

MATH CITY

A Futuristic Math classroom for STEM skills

a virtual city for real knowledge



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- Subject Coordinator – BEd (Secondary ICT)

TEACHING INTERESTS

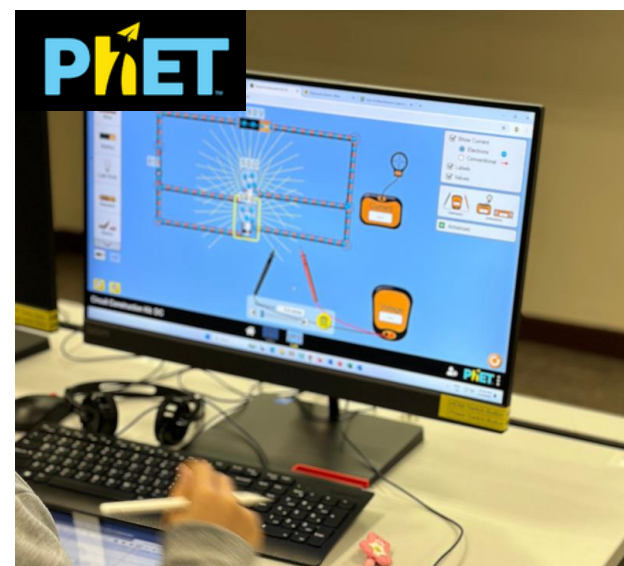
- Technologies in STEM and AI Education (Undergraduate university course)
- Information Technology Supported Learning Environment (Undergraduate university course)
- Learning and Teaching of Selected Topics in IT (Undergraduate university course)
- Trends and Development in Learning and Teaching of ICT (Undergraduate university course)
- Data Mining and STEM Education (Postgraduate university course)
- Metaverse in Education and Society (Postgraduate university course)



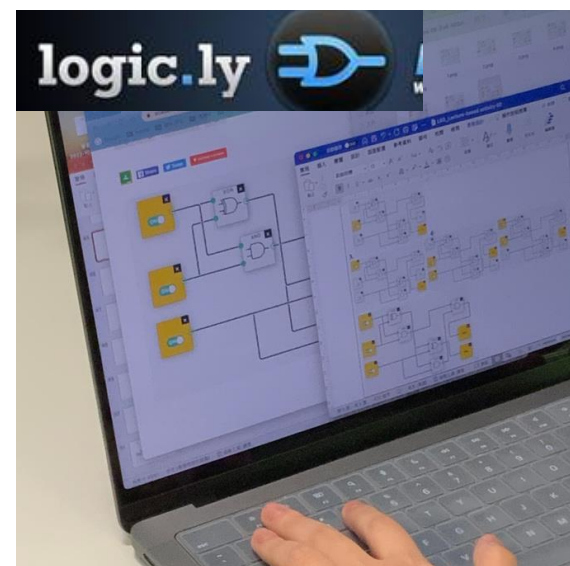
RESEARCH INTERESTS

- Immersive Metaverse technologies
- Interactive Simulated Experiments
- Gamification of STEM Education
- Artificial Intelligence (AI) & Virtual Reality (VR) in Education
- Human-AI interaction
- Virtual environments

Immersive STEM lessons



Electronics Fundamentals using a Simulated platform PhET



Boolean Algebra using Simulated platform logic.ly



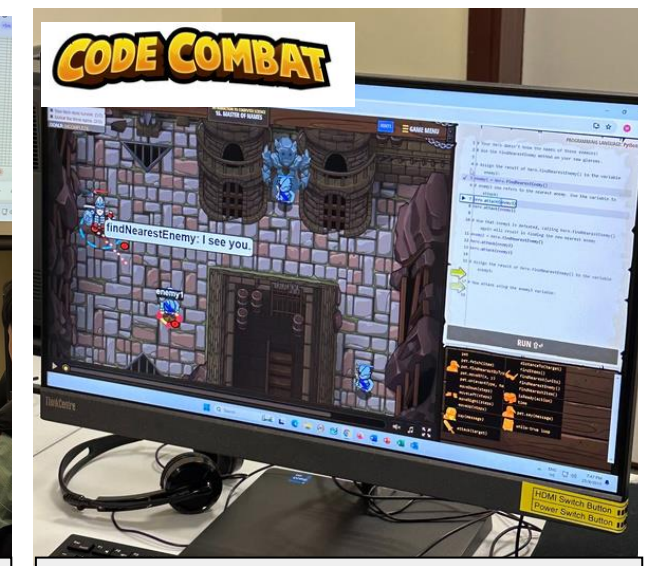
Mathematics using Immersive Metaverse Platform spatial.io



Chemistry lesson using the gaming platform Minecraft Education Edition.



Real-time teacher intervention using Collaboration board Miro



Coding fundamentals (Python) using a Gaming platform Code Combat

PART 1

INTRODUCTION



PART 2

FEATURES OF MATH CITY



PART 3

ENTER MATH CITY



PART 4

MATH CITY BADGE & DISCUSSION



MATHEMATICS

Discussion questions

Mathematics is considered one of the more difficult subjects studied in school, as students are required to solve verbal problems, handle research assignments, present situations using illustrations and mathematical representations, understand the properties of concepts and their relationships, and more (Gafoor, & Kurukkan, 2015).

“Why do you think students find mathematics difficult?”

“What’s the role of Visualizations in problem-solving in mathematics?”

ABSTRACT IDEAS?

LACK OF VISUALIZATION

TOO MUCH MEMORIZATION?

NO REAL-WORLD RELEVANCE?

$a^2 + b^2 = c^2$



- The ability to apply mathematics in real-world contexts is an essential skill for students.
- The HKSAR 2023 policy address (HKSAR Government, 2023) emphasised the need to strengthen students' mathematical modeling skills, thereby fostering local talent in STEAM education.
- The Education Bureau (2025) is also promoting mathematical modelling in schools.

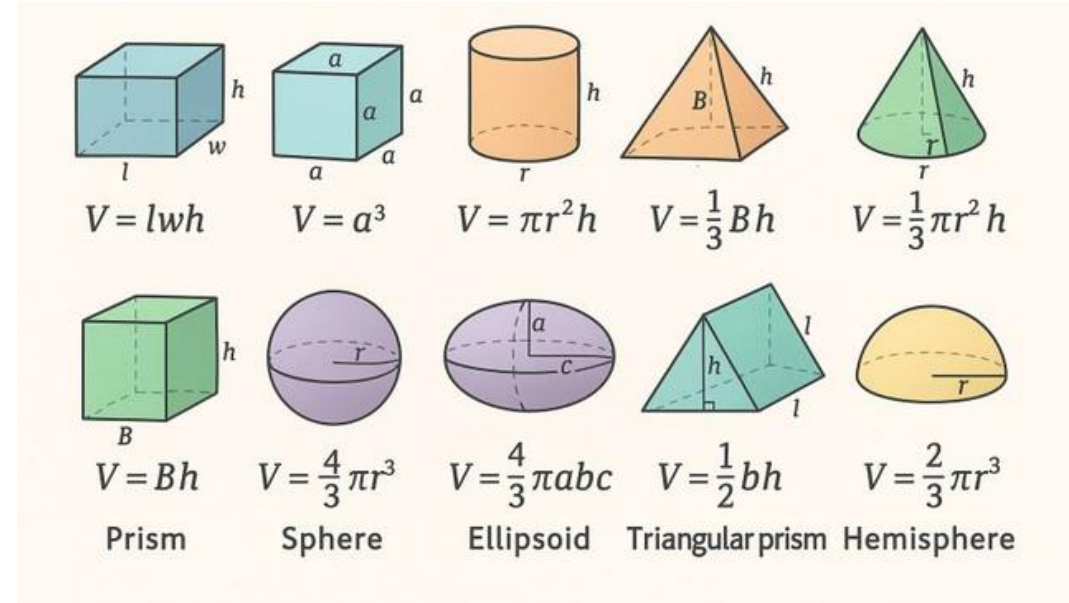


visualizing 3D SHAPES

- Folding a 2D "net" into a 3D shape
- Interpreting "plans" and "elevations."
- Euler's Formula
- Platonic Solids
- Polyhedra and Frustums

