wikipedia article informed my future decisions well as I knew I wanted to avoid rigorous maths, as part of appealing to my target audience. From the comment on Erdős, I knew that simulation would be a good way to give intuition to the answer. I wanted this to be as interactive as possible (I learned from the Compare & Contrast the importance of interaction)- so I couldn’t do just simulations. A good balance would be supplementary explanations which could then be followed by/packed around doing aforementioned simulations.

The different pieces of content were vital in giving me direction for my game. An example that cropped up more than once was scaling the problem up from 3 doors to N doors. This skews the probabilities in such a way that it is intuitive to what decision is best, without having to see the probabilities written down. This leans very well into my target audience not requiring extensive mathematical knowledge. I really enjoyed Dan’s explanations of variants of the problem. They really helped in concreting an understanding of the maths – for my purposes however, this is not a key focus.

The Numberphile video had really good graphics and is something I wished to emulate – especially the use of colour as it helps direct the viewers focus to specific doors in the 100 door example.

I liked Michael’s marble example as it was intuitive and took away some of the context of the problem that may make it confusing for some people – removing a marble is much more in line with the probabilities changing. This isn’t as obvious when you can still see the door the goat is behind, even when it has been ‘removed’ in the context of the problem.

Creating the game

Initial Ideas

I was creating a game but wanted to make something more in line with an ‘interactive demonstration’. I wanted the user to input at multiple stages and be able to decide the pace at which they wanted to play the game, as different players will have varying comprehension speeds. I also wanted it to be quite linear in fashion akin to how one would follow an article or a video, and have multiple stages (distinguishable to me, I would like it to flow naturally from section to section for the user). I initially had a rough structure for the game and what content I would like to include:

* Player has to click a ‘Start’ button to begin the demonstration
* Cinematic of gameshow set, which then focuses on the 3 doors used in the problem
* Have the user play a few times (able to click doors to make their decision, have doors open to reveal car/goat)
* Run ~10 simulations with a strategy of their choice and keep track of wins/losses. Have a graph shown on screen that keeps track
* Conclude that switching is the best strategy and have a look at the maths behind it
* Reiterate the host always knows where the car is, and will only ever reveal a goat
* Do an example with 100 doors and do the marble example (D!NG video)
* Take polls throughout the game to gauge the progress of the player – pose a new version with different doors and ask the user about the probabilities.

Development Stage 1

I had a rough idea of what I wanted to do – I decided to now jump into ROBLOX Studio (their development software) and start coding and modelling. I wanted this to be an iterative design process as I would have ideas and not all of them would be feasible (e.g., not possible or too time consuming). I began by creating a simple gameshow studio set – I took inspiration from some google images. I didn’t need to create anything too fancy as the focus was always going to be on the doors – I went for a minimalistic design to cater to this. I next created a door asset that was able to slide open and closed, with an area on the top where I could put a door number. I didn’t end up adding door numbers but the space proved useful to attaching texts with probabilities on for the doors. I pulled a model of a car and a goat off of the marketplace for free – I wanted a high quality asset but didn’t have the skills to create them.

Figure A generic gameshow studio

A picture containing text, black, screenshot, computer

Description automatically generated

At this point, 90% of modelling was completed and I moved onto the programming. ROBLOX is coded in LUA which is a simple programming language (it starts counting at 1!) but by use of ‘metatables’, it is able to be adapted to Object Orientated Programming. I have uploaded my whole project onto Github and can be found here: <https://github.com/Integern/MontyHall>

There were some game design premises that I wanted to keep in mind when developing my project. I wanted there to be a lot of feedback (audio and visual) so the user feels their impacting on the game. I also wanted it to be at a pace the user chooses as people have different reading and comprehension speeds.

Code Structure

**Classes**

I created a **door class**; each class can have a door model linked to it and I had functions that were able to open and close the door. Each door is assigned as a car or a goat door (default goat).

