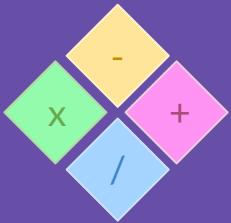


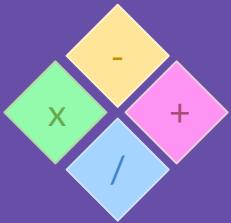
Mathemagica: Runes of Revival

A game for learning the foundations of maths



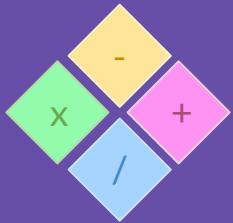
Client Requirements

- target audience: adults aged 19+ with a weak mathematical background
- numeracy game - learn and practise basic maths concepts
- practical applications of math skills, real world scenarios, introduction to career paths
- engaging/immersive
- increasing difficulty
- cross-platform compatibility
- accessibility
- personalised feedback & progress tracking, gain confidence
- collaborative elements

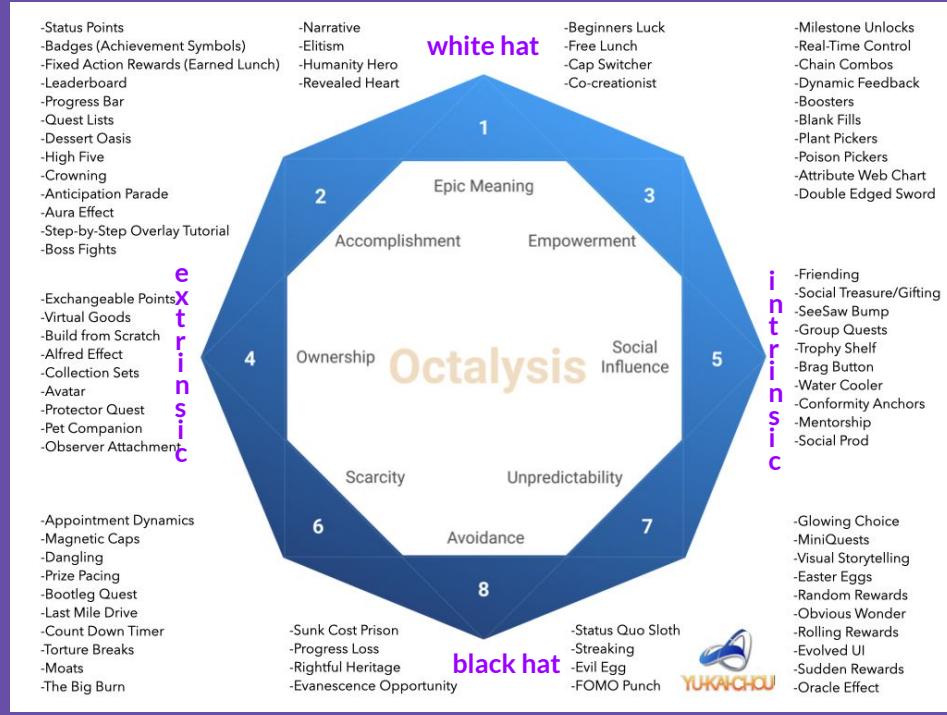


Reasons why people struggle with, or dislike, maths

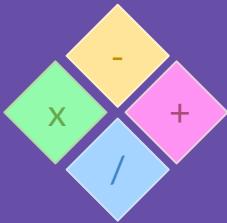
1. Weak knowledge of mathematical foundations and non-calculator maths
 - Each step is clearly explained and illustrated
 - Each topic is fully broken down to the basics
 - Map shows how concepts are related
 - Minigames show what concepts they focus on
 - Whiteboard to aid with mental maths, making it less overwhelming
2. Maths worksheets are boring and lack the satisfaction of achieving a goal, unlike logic puzzles (e.g. sudoku, picross, Rubik's cube)
 - Overall goal to max out the knowledge of the concepts displayed on the map
 - Smaller goals for each puzzle/quest with a final state to achieve
 - Less like a quiz and more like a puzzle



Gamification of learning



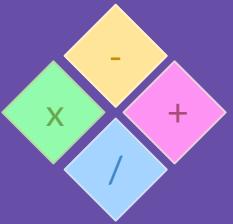
- Gamification framework by Yu-kai Chou
- Takes advantage of our innate psychological drives
 - Extrinsic vs intrinsic drives
 - Black hat vs white hat drives
- Not all drives need to be achieved equally for successful gamification, but it's preferable to have a balance of drives from around the wheel to appeal to a variety of people