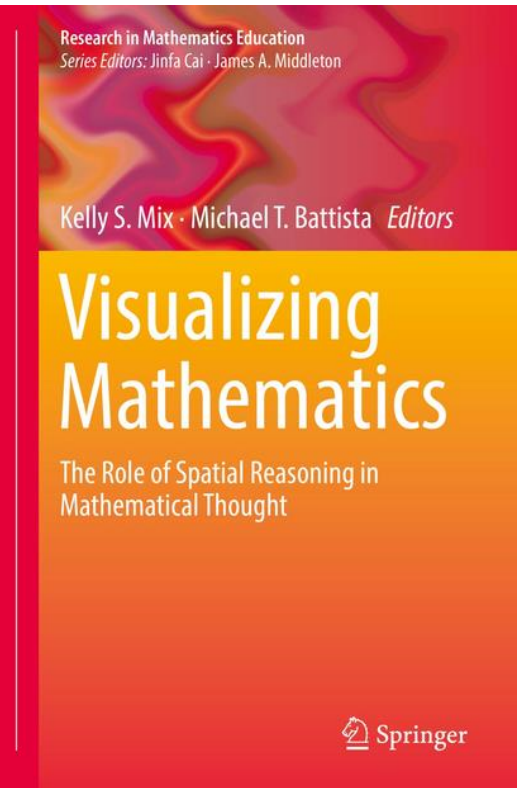
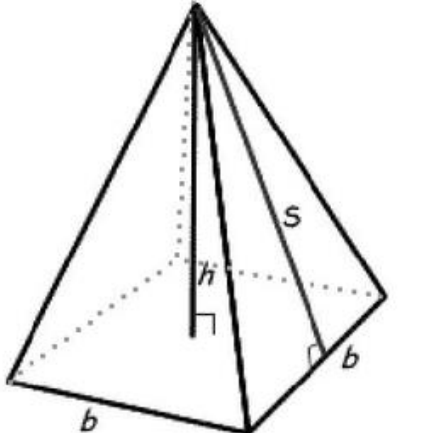
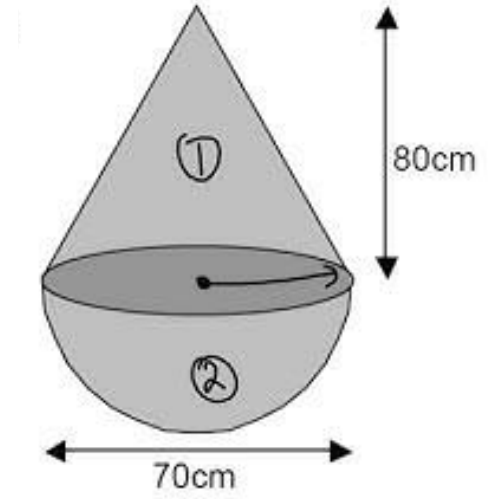
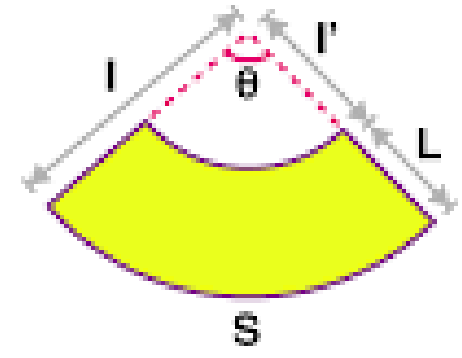
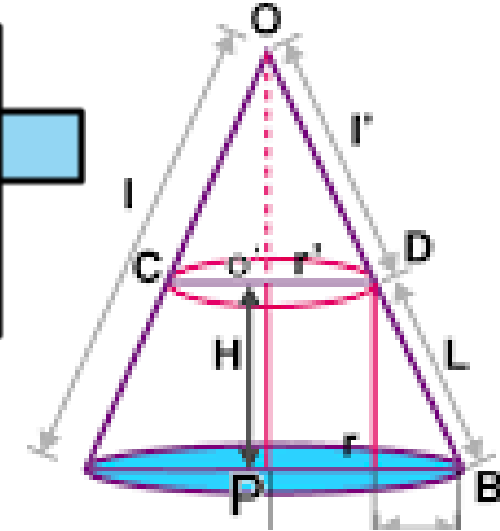
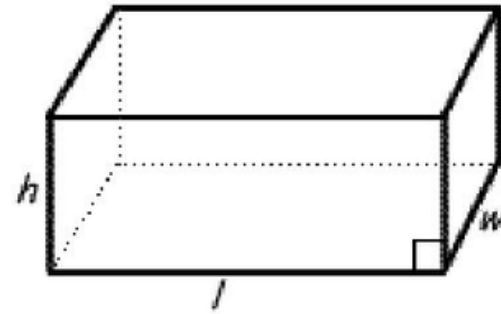
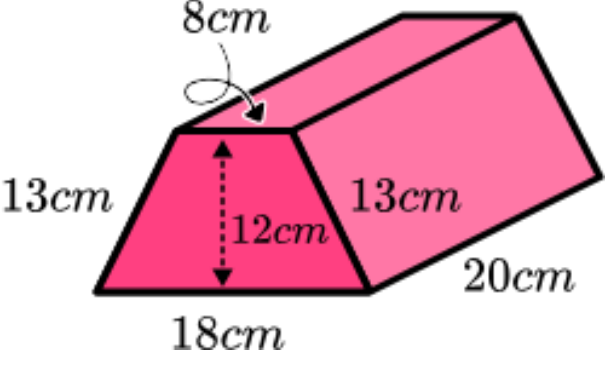
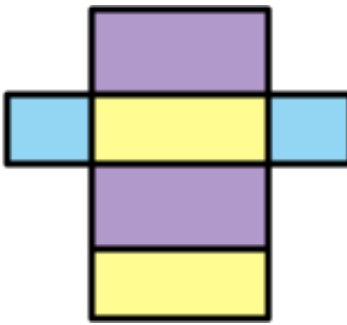
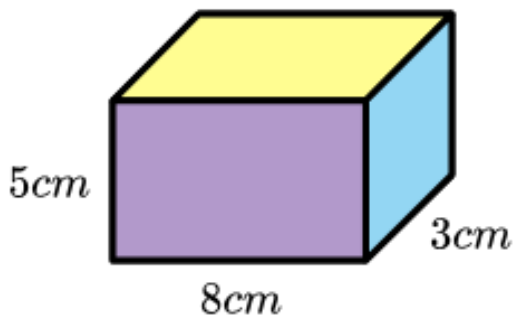
TRADITIONAL CLASSROOMS

- Static diagrams
- Passive learning
- Limited interaction



Abstract concepts such as 3D shapes are challenging under conventional teaching methods (He et al., 2020).

Spatial imagination, calculation, and reasoning abilities are also positively linked to STEM multidisciplinary literacy. (Ibrahim et al., 2024)



• He, X., Li, T., Turel, O., Kuang, Y., Zhao, H., & He, Q. (2020). The Impact of STEM Education on Mathematical Development in Children Aged 5-6 Years. *International Journal of Educational Research*, 109, 101795. <https://doi.org/10.1016/j.ijer.2021.101795>

• Ibrahim, M., Herwin, H., Retnawati, H., Firdaus, F. M., Umar, U. and Mufidah (2024). STEM Learning for Students Mathematical Numeracy Ability. *European Journal of STEM Education*, 9(1), 20. <https://doi.org/10.20897/ejsteme/15750>

rationale behind

MATH CITY

MATH CITY IS DESIGNED TO ADDRESS EXACTLY THESE

CHALLENGES.

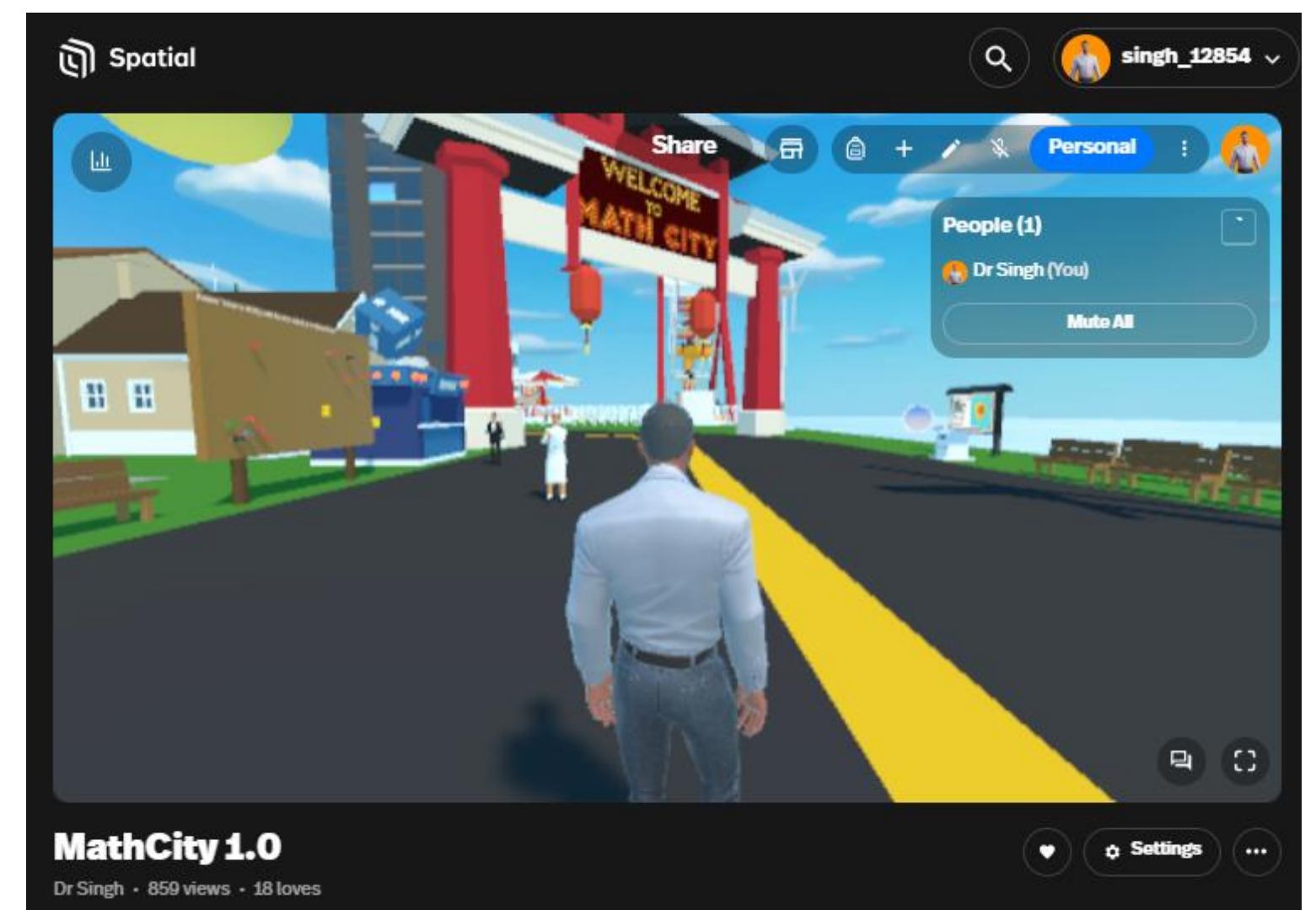
- Static diagrams
- Passive learning
- Limited interaction
- Visualizing 3D shapes in immersive environment
- Active learning
- Interactivity



MATH CITY?

gain real knowledge in the virtual world.