I next created a **gameshow class** – this can have any number of door classes attached to it. The gameshow class runs all of its door classes as a whole which allowed me to easily create a Monty Hall problem setup – or if I wanted to scale it up, a 100-door version! It is able to randomly assign 1 door as a car, open up a random door(s) that has a goat behind it, open/close all doors etc... For example, I could supply a gameshow class with 3 doors, randomly assign 1 car and 2 goats. The user can then select a door (door turns green), then it will open a random goat door (that isn’t the same as the users choice) and when it closes turn it red so that there are then 2 doors to choose from (stick or switch).

**Libraries**

I’ve got a **tweening library**; tweening takes an object from state X to state Y in a smooth transition. For camera work, I can just change the position of the camera, but it would make it cut jarringly. Instead, I can smoothly tween it to its new position.

I also created an **audio library** that has a list of stored audio/music with functions to play them with options for varying volume.

**Clientside Code**

There is some code based around a **text prompt** – I’m able to pass strings to a function that then presents them in my text prompt. The user can click a next button with their mouse or by pressing the ‘Return’ key. This is vital for giving explanations and allows the user to move the game at their own pace.

A **bar graph** to pair the stick and switch strategies up against one another is used enough I created some functions for it. One is able to add ‘points’ (a round has occurred) to the stick or switch strategy, and a bar chart slowly begins to form.

The user selects a door by clicking so I have some code that **tracks the user’s mouse**. When their mouse is hovering over a door, it highlights it to show it is selectable. A user is then able to click a door to select it which promptly turns the door green! Once a user has clicked a door it stops tracking their mouse until the code is called upon again.

The main meat of this project is in the **demonstration** file – this is the brain behind the whole project and controls everything. I am able to change camera angles, initiate text prompts, run code on the gameshow class to have the user run through an example themselves and much more. The :Run() function gets the ball rolling, and inside that function it calls sub-functions dubbed :Section1() through :Section4() which just initiates new sections in the game.

Development Stage 2

A picture containing text, light, traffic, way

Description automatically generated was creating this code as I went along with my original idea and eventually I reached a point where I needed to come up with a more concrete plan – I had all the building blocks I just needed to put them in place. I came up with the following flow for the demonstration:

Changes from Initial Ideas

I wanted to give the user a bit more of an explanation of the problem; the history, how it works. They may have been able to figure it out from playing multiple rounds of the 3-door version, but it may not be that intuitive for all users – especially the younger audience. I changed from running of 10 simulations with a chosen strategy to playing 5 and tracking the winning strategy instead. This would remove any danger of a user picking a strategy that loses a considerable amount - which may demoralise the player and not have them want to play anymore. I did decide to keep the simulation though (as per my research), but to scale it up to 100 runs as that’s when we will likely see estimates to the true probabilities. I included the 102-door concept as it really helped with my understanding of the problem. I wanted to do all of the above before delving into the maths – not all users would want to look at the maths but by this point could have had a lot of fun with the demonstration. I decided to scrap the marble idea as I felt 1)The content I had would sufficiently explain the problem 2)May confuse users to the relevance of the marbles in relation to all the doors they’re seeing! I wanted to allow the player to run as many rounds as possible at the end as some users may need to do it themselves many times to truly get to grips with the content.

As a final note, I decided against taking polls throughout the game; this would result in me having to handle data stores and just add a lot of overhead to the game. Instead, I opted in creating a google form and asking users to fill it out once they finish the game (not too difficult to find as users will be familiar with the ROBLOX platform). ROBLOX does also track other statistics for me (age ranges of players, average playtime)

Getting Engagement

There was a multitude of ways I got my game out there and got people to play. These included:

* Asking friends and fellow mathematicians to play
* Advertising on the platform
* Informing my ROBLOX following of my new game via Discord



Figure One of the ads I ran

Final Product

The game is split up into 5 main sections that may be distinguished by the player, but was more so for keeping the project organised for myself.

**Section 1**

An introduction to the problem followed by playing a 3-door round in the gameshow studio set. There is then a brief discussion about whether switching or sticking with your original choice is the best strategy. The user now has 5 rounds of the 3-door version, where we track the winning strategy using a bar graph. Finally, run a simulation of 100 rounds of the 3-door version keeping track of the winning strategy via a bar graph.