Mathemagica: Runes of Revival

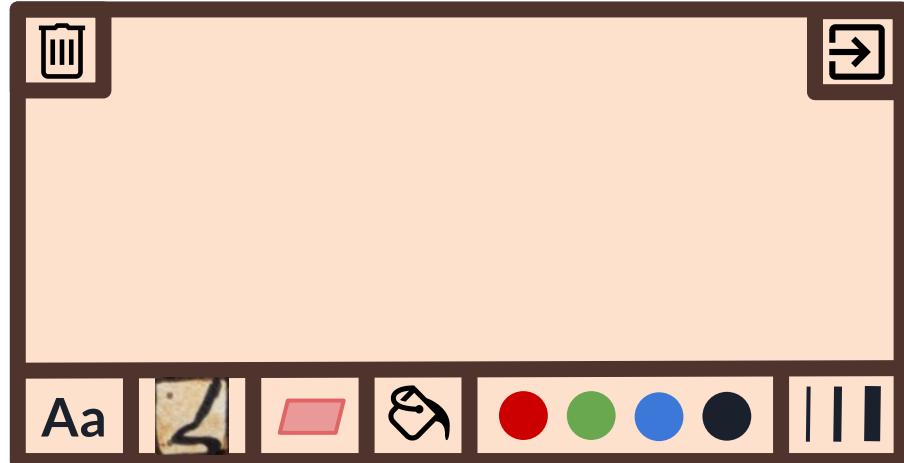
Mechanics Overview

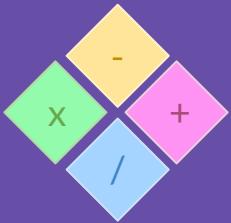
- Mobile & desktop 2D RPG game
- Point and click
- The centre of the map will have a progress indicator of the learner's skill level in each maths topic
 - It's the main hub for learning new concepts
- Separate minigames in different sections of the world to practise maths concepts
- Focuses on the foundations of maths, i.e. +, -, /, x, order of operations
 - Covers topics deriving from them, such as %, decimals, fractions, factors
- Always available whiteboard screen
- Each concept has 4 skill levels to achieve
 - Puzzle difficulty gets harder for each level
- After each user input, the game will react to respond to it, whether the input is correct or incorrect
 - No harsh punishment for incorrect input - promotes exploration and experimentation



Whiteboard

- Retains contents between scenes
- Used to make notes or help with mental maths
- Features:
 - Text option (for desktop)
 - Pen option (for mobile)
 - Eraser
 - Paint bucket
 - Selection of colours
 - Different pen/text thicknesses