- A 3D virtual city aligned with the 5E inquiry model for studying the abstract mathematics topic “properties of 3D shapes” in an immersive game-based collaborative learning environment
- Focusing on Mathematics Education and STEM skills



Developed by using..



Unity



Sketchfab



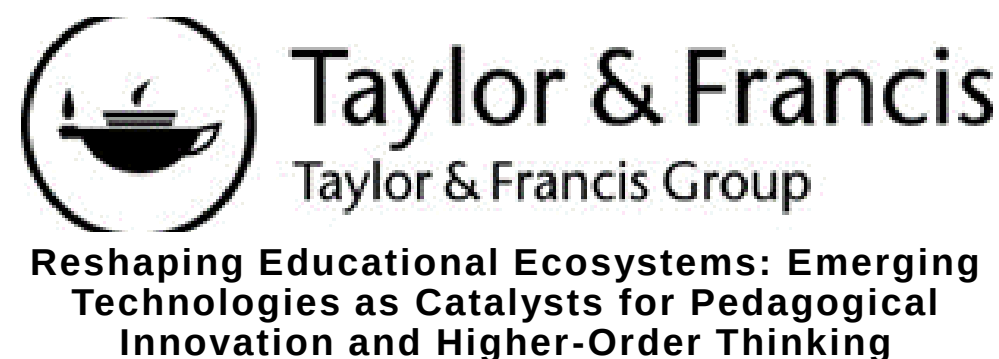
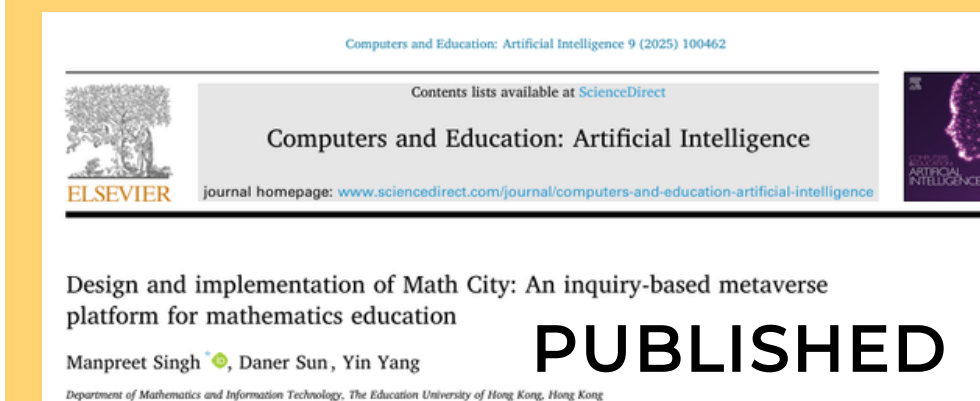
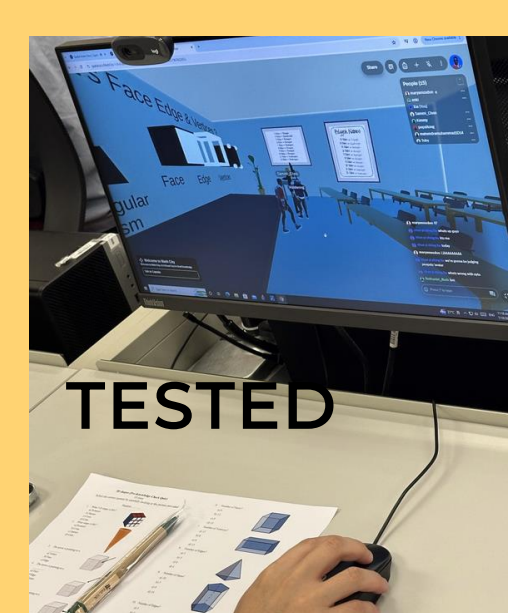
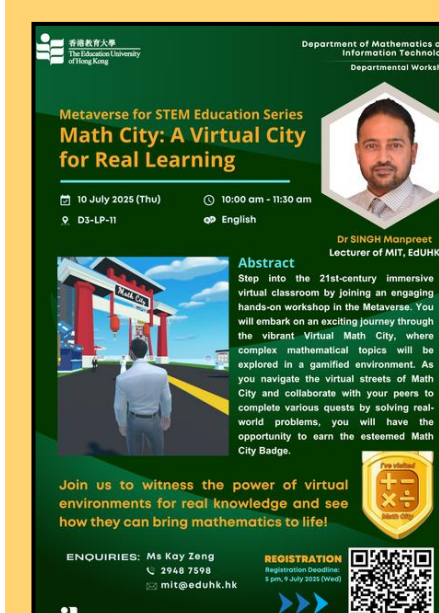
Spatial



MATH CITY *validation*

TESTED * PUBLISHED * SHORTLISTED * NOMINATED

- After pilot-testing with approximately 1.4K diverse users from backgrounds in science, education, and technology programs, Math City has achieved a Sysyen Usability Score (SUS) of 74.39, placing it in the acceptable usability tier.
- The peer-reviewed research publication in the Q1 journal Computers & Education: Artificial Intelligence (Singh et al., 2025).
- Math City was featured as a model teaching initiative by the Faculty of Liberal Arts and Social Sciences (FLASS) at the **Learning and Teaching @EdUHK Festival 2025**
- Math City was among the shortlisted entries for the Times Higher Education (THE) Awards Asia 2026 in the category **Technological or Digital Innovation of the Year**, from over 500 international entries
- Math City is nominated for **TIME Best Inventions of 2026—Education: Classroom & Teaching Tools**.
- Math City is included as a Routledge book chapter titled "**Reshaping Educational Ecosystems**".



- Singh, M., Sun, D., & Yang, Y. (2025). Design and implementation of Math City: An inquiry-based metaverse platform for mathematics education. Computers and Education: Artificial Intelligence, 9, 100462. <https://doi.org/10.1016/j.caeai.2025.100462>

PART 2

FEATURES OF MATH CITY



PEDAGOGICAL MODEL

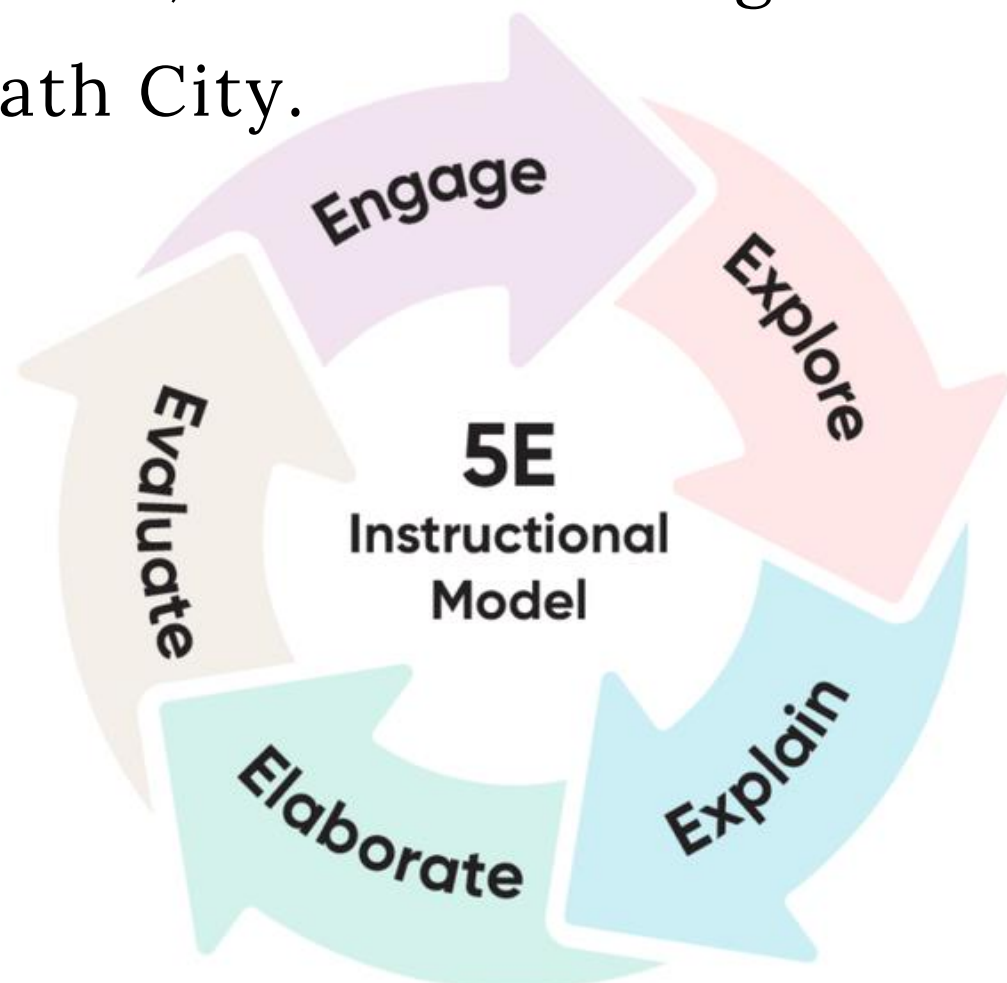
VIRTUAL SPACES

NON-PLAY CHARACTERS (NPCS)