**Section 2**

We now move onto a 5-door version, where 3 goats are revealed. Probabilities are a tad more bias/obvious here.

**Section 3**

The framing moves to the 102-door version against a plain background, with some discussion that uses the exaggeration of 102 doors to explain why switching is optimal. We let the player play a few rounds of the 102-door version to let them see the results for themselves.

**Section 4**

We move back to the 3-door version in the gameshow studio. At this point the user is informed we are now going to cover the maths behind the problem (albeit simple) – some users may leave at this point, so they are informed about the google form.

The probability of picking doors is explained, with a quick interlude over to the 102-door version to help explain where these probability values come from. More discussion ensues around the probabilities to help inform us of the best strategy.

**Section 5**

A never-ending loop of the 3-door version for the user to test out what they’ve learnt.

**DELIVERY**

The game is delivered using ROBLOX and one must download a ROBLOX client (this can be uninstalled after the demonstration has been completed) to access the game as well as have a ROBLOX account. It is available only on PC (other options would be Mobile/Tablet/XBOX).

Game Link: [https://www.ROBLOX.com/games/6550260745/The-Goat-Car-Problem](https://www.roblox.com/games/6550260745/The-Goat-Car-Problem)

You may use the following login credentials if you don’t want to make your own account:

Username: BathCommMaths2021

Password: masterclass

Click the play button, and you will either be prompted to download the client or you’ll immediately join the game. Ensure that your audio is on for the full experience! If you cannot hear anything once you click start, the audio may be turned off within the ROBLOX client (press ESC to go to the options). One section shows 102 doors, and some of my users weren’t able to see all of them – in the options, there is a graphics slider that may help with this (discussed in my evaluation).

**EVALUATION**

Strategy 1

My plan was to get some basic data from ROBLOX that is automatically recorded (age of players visiting and average length playing) then get some more specific feedback via a google form. I am able to put my twitter link on the game page, and I put a link to the google form in my twitter description. I asked multiple times during the demonstration if users could give me feedback as the game was created as part of my University degree and told them how they could find it.

I now needed some players – ROBLOX allows you (for a fee) to advertise your game. All you need to do is create an advert following a certain template and place a ‘bid’ on it to have the advert run for 24 hours. I ran one advert for 24 hours but got quite a low CTR (percentage of users who are shown the advert who click it). I created a new advert and this had a (slightly) higher CTR after running it for 24 hours.

|  |  |  |
| --- | --- | --- |
|  | Advert 1 | Advert 2 |
| Bid | ~£2.50 | ~£7.65 |
| Impressions | 127,327 | 492,747 |
| Clicks | 268 | 1416 |
| CTR | 0.21% | 0.29% |

Strategy 1 Issues

After running both adverts, I ended up getting around 280 plays on my game. From these 280 plays, I collected the following data on my players:

|  |  |
| --- | --- |
| Age | Total Players |
| <= 6 | 18 |
| 7-8 | 24 |
| 9-10 | 43 |
| 11-12 | 44 |
| 13-15 | 53 |
| 16-17 | 12 |
| 18+ | 87 |