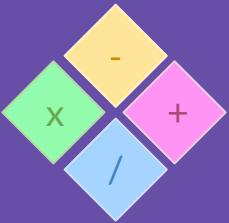




Mathemagica: Runes of Revival

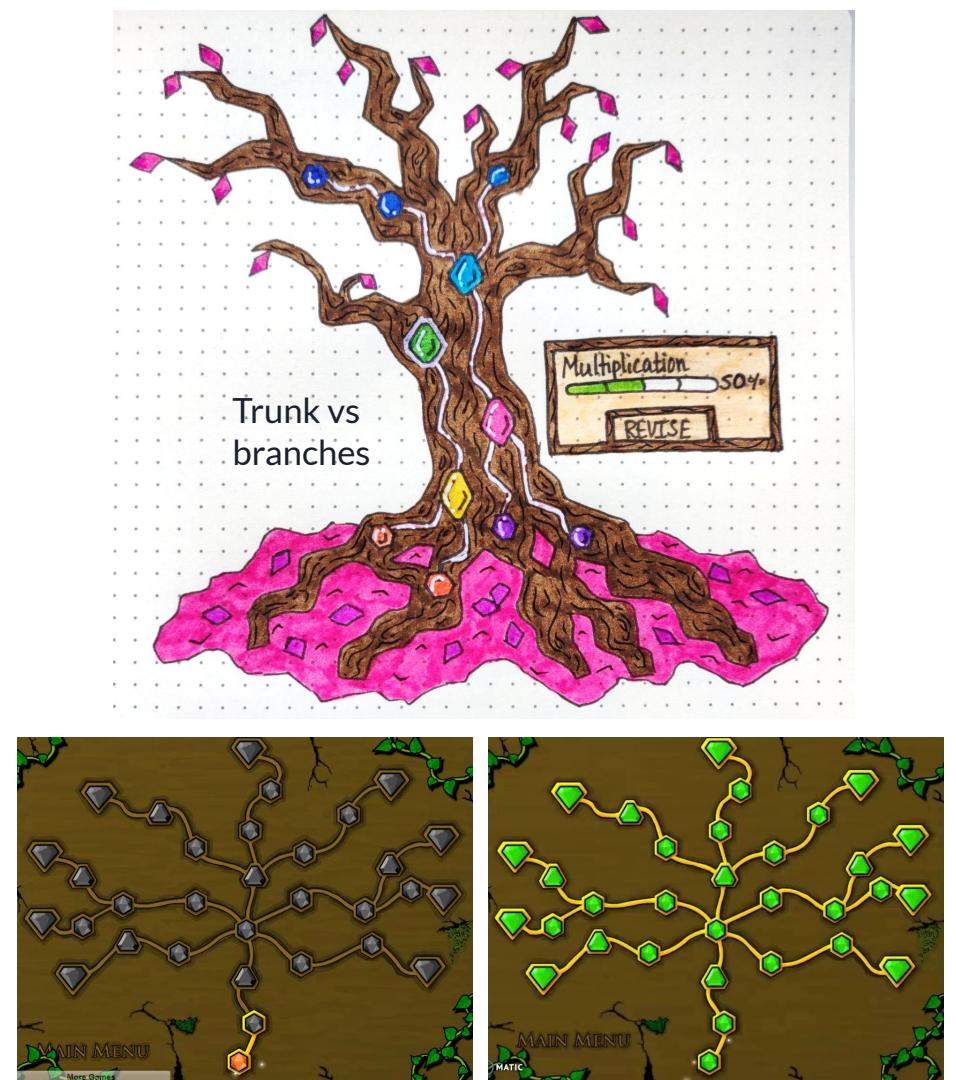
Story & Setting

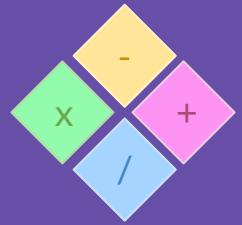
- Launching the app opens a portal to another world on the other side of your screen that is populated by cute magical monsters
- This world has never had maths before, and they need your help to understand maths and its uses as their world begins to react to this change
- Their Tree of Life has began to die once maths entered their world, and now they need to charge up 4 magical runes (representing +, -, /, x) to embed into the tree and return it to life
- You meet several characters of different professions who demonstrate how maths can be used in everyday life
- You meet a Wise Spirit who resides in the church of Bedmas and you act as the messenger between the spirit and the villagers, teaching them what the spirit taught you



Map of Concepts - Tree of Life

- Inspired by the map of Fireboy and Watergirl
 - Each level is associated with a gemstone
 - The colour of the gemstone indicates your skill level
 - Gemstones have different shapes, which i can use to separate concepts
 - Gemstones are originally greyed out and are coloured in as you attempt the level
- The user can click on a rune to learn the associated concept
- The user's proficiency is tracked by the rune colours
- The game is completed when all runes have been "maxed out"
- Runes are only accessible when adjacent runes have been unlocked

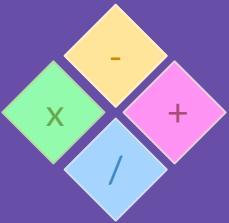




Mathemagica: Runes of Revival

Characters

- Each character is associated with a rune or a selection of runes
- Interacting with a character increases the skill level of their associated runes on the tree of life
 - How the player practises and applies concepts



Wise Spirit

- Invisible to villagers
- Resides in the stained glass windows of the church of Bedmas
 - You can see sacred scrolls in the church, i.e. diagrams of math concepts for easy reference
- Teaches maths concepts associated with each rune
- Shows example problems and walks you through solutions
- Each unlocked lesson can be referenced later as a sacred scroll (cheatsheet)



- addition

- column

- subtraction

- column

- negative numbers

- multiplication

- 0

- exponents

- BEDMAS

- basic probabilities, set theory

- division

- 0

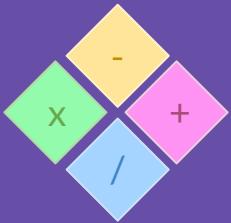
- percentages

- fractions

- decimals

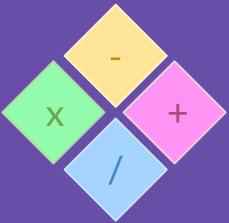
- ratios

- creating equations from words and scenarios



Cubing guide for absolute beginners

- Recent project from a week ago
- Focus on illustrating every step to reduce perceived complexity of the process
 - Visual changes in each step
- Convey information through different means (visual, textual, auditory, etc)
- Bold, capitalise, and highlight key words to make it easier to read and process the text
 - Break up a wall of text into something more bitesize
- The test learner made no big mistakes until step 6 of 7 of the guide