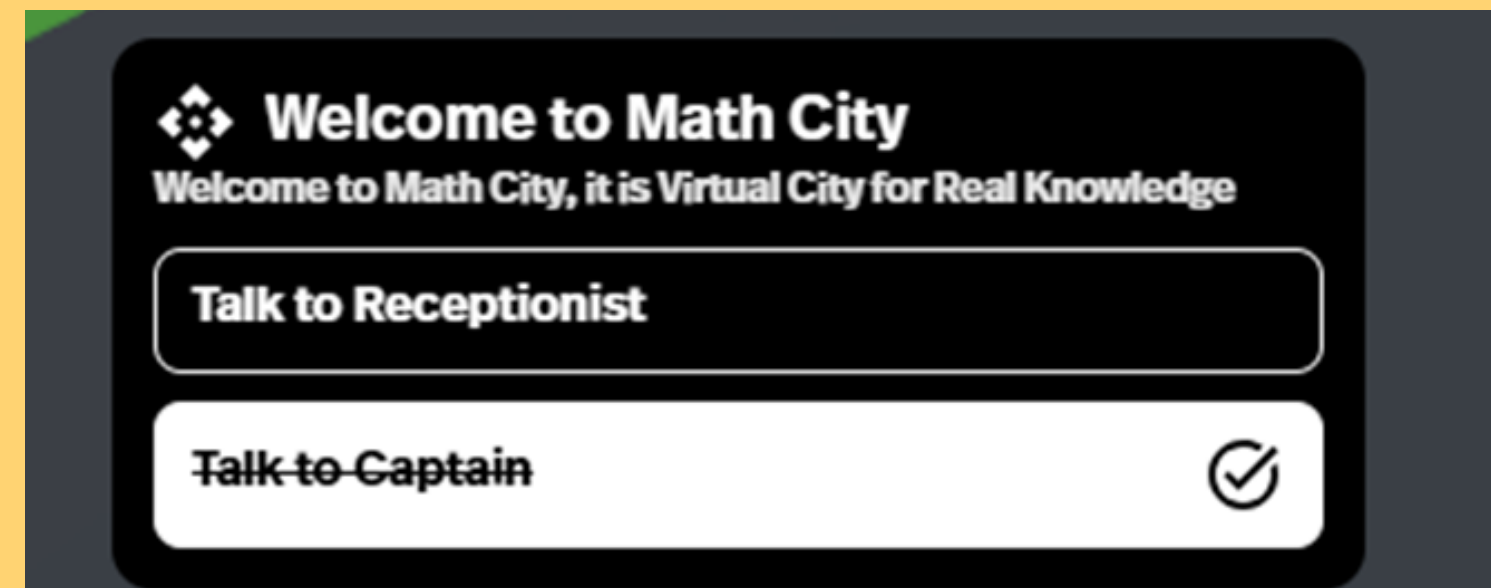
PEDAGOGICAL *frameworks*

The 5E Inquiry model (Bybee 2009), a well-known pedagogical framework in science and STEM education, is used to design various virtual spaces in Math City.



5E INQUIRY MODEL

Game-Based Learning is an educational approach that uses games to enhance student engagement and facilitate learning (Ding & Yu, 2024)



GAME-BASED LEARNING



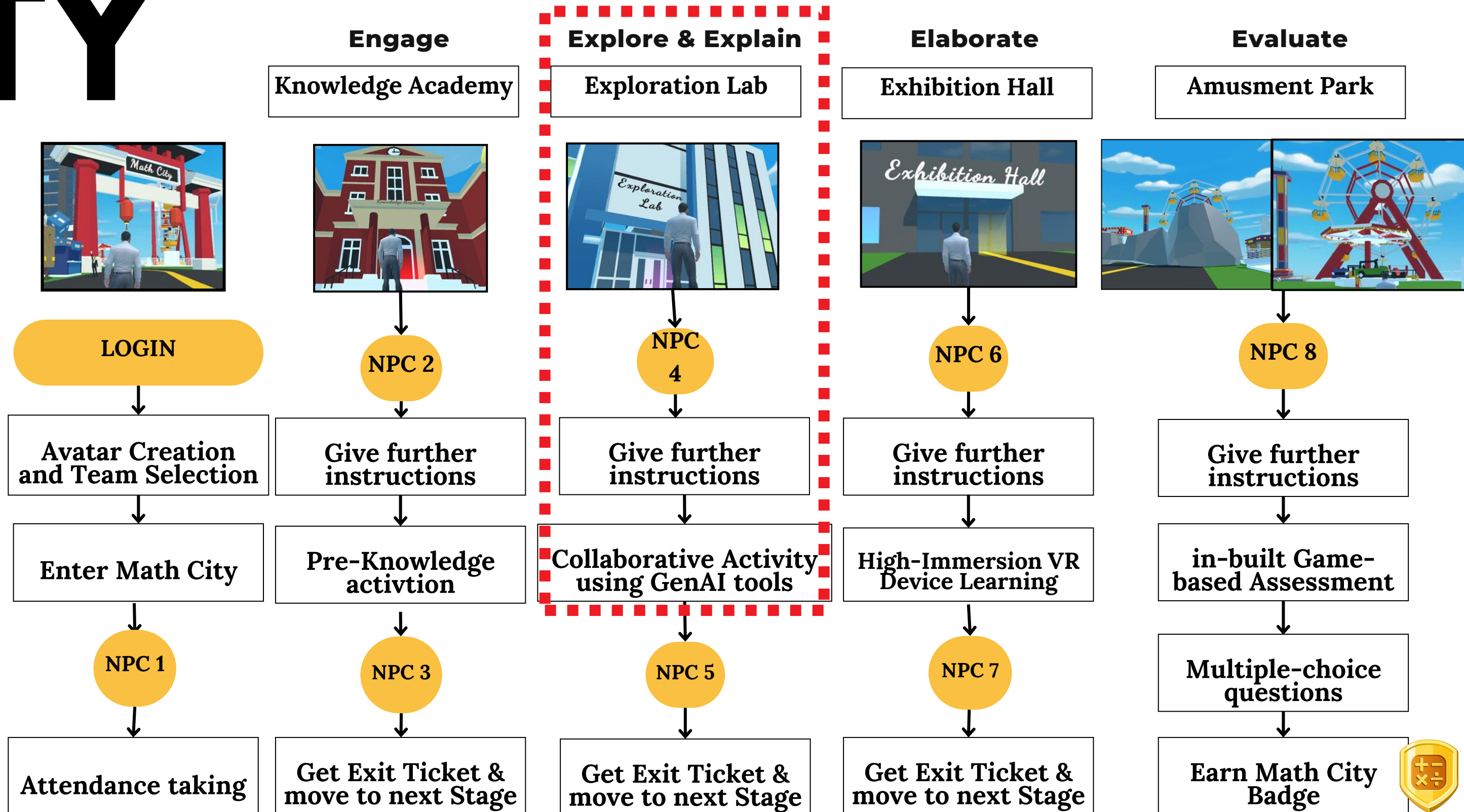
- Bybee, R. W. 2009. The BSCS 5E Instructional Model and 21st Century Skills. Colorado Springs, CO: BSCS
- Ding, A. E., & Yu, C. (2024). Serious game-based learning and learning by making games: Types of game-based pedagogies and student gaming hours impact students' science learning outcomes. Computers & Education, 218, 105075. <https://doi.org/10.1016/j.compedu.2024.105075>.

MATH CITY

VIRTUAL SPACES

The different virtual spaces in Math City are designed to align with the different stages of the 5E Inquiry model (Bybee 2009). Collaborative activity using the GenAI tool is embedded in the exploration stage, and an authentic assessment is embedded in the evaluation stage.

5E INQUIRY FRAMEWORK



The passage to the amusement park would be blocked at first, and it can be cleared only by completing all the tasks in the quest.