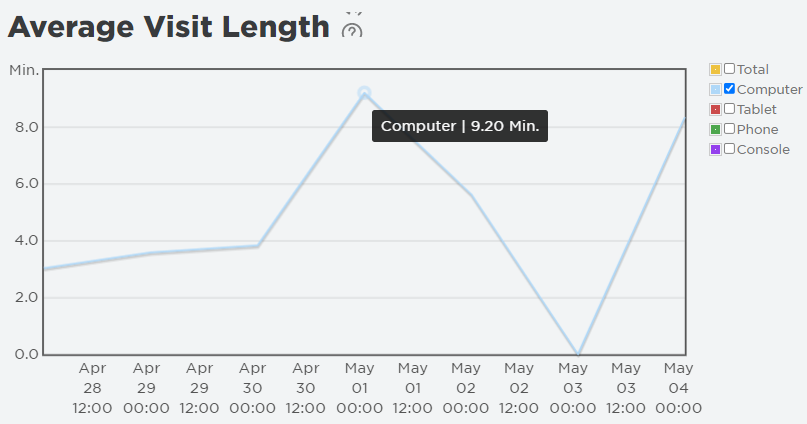


Figure Average visit length

From these 280 plays, around 50% were my target audience and had a total average visit time of around 5 minutes. For context, if you’re running through the demonstration properly it should take 10-15 minutes. This accounts for users that left as soon as they joined, got bored halfway through and some who stuck around to the end. From this sample of ~280, I gained a meagre 3 filled out forms on my google form (from 3 different ages). I was equivalently paying £3 per form entry. This was not going to be a feasible strategy for gaining good volumes of feedback.

Adapting Strategy; Strategy 2

I moved away from advertising on the platform and moved to my own ROBLOX community. I run a discord server with over 300 members. Discord is a VoIP, instant messaging and digital distribution platform designed for creating communities – think of it like Facebook for gamers. I adapted the google form by allowing users to add their ROBLOX username and posted in my Discord about the demonstration. If users put their username down in the form, they were in the chance of winning a prize. This managed to gain me just over 12 more filled out forms.

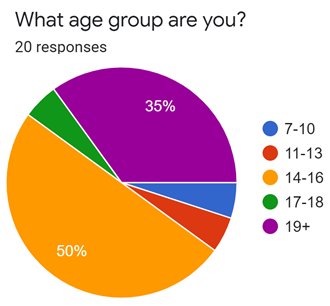
I then went and asked fellow communicating maths students as well as friends to help give me feedback. Even though these people are outside of my target audience, they were aware of the target audience while completing the demonstration and gave according feedback. Due to being older, they were also able to give me more useful and eloquently written feedback which was beneficial as previous feedback was lacking in parts.

Strategy 2 Issues

This adaptation was much more successful, but I still ended up with only 20 form entries in total after the fact. I was hoping to have closer to 30 – more data the better. I also was now getting more feedback from users outside of my intended audience – it was harder to discern from these users if my explanation of the problem was lacking in certain places or whether it was fantastic.

Feedback Evaluation

Chart, pie chart

Description automatically generated

The entries to the google form are definitely a skewed audience; I have the friends/peer responses in the 19+ bracket (plus 1 or 2 more other players) . Half of the responses are in the older bracket of my target audience with only 2 responses from the younger end.

From this chart one can ascertain the average play time (for completion) was around 10 minutes. Comparing this to the average playtime, it is evident a majority of players quit the demonstration halfway through or earlier.

Chart, bar chart

Description automatically generatedFrom the following 2 graphics we can see there is a spread of mathematical capabilities and previous knowledge of the Monty Hall problem. Additionally, less than 30% of my respondents were aware of the winning strategy beforehand.

Figure 7 1=Very Little, 5=Maths Degree

Chart, pie chart

Description automatically generatedI was hoping to have a less mathematically inclined audience give me feedback as this was who the demonstration was aimed at – but the silver lining of this is I got more feedback from people who have a deeper understanding of mathematical teachings. Alas, with this audience it is harder to say with certainty just how good my game was at educating users on the Monty Hall problem.

I am actually quite happy with the spread of users who were/were not familiar with the Monty Hall problem, as it gives me equal amounts of 2 types of feedback: One being from those with a fresh perspective, who I can gauge if they truly understood the content. The other from users who already knew/understood the problem, where their feedback will be to do with the quality of the delivery. I think of it as getting feedback from students and fellow educators.

Figure 8 How many users were familair with the problem

Overall, I’m quite happy with the pool of respondents that I got. I was disappointed I only got 20 responses (I was hoping for more than this) and it was frustrating I wasn’t able to get a solid amount of feedback from the whole of my target audience. As already mentioned however, this did result in me getting more useful feedback – feedback from younger audiences can often not be as useful as they haven’t honed in the skill of constructive criticism and critical thinking.

Qualitative Feedback; What Went Well & Even Better If

**What Went Well**

I posed the following question to my respondents: “What were some good features of the game? Did anything in particular help your understanding?”. The most frequent answer was related to the 102-door example – a lot of users found that the extreme probabilities used in this answer made the winning strategy much more intuitive to reach. On the topic of probabilities, users that stayed for the maths section at the end found having the probabilities shown on the top of the doors helped their understanding as well.