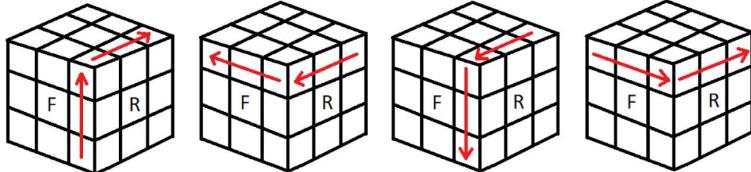
Example 1

For this, you will need to learn your first algorithm. It's called the **Sexy Move** (yes, really!). It has 2 versions, **Left Sexy Move** and **Right Sexy Move**. It's the same algorithm, but mirrored. It goes like this (relative to your hand):

Up, Away, Down, Towards

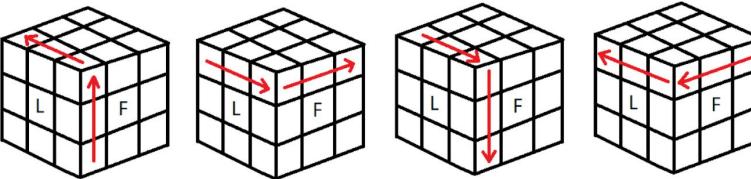
Right Sexy Move - R U R' U'

Use the RIGHT HAND to do the moves



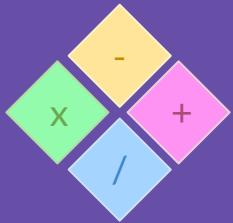
Left Sexy Move - L' U' L U

Use the LEFT HAND to do the moves



The **sexy move** can be used to **rotate a corner piece**, which is what we will use it for in this step.

- Fun name to remember and recognise the algorithm by
- Easy to remember phrase to repeat when doing the algorithm
- Shows which way the cube should be oriented to avoid confusion
- Tells which hand to hold it in
- Cube notation alongside diagrams to ease beginners into the world of algorithms
- Diagrams to illustrate each move
- What the algorithm does

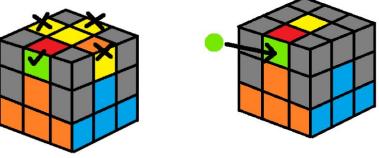


Example 2

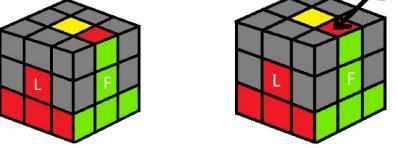
Step 3: Second Layer

Now we will use the left and right sexy move to **fill in the 4 edges of the second layer**.

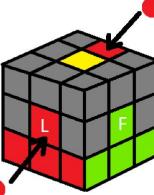
1. Look at the **top layer** and select an **edge piece** that **doesn't have yellow** on it.
2. Make note of the **side colour** of the **edge piece**



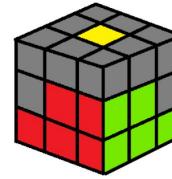
3. Rotate the **top layer** to match the **centre colour** of the **edge side**. Face that centre until step 7
4. Make note of the **top colour** of the **edge piece**



5. **rotate the top layer** so that the **edge piece is opposite its top colour centre**. Make sure you are still facing the centre of the side colour
6. Do the **sexy move** of the hand that holds the **top colour centre** (in this example, red = left sexy move)

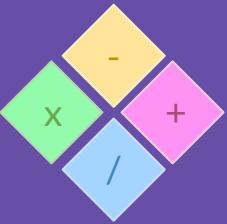


7. Your **corner** will pop out. You will need to fix it with the **opposite hand**, so change what hand you hold the cube in, now **facing the centre of the top colour** and holding the **centre of the side colour** with the **other hand**
8. Do the **sexy move** of the new hand. This will **join the corner and edge pieces together and insert them into the column between their centres**
 - a. It's the same thing you would do in step 2 to insert the white corner into the correct slot on the bottom layer, just this time along with the edge

Your **edge piece** should now be **inserted in the correct place**. Great! Now **repeat it for the remaining edges**.