MATH CITY

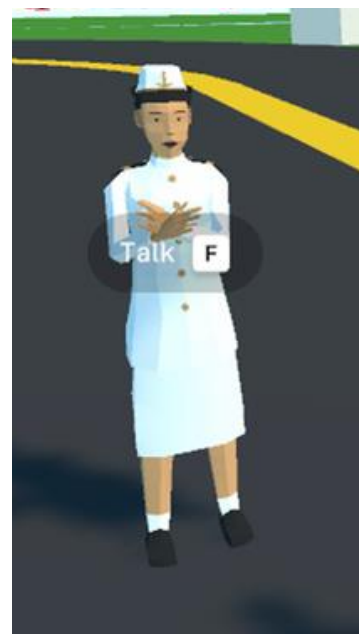
NON-PLAY CHARACTERS (NPCS)

PRESS

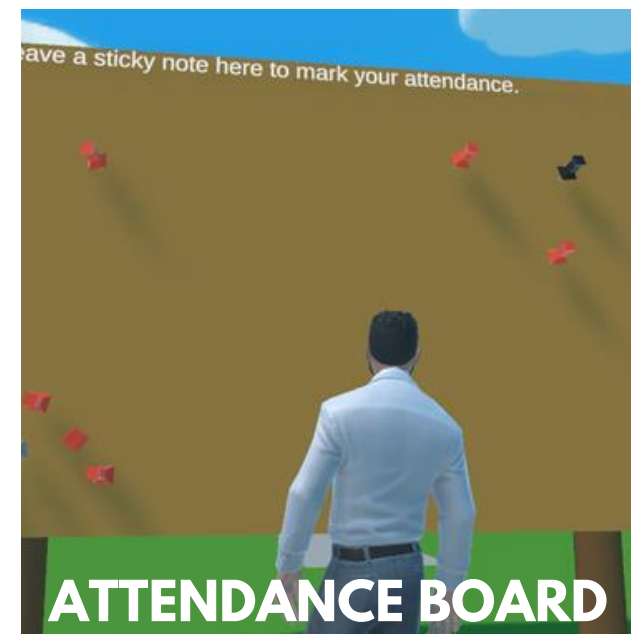


interact with
everyone

- Based on game-based learning (Ding & Yu, 2024), a quest-based system embedded within a game world in which students receive quests from non-player characters (NPCs) and complete math tasks to progress is embedded in the Math City to improve mathematics achievement and maintain high interest, especially in low-achieving students (Yeh et al., 2019).
- Game-based interactive features like attendance board and instructions guide are also embedded to promote active learning, student engagement, motivation, and enjoyment (Sun et. al., 2023)



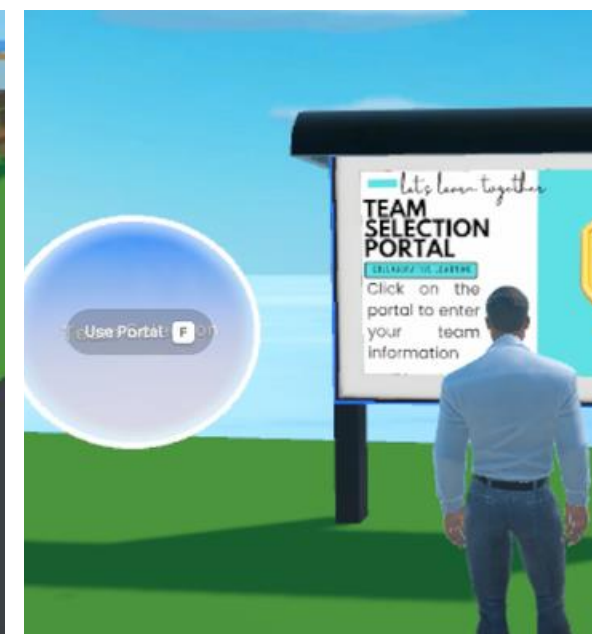
Talk to NPCs by pressing F Key to get further instructions



ATTENDANCE BOARD
Leave a sticky note on the board to mark your attendance in the Math City



INSTRUCTIONS GUIDE
Read the instructions



Click on the team selection portal



Game-Quest to earn Math City Badge

- Ding, A. E., & Yu, C. (2024). Serious game-based learning and learning by making games: Types of game-based pedagogies and student gaming hours impact students' science learning outcomes. Computers & Education, 218, 105075. <https://doi.org/10.1016/j.compedu.2024.105075>.
- Yeh, C., Cheng, H., Chen, Z., Liao, C., & Chan, T. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. Research and Practice in Technology Enhanced Learning, 14. <https://doi.org/10.1186/s41039-019-0100-9>.
- Sun, L., Kangas, M., & Ruokamo, H. (2023). Game-based features in intelligent game-based learning environments: a systematic literature review. Interactive Learning Environments, 32, 3431 - 3447. <https://doi.org/10.1080/10494820.2023.2179638>.



Submission portal

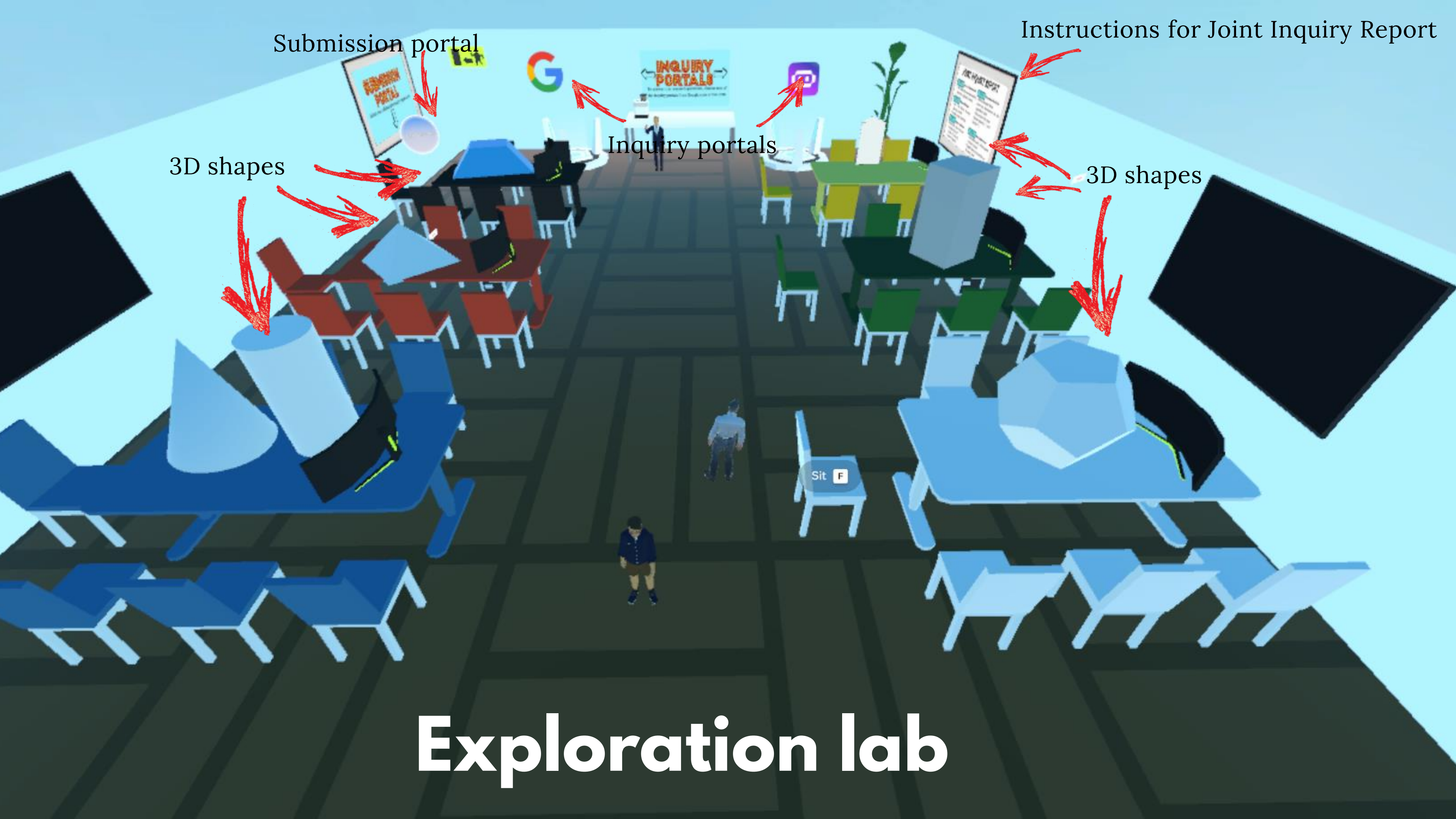
Instructions for Joint Inquiry Report

3D shapes

Inquiry portals

3D shapes

Exploration lab



integration of GenAI

- GenAI portals (poe.com and Google AI) embedded in the Exploration Lab
- Exploration Lab aligns with the Explore and Elaborate stages of the 5E model