A lot of the responses gave a general comment on that the visuals used in the game really helped their understanding along with the explanations in the text prompt. Having the probabilities talked about in text and visually shown over the doors really complemented one another. Users found all the examples used really useful for their understanding – giving different problems with the same key ideas really helped. There were also a fair few responses that touched on the game as a whole – the use of audio feedback, the music, art style etc… Players really appreciate this and said it helped engage them in the content. One respondent said:

*“I liked the way everything was presented, it was a well designed game and helped visualize the way probability worked. I also thought that the game was well coded in general, since the transitions were smooth and everything was very clean looking.”*

It was very rewarding to see the effort I put in and all the small details I worked in were recognised and aided everyone’s understanding in the problem.

In regards to the maths section toward the end of the demonstration, the majority of users found it easy to follow and increased their understanding of the problem. For those that didn’t, they commented on how the visuals of the doors really helped their understanding.

One respondent gave their feedback as ‘Good Grammar’ – this user was in the 14-16 age bracket. I touch on this more in the next section.

**Even Better If**

The next question I posed my respondents: “What improvements would you suggest to make the experience better for other players?”

I want to first touch on the ‘Good Grammar’ comment – I saw this as a criticism as I wanted this content to be accessible to 9+ year olds, and if some of the language is too advanced this will inhibit their learning. Some users commented on the initial explanation being a bit confusing and lacking. This may have been linked to the grammar I used, but also to my actual explanation. More than one respondent commented on how it was not made clear that the goats and cars were randomised each time a new round starts.

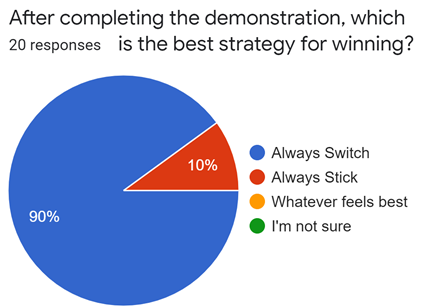
Some users however did know they were randomised – but to this effect, there were some complaints that they didn’t seem to be random! One user reported that on the 5-door version (with 3 rounds) the car was always in the same position and that this was confusing. Another said that the game was rigged to have switching always be the winning strategy (instead of 2/3 of the time).

There were multiple answers relating to improving the design of the game – some for accessibility, some for understanding. A user requested the game be accessible on Mobile instead of just PC. Some users reported issues related to their hardware - couldn’t display all 100 doors at once, text overlapping important visuals. With the design, a user said it would be amazing if they could customise the number of doors themselves to see how that changes the probabilities. The same user commented on making the game less linear (sections could be repeated or completely skipped). The design of the graph caused some issues too – there was confusion that the graph showed what the user picked when it was actually showing the winning strategy for each round. One player said graphs could’ve been shown at all times akin to a progress meter. Another user suggested the idea of having arrows point to the doors to make it clearer that you should click one.

When it came to the maths section, some users found it a tad confusing – the language was confusing for a few players. Other users didn’t give much useful feedback as to what was confusing about it.

Finally, there were a few players who commented on how some parts of the game were too long or useless (the 100-door section was too long for a select few).

Quantative Feedback; Was this a good education tool?

From Figure 8, 55% of players hadn’t heard of the Monty Hall problem and less than 30% of players were aware of the winning strategy beforehand. After the demonstration was completed, 90% of players were able to correctly identify the winning strategy. This was more a judge of users paying attention, as it was reiterated at length that switching was the best strategy. To this end, I may guess that the users that picked ‘Always Stick’ may have got confused and meant to pick ‘Always Switch’. Either way, going from 30% to 90% understanding of the winning strategy is a good sign! I followed up this question by posing a new scenario that we hadn’t see in the game:

Figure

|  |  |
| --- | --- |
| Answer | #Responses |
| 19/20 | 8 |
| 2/20 | 3 |
| ½ | 2 |
| 1/20 | 2 |
| 1/10 | 1 |
| 2/3 | 1 |