- Diagram of the final product so the learner knows what they will achieve
- Each bullet point is illustrated
- Unimportant pieces are not coloured in
- Important diagram elements are highlighted
- Cube orientation is noted when appropriate
- Diagram of the outcome of the step so the learner can compare it to their cube and see if they solved the piece correctly



Ratio lesson

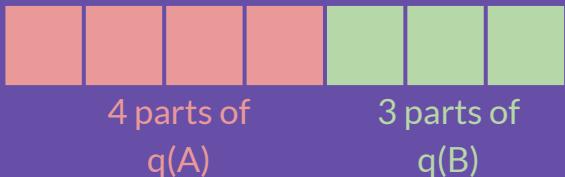
KEY
$q(A)$ = quantity A
$nq(A)$ = amount of quantity A
$q(B)$ = quantity B
$nq(B)$ = amount of quantity B

Ratios show the **amount of quantity A** relative to the **amount of quantity B**

A ratio is **written** as:

$$nq(A) \rightarrow 4 : 3 \leftarrow nq(B)$$

↑
Relativity symbol



The total number of parts is:

$$4 + 3 = 7$$

Ratios can also be written as a **pair of fractions**:

$$nq(A) = 4/7$$

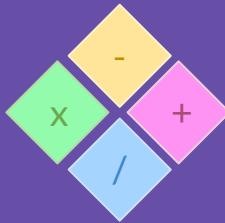
$$nq(B) = 3/7$$

Like fractions, **ratios** can (and should be) **simplified**, since the **quantities** are **relative** to each other:

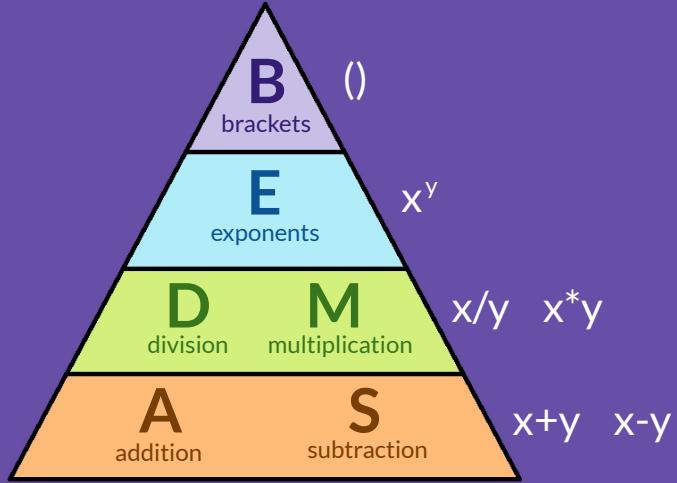
$$8 : 4 = 2 : 1$$

(the **common factor** is 2)

- Key of abbreviations
 - Reduces visual clutter
- Bold words and colours break up the mass of text to make it easier to read
- Colours show the relationship of each subject to each example, and where the subjects change



Sacred Scrolls

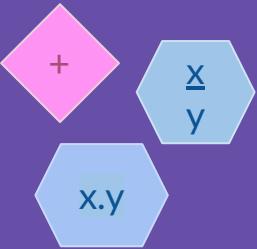
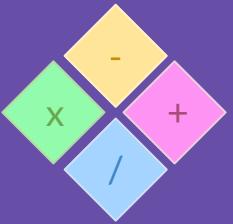


(Times table sample)

1x1=1	2x1=2	3x1=3	4x1=4
1x2=2	2x2=4	3x2=6	4x2=8
1x3=3	2x3=6	3x3=9	4x3=12
1x4=4	2x4=8	3x4=12	4x4=16
1x5=5	2x5=10	3x5=15	4x5=20

- The mnemonic “BEDMAS” (or PEMDAS) doesn’t actually tell you that division and multiplication have equal priority, so learners may try to apply bedmas incorrectly in an equation
 - Think about “ $7-3x2+8/4$ ”
- Colour-coded pyramid creates further mental separation between the levels
- Example of what each operation looks like to connect the word to what the learner will see in real life

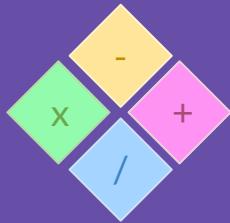
- Colour-coding each result helps uncover visual patterns in the times table to make it easier to recall from memory
- Helps remember factors of numbers through colour patterns
- Colours visually break up a wall of numbers, so it’s easier to process and focus on one set at a time



Alchemist

- Mixes potions - analogous to cooking recipes
- Charges up runes
- Main caretaker of the church of Bedmas, trying to revive the tree of life
- The player's sidekick
 - Sends player on quests with the other characters to get her items or information she needs for her magic