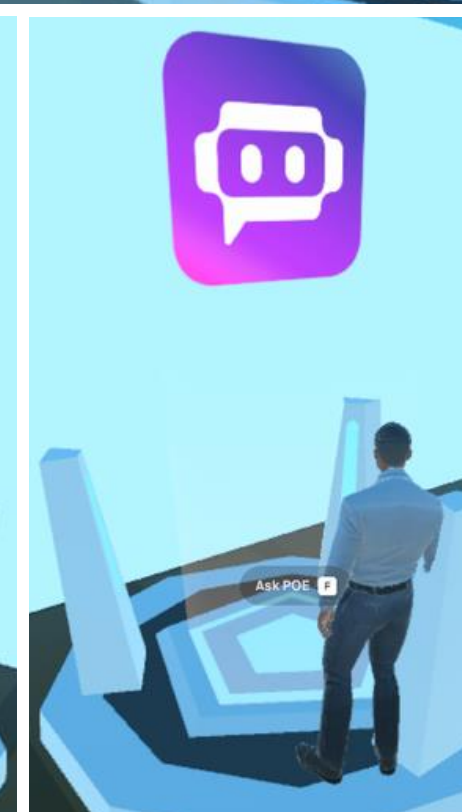
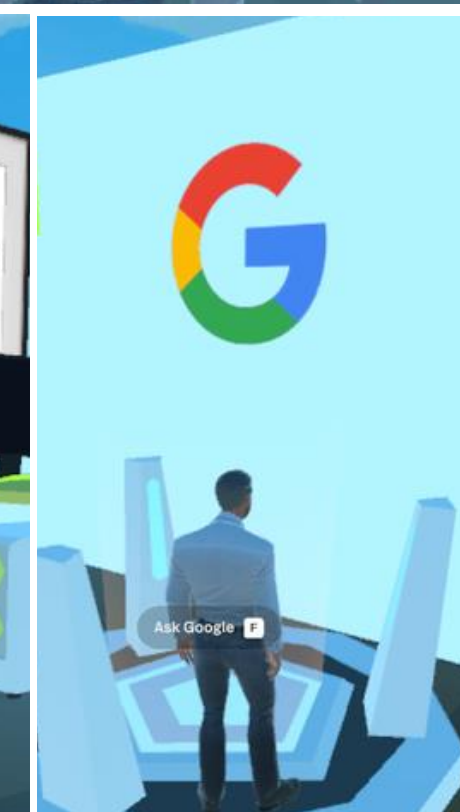
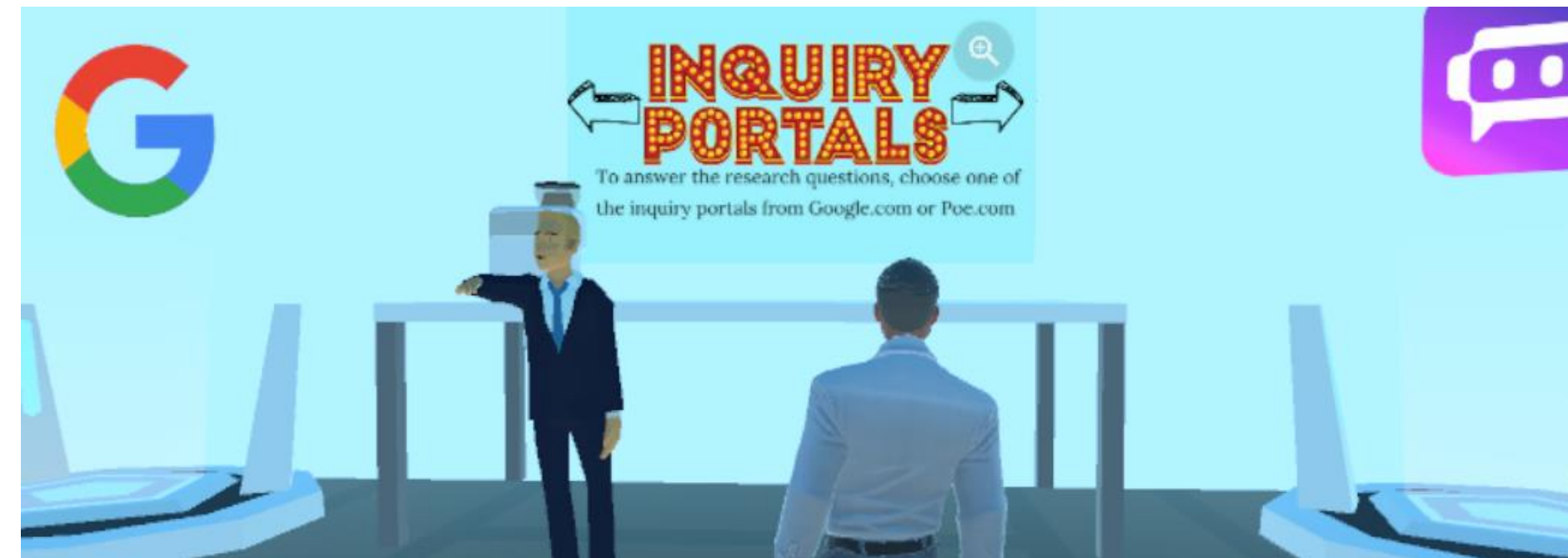
GenAI tools act as “objects-to-think-with”:

- Support deeper conceptual understanding
- Encourage reflective dialogue
- Inquiry questions are displayed in the virtual lab

collaborative Inquiry & Assessment

Work collaboratively in teams to:

- Read inquiry questions posted in the Exploration lab
- Use GenAI tools under teacher supervision
- Prepare and submit a joint inquiry report
- Completion of reports unlocks subsequent quests in Math City



Math City - Exploration Lab
Joint Inquiry Report

Submitted by: _____

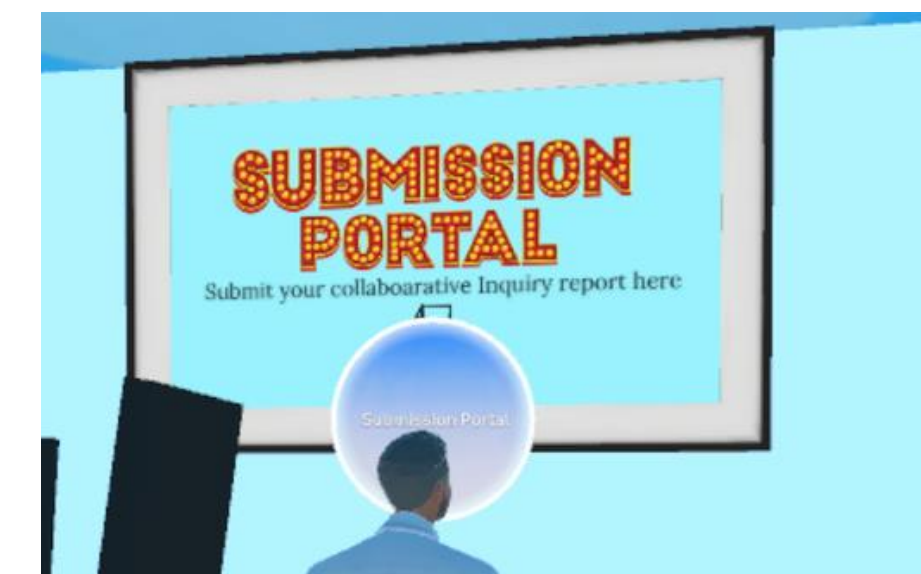
Item	Name of the Shape	Number of Faces (F)	Number of Vertices (V)	F+V	Number of Edges (E)
1					
2					
3					
4					
5					
6					

Report your findings

Compare the values of F+V and E

1. What do you notice about the relationship between F+V and E?
2. Do all shapes follow the same pattern?
3. Can you form a rule connecting faces, edges, and vertices?

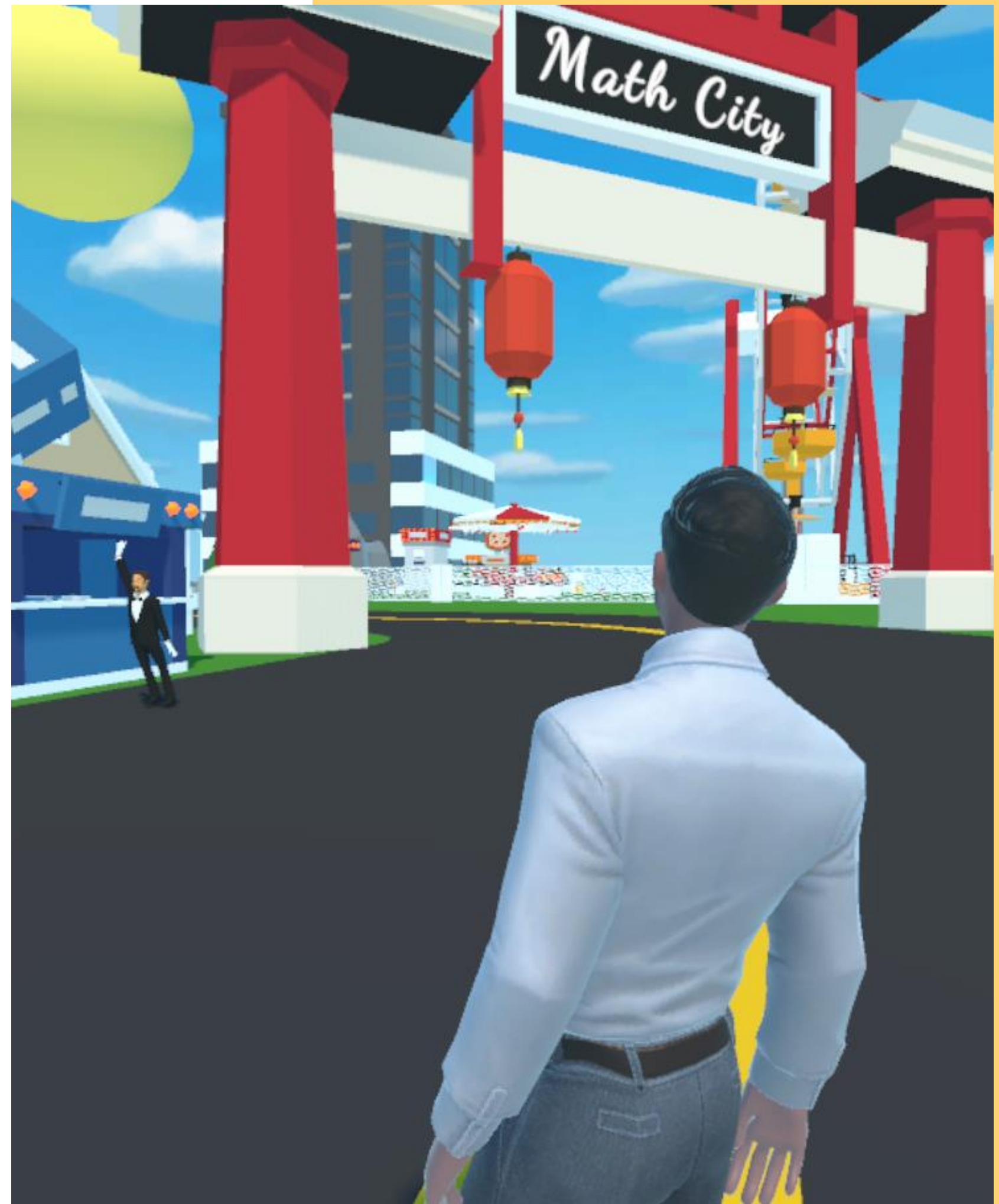
Copy the links from the Exploration portal and paste them here _____