“Picture 20 doors - so 19 goats and 1 car. If you use the switching strategy, what is the probability of you winning the car?”. The answers have been summarised in the table. The correct answer is 19/20 which over 50% of respondents gave! Unfortunately, given 40% of my respondents were adults, this leads me to believe that the younger of those in my target audience were unable to grapple with the maths. Some users were in the correct ballpark where they adapted their answer to the problem (answers of 2/20 and 1/20 from 17% of users). Other users either used the answer from the 3-door version or evidently did not get to grips with the material at all.

Did I meet my aim and objectives successfully?

As a recap:

*Aim: To delve into the Monty Hall problem and give users an understanding of how it works and how best to approach it intuitively and mathematically.*

*Objective 1) To teach users the best strategy for the Monty Hall problem*

*Objective 2) To give users the intuition for why the best strategy should be chosen*

*Objective 3) For users to understand the maths behind choosing the best strategy*

The higher up the list, the more I wished to meet any given objective (1 being at the top). Ideally, I would meet all 3 objectives for every user, but I was aware there was going to be a range of abilities. I would confidently say I met objective 1 as by the end of the demonstration, 90% of users were able to identify the best strategy. For objective 2, based on the qualitative feedback I received I’d say this was met too but not to the extent I wished for. A lot of users commented on how different examples made the best strategy intuitive – but this was not the case for all users or even a majority. As is clear by the answers to the final question (20 doors), some users just had a good memory of what was told instead of having an actual understanding. With objective 3, not all users answered this question as looking at the maths was optional, extra content. Of the users that did answer the question, less than 60% of users got the correct answer. This shows that a majority of users did have an understanding, but as ~30% of users are adults that I know of (attend university or even do a maths degree), this may be less reflective on the quality of my content and more on the knowledge they already had. I imagine my explanations helped them get to the answer, but I wanted to be able to show this to, let’s say, an unknowing 13 year-old and by the end have them give 19/20 to the new problem. I think it would be bold for me to say that objective 3 was met in the context of my target audience – so I will conclude objective 3 was not met (however not a complete failure!).

Critical Reflection

**What Went Well**

Text

Description automatically generatedI believe that the demonstration as a game was built very well; it looks and plays professionally, has good use of auditory feedback and some calming background music (and this was backed up by the feedback I received). There are smooth animations/transitions used throughout. I’m happy with the graphics that I produced for the game (title image and adverts) as well as the physical assets I created (the opening doors, the gameshow studio set) that can be seen in Figure 10. The code, albeit bulky at points, is laid out well and organised and I am just really happy with how it all turned out. It is satisfying to play as a game (due to the visual and auditory feedback) and I’ve found myself playing through it multiple times just for the sake of enjoying what I’ve made. The design of the game is quite intuitive, especially to an audience that have been ‘trained’ on playing many video games in the past. Although there was a comment on having arrows pointing toward the doors, I believe it is enough instruction to tell users to click a door and then have a door highlighted when the user hovers their mouse over it. Being able to press ‘Return’ to go to the next text prompt makes the game that much easier to interact with too.

Figure 10 Title screen for my game

I believe how I chose to teach the Monty Hall problem was the best approach I could’ve taken; giving multiple examples, especially the exaggerated 102 doors. An issue with the 3-door version is the probabilities are quite close to one another so a clear answer isn’t intuitive – with the 102 doors, it is quite obvious. So much so that one needn’t really think about the values of the probabilities at all. This lends well to my goal of educating a younger audience and not bringing in the optional maths until the very end.

Giving the probabilities above the doors was a good touch I believe; it was a good way of linking what was being discussed in the text prompts and the visuals they have in front of them. From the feedback, I can say this for certain.

For gathering feedback, Strategy 2 ended up working much better than Strategy 1 for getting many responses – albeit a bit skewed towards older players. Getting more eloquent and thought out feedback has made it easier to construct a good evaluation however!