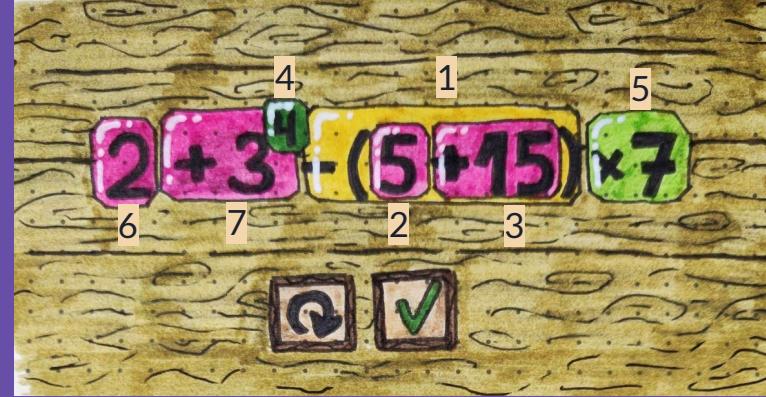




Alchemist's minigames



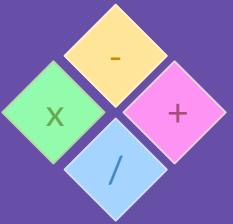
Potion mixing



Rune charging

- Decimal practice
- Adjust the potion level in each container to match the requirement
- More advanced levels include:
 - combining fractions and using ratios
 - Teaspoons, tablespoons, mixing units

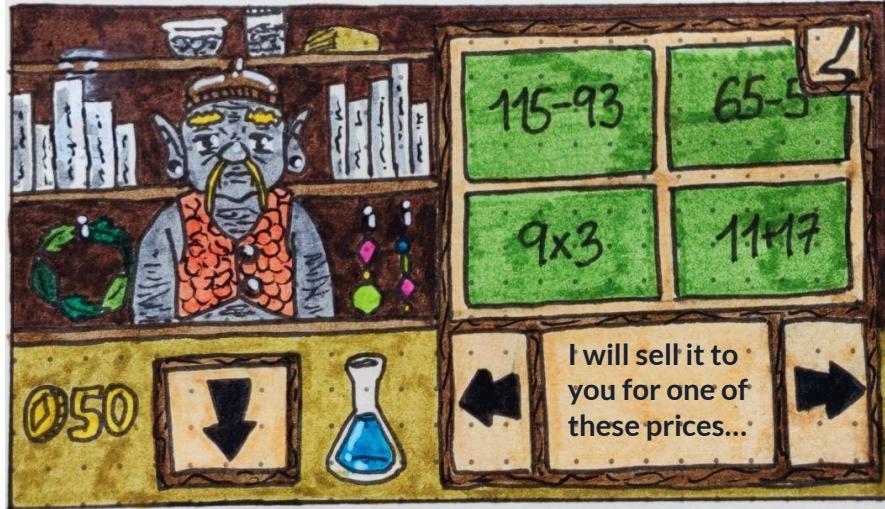
- BEDMAS practice
- Tap the runes in the correct order of operations to charge them
- You collect runes from completing character minigames



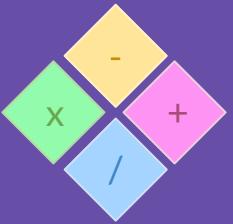
%

Old Man Abacus

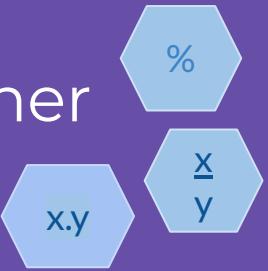
- Runs a shop
- Buys artefacts
- Sells power ups/boosts for minigames
- Calculates item prices & profits
- Offers sales
- He used to set prices by randomly grouping abacus counters, but he lost his abacus and now gives a selection of random equations as prices
- The player gets coins in exchange for helping villagers or selling potions to the shopkeeper