let's explore it together

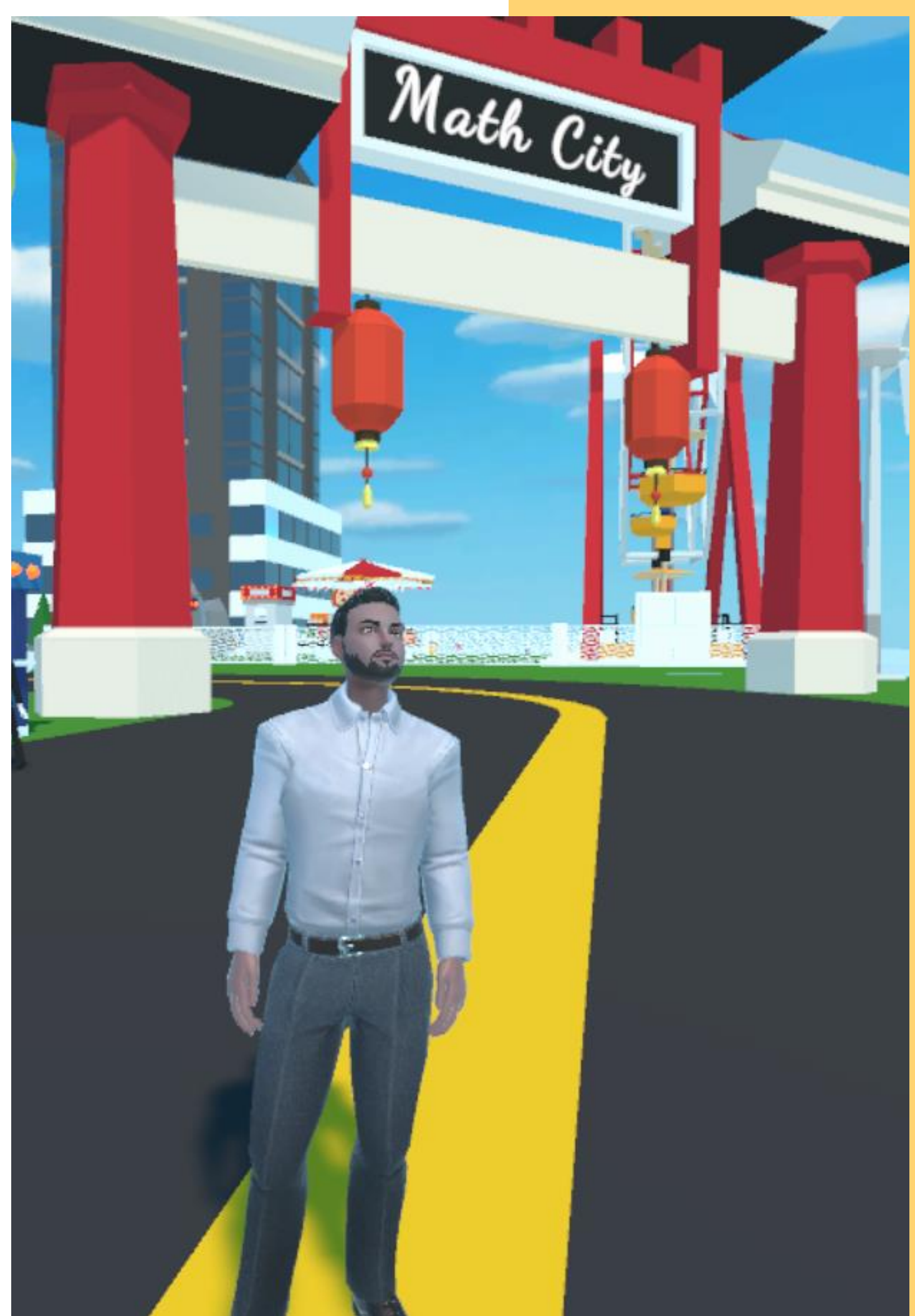
PART 3

ENTER MATH CITY



steps to enter **MATH CITY**

- 1 LOGIN
- 2 DIGITAL AVATAR CREATION
- 3 TEAM SELECTION
- 4 ENTER MATH CITY

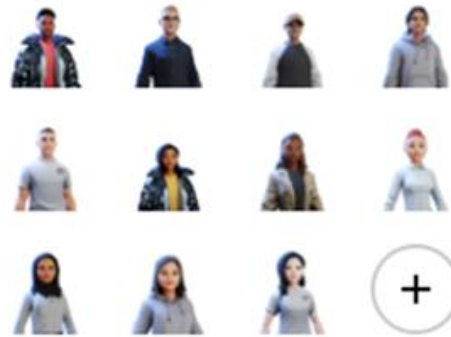


1

LOGIN



Customize Avatar



CREATE *READY
PLAYER