**Even Better If**

My first comment for this section is on my method of collecting feedback. I wasn’t able to collect nearly as much feedback as I would have liked, and it was skewed toward the older end of my target audience – and some users so old they were not in my target audience at all. This could’ve been fixed a few ways. One idea would be to incorporate the feedback into the game as I originally planned. This would’ve created more overhead so only if I had the time would I have done this. As there was a range of understanding (found in my feedback), polling throughout the game could take users into deeper/simpler explanations to ensure equal understanding before moving into new sections. An alternative idea would’ve been to get in contact with an educator (e.g., year 6/year 7 teacher) who could put kids in front of my game and ensure they filled out some feedback for me. Having the opinion of a teacher would also be great for my evaluation.

There are definite improvements to be made to the game. The Monty Hall problem is all about probability – the doors that the car and goats are behind are randomised in every round. Some users found that the car was never moving positions and that this was confusing! I draw a parallel with when the iPod shuffle was first released; people complained that they would shuffle and 2 songs from the same album or artist would play after one another. Apple ended up making the iPod shuffle less random (wouldn’t play songs from the same album/artist twice in a row) to make it seem more random. I think in places I should have actually set what permutations would come up (or at the very least, limit the possible permutations) to make it feel more random to the user. In the beginning section where the user runs 5 rounds of the 3-door version, the winning strategy is tracked. It is entirely possible to get 5 situations in a row where sticking is the optimal method. This would be very confusing to some users to then be told switching is the best method.

In regard to grammar, a simple change I would make is to go through all the text in the text prompts and simplify the language used. Some users commented on how some of the language was a tad advanced, and others touched on how some explanations were difficult to follow. I was excited to create this project, and this was an oversight on my part to adapt the project for the intended younger audience.

Background pattern

Description automatically generatedAnother change I would make is the graph – it is currently a bar chart that would show the winning strategy. Some players found this confusing as to what was actually being shown. I would give the graph a clear label and change its behaviour. I would have it track and count the choices made by the player, but then use a red/green colour across the bar to show the number of choices that were correct or not.

Figure 11 Bar graph of winning strategy per round

Following on from this, if I had more time, I would have added more design features. I would’ve liked to have had a section where the user can choose the number of doors along with the amount of cars and goats, to see how this would affect probability. Having more than 1 car is a different version on the Monty Hall problem; this could’ve been some extra content. This would let players play with the probabilities, and in my experience letting someone experiment with maths only aids in giving a greater understanding.

Another idea: being able to view the game as different ‘chapters’, and possibly having a quiz at the end of each chapter to reach the next chapter. On the one hand this may make players quit quicker, but the demonstration is made to be run through to completion. Giving the player this flexibility would allow them to replay sections of the game while also allowing the player to view the structure of the whole demonstration instead of playing blindly in the given linear fashion. The quizzes at the end of each section would not only ensure understanding required for the next section, but also give invaluable data for evaluation to see the success of the content.

Finally with the maths section, I think this could’ve really benefitted from some more mathematical notation. I was explaining the maths to users a sentence or two at a time, where they couldn’t go back, with the only mathematical notation being x/y. For starters, users may be more familiar with a vertical line for fractions. Players, especially younger players, may only be familiar with probability in the context of chance and percentages. One solution could be creating a .png image of a description of the maths (e.g., equations and displaying this to the user). A more involved solution would be the same idea, but users must type in the correct values where there are blank spaces. This would be more involved learning and ensure greater understanding.

Resources

<https://en.wikipedia.org/wiki/Monty_Hall_problem>

<https://math.stackexchange.com/questions/41807/variation-on-the-monty-hall-problem#:~:text=For%20the%20first%20rule%20there,B%2C%20you%20switch%2C%20you%20win>

<https://www.untrammeledmind.com/2018/11/monty-hall-problem-and-variations-intuitive-solutions/>

<https://www.youtube.com/watch?v=4Lb-6rxZxx0&ab_channel=Numberphile>

<https://www.youtube.com/watch?v=TVq2ivVpZgQ&ab_channel=D%21NG>

<https://www.youtube.com/watch?v=AD6eJlbFa2I&ab_channel=BrooklynNine-Nine>