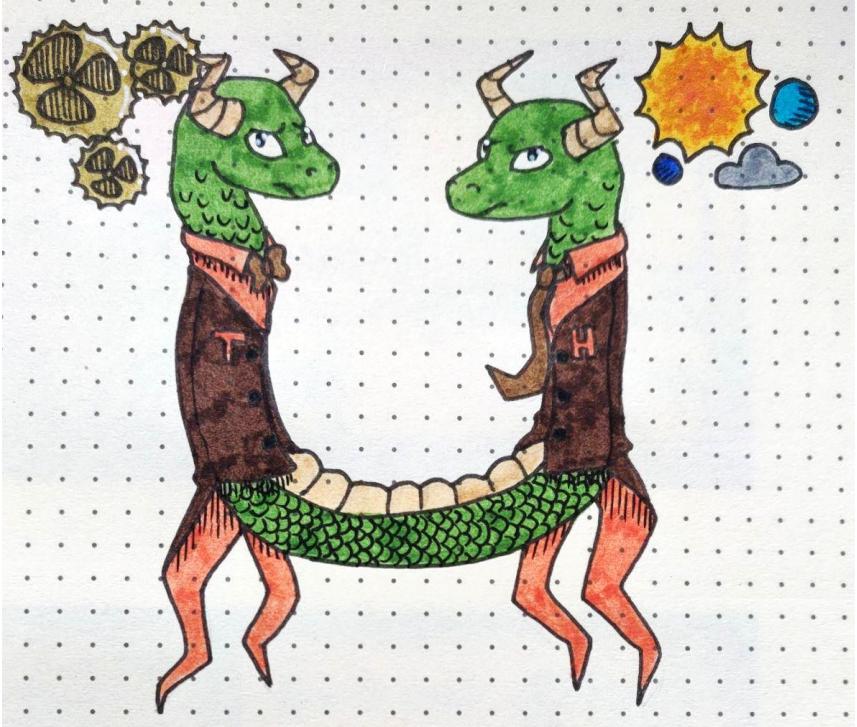
- Solve the equations and choose the price that is the best for you financially
- Harder levels include:
 - Percentages (sales and taxes)
 - Calculating “get one get second half price” deals
 - Calculating profits

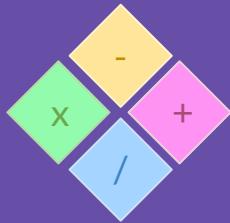


Tim & Heather twins

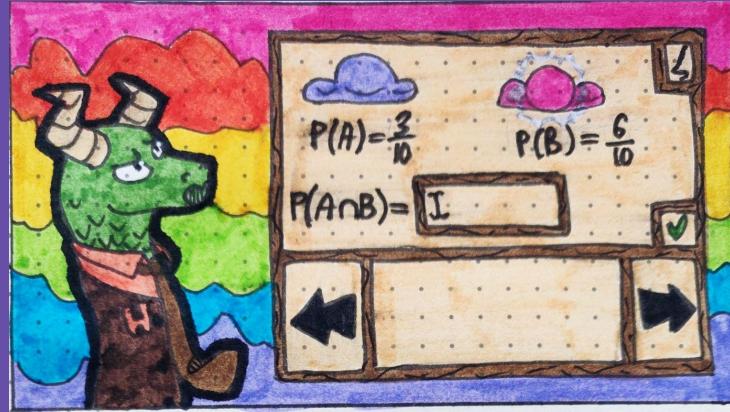


- Time and weather have never changed until maths came to this world
- Tim tells time
 - The clock hands have never moved before and now he needs help telling the time
- Heather calculates the probability of weather
 - The sky has always been the same purple colour, but now it occasionally changes to other colours every hour and she doesn't know how to predict that





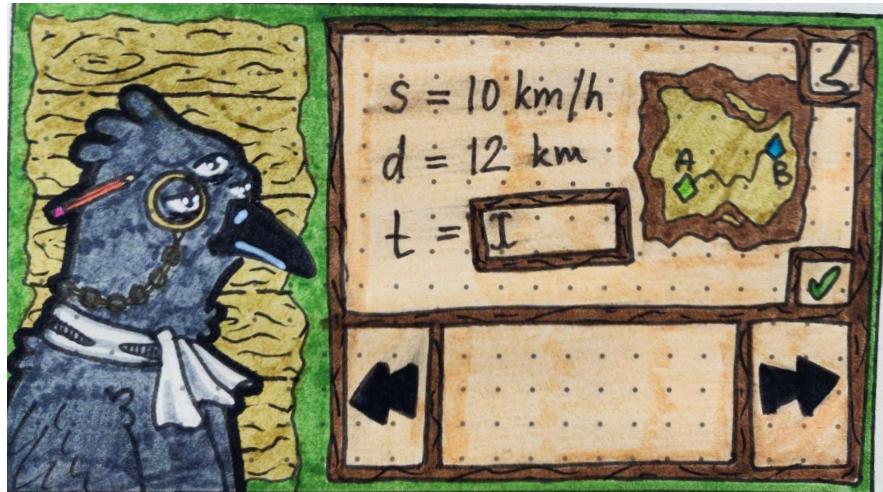
Tim & Heather puzzles

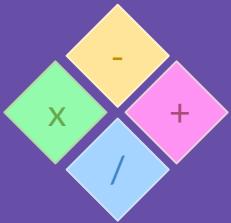


- Puzzles start at setting the correct time on a clock
- More advanced puzzles:
 - 24 hour vs 12 hour clock
 - Time equations ("if i leave at 3:30pm and travel for 2 hours and 15 minutes, at what time will I arrive?")
 - Converting hours and minutes to decimals
- Probabilities of different colour clouds based on daily forecast
- Set theory operations: union, intersection, not
- Advanced puzzles: conditional probability

Karr-tographer

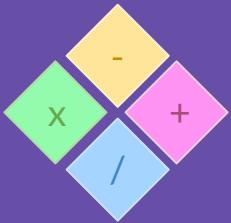
- In the past, travel was instant and the cartographer's maps were very simple, but now he needs help making accurate maps
- works with distance, time, and speed
- scales/ratios
- Basic pythagoras theorem for different roads going to one place





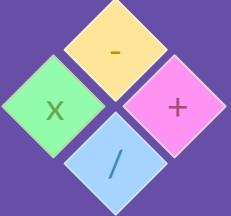
Accessibility - visual & auditory

- Visual
 - Strong reliance on colours in the game: setting to adjust hues or replace colours
 - Adjustable font & icon size
 - Auditory cues and voiced dialogue in each scene and minigame
- Auditory
 - Volume control setting (split into dialogue, ambient sounds, auditory cues, etc)
 - Helps people with auditory processing disorder (e.g. autism)
 - Subtitles on screen (i.e. text to accompany each instruction/dialogue)
 - Visual feedback when a button is pressed or an item is selected to pair with the auditory cues



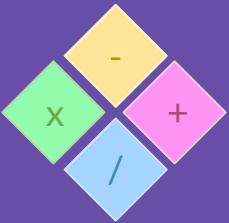
Accessibility - cognitive & mobility

- Animations and sound toggle
 - E.g. people with ADHD vs autism
- Timed puzzles are optional - don't penalise learners for answering slowly
 - Can be used to advance through the game faster (the faster you answer the more points you earn) but should not be essential for progression at a reasonable pace
- No dexterity- or reaction-based puzzles
 - Accessible to people with dyspraxia, mobility issues, other physical disabilities
 - The game is made engaging through other means instead
- Information is conveyed through both images and text where possible
 - Caters to people with different learning styles
 - Helps non-native english speakers



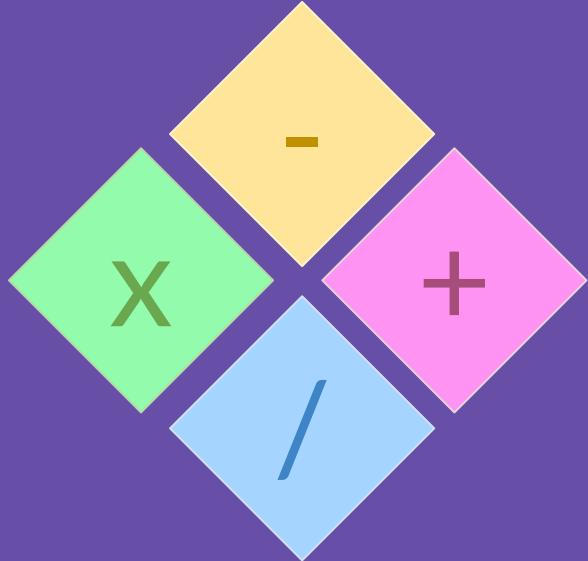
Evaluation - client requirements

- numeracy game - learn and practise basic maths concepts
- engaging/immersive
- increasing difficulty
- cross-platform compatibility
- Accessibility
- practical applications of math skills, real world scenarios,
- introduction to career paths
- collaborative elements



Evaluation - Octalysis

- **Epic meaning**
 - The player saves the world and helps villagers understand maths
 - Each minigame has a final goal that helps a character/advances their story
- **Empowerment**
 - Real-time feedback
 - Milestone unlocks (runes, sacred scrolls)
 - Some types of minigame boosts are available to buy from the shop (e.g. reveal the last number of the answer)
- **Social influence**
 - The player is a mentor to the characters
- **Unpredictability**
 - Randomly generated minigame values & equations
 - Visual storytelling
- **Avoidance**
 - Avoidance of progress loss within a minigame (incorrect answer = minigame restart) (however, no death)
- **Scarcity**
 - Characters are available for interaction at certain in-game times but not others (eg because of weather or away on own mission)
- **Ownership**
 - Exchangeable points (exchange coins for items in item shop)
 - Whiteboard (user has degree of control)
- **Accomplishment**
 - Progress bar on runes to show skill level achieved
 - Unlocking new runes



Thank You

Any questions?