ME* AVATAR

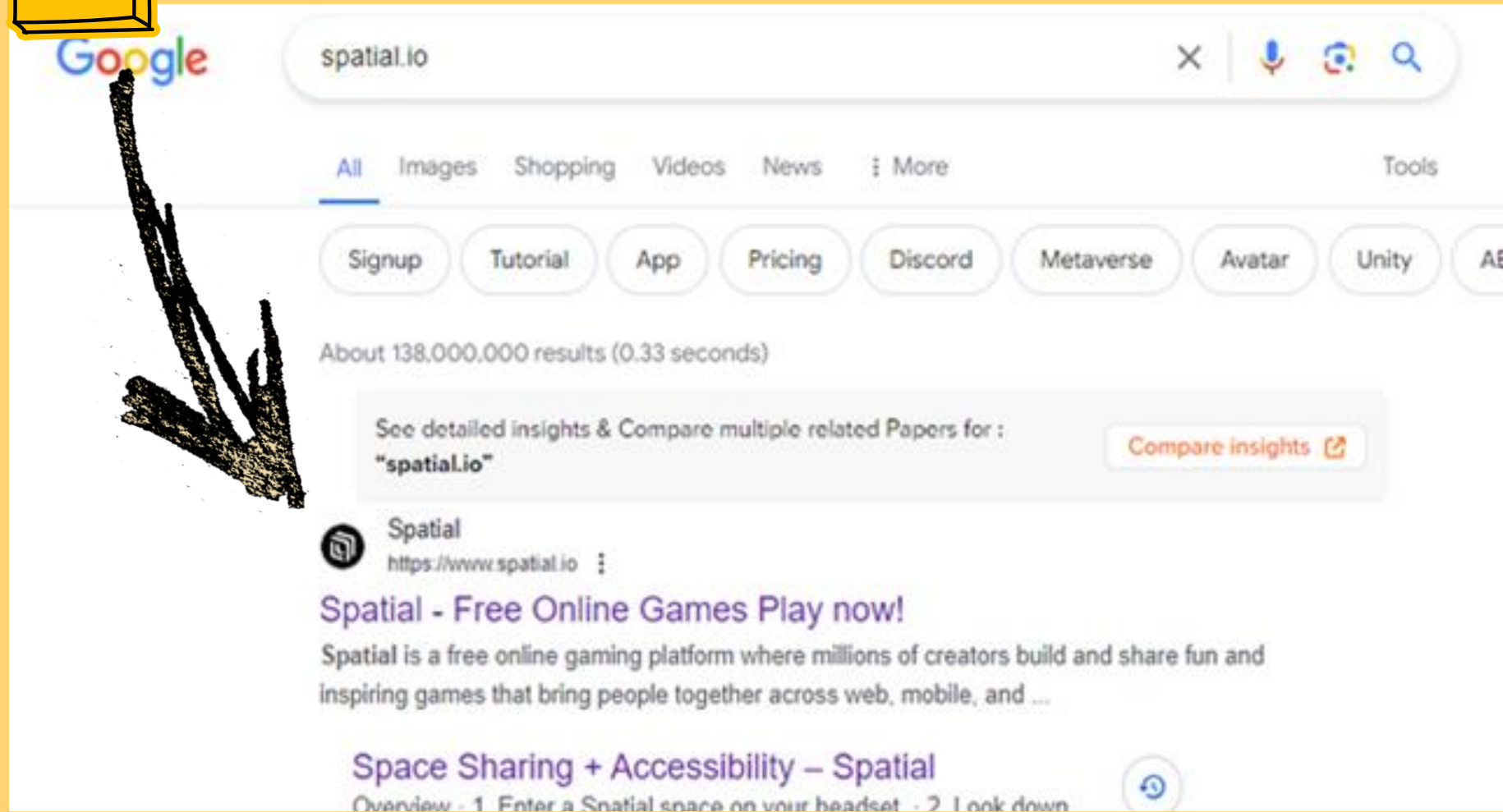
USE REALISTIC HEAD

Save

Cancel

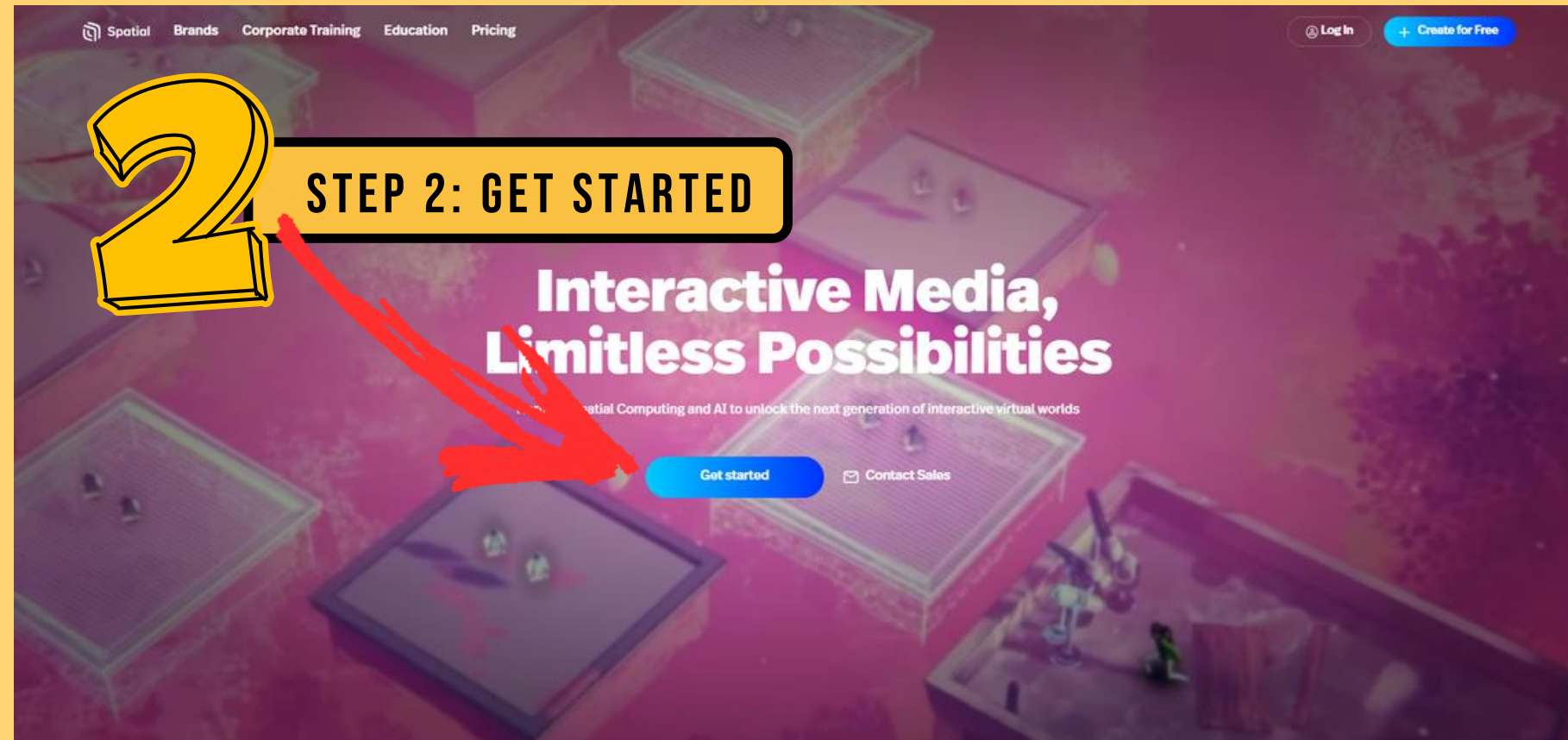
1

STEP 1: GO TO SPATIAL.IO

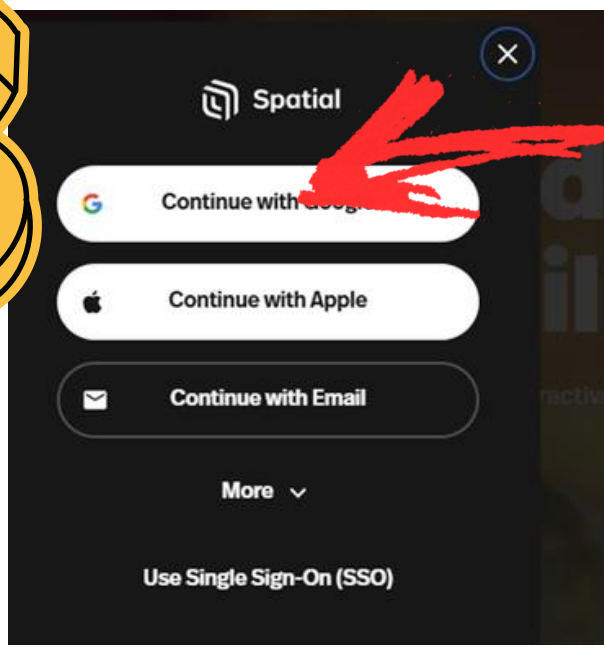


2

STEP 2: GET STARTED

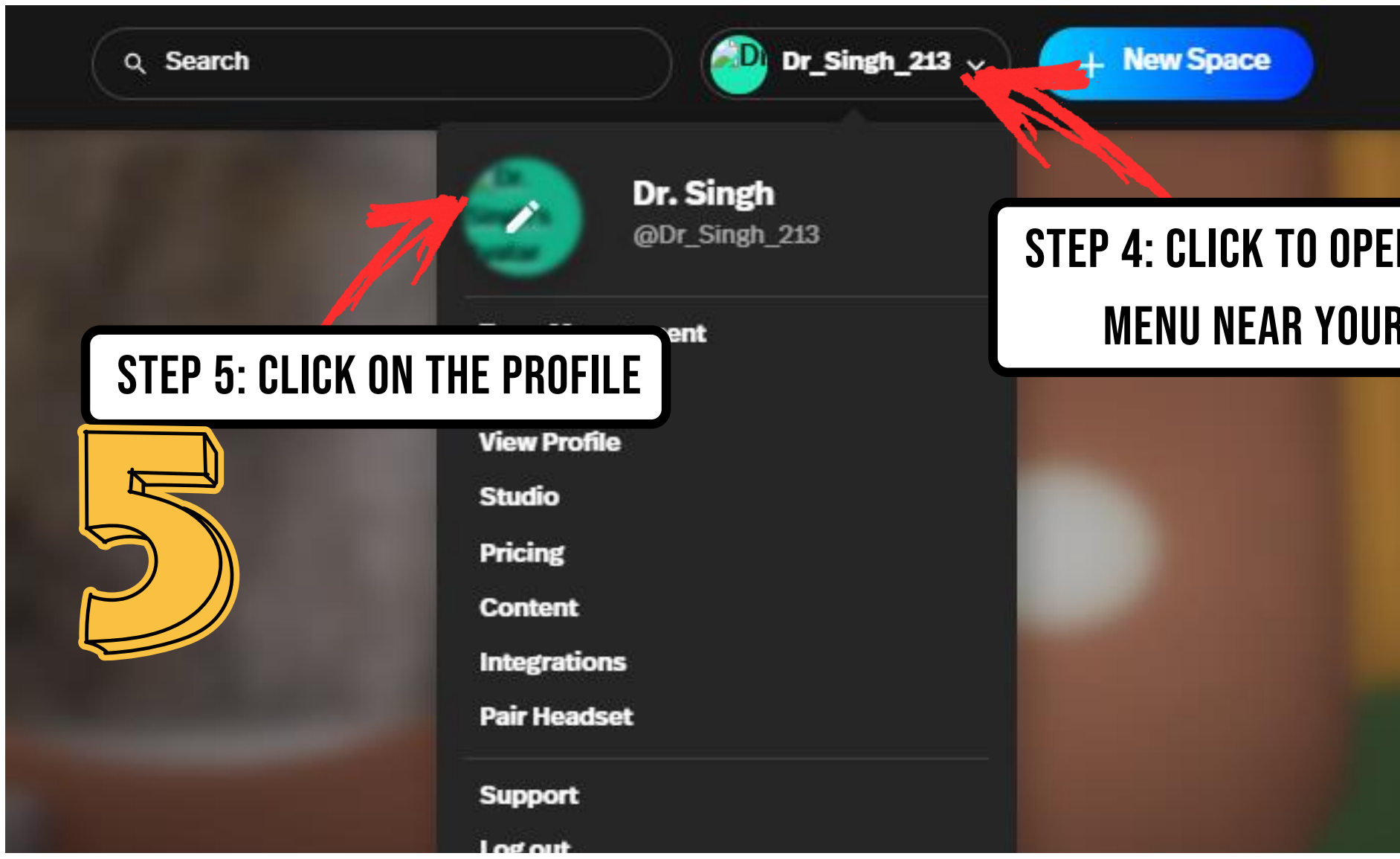


3



STEP 3: CONTINUE WITH GOOGLE

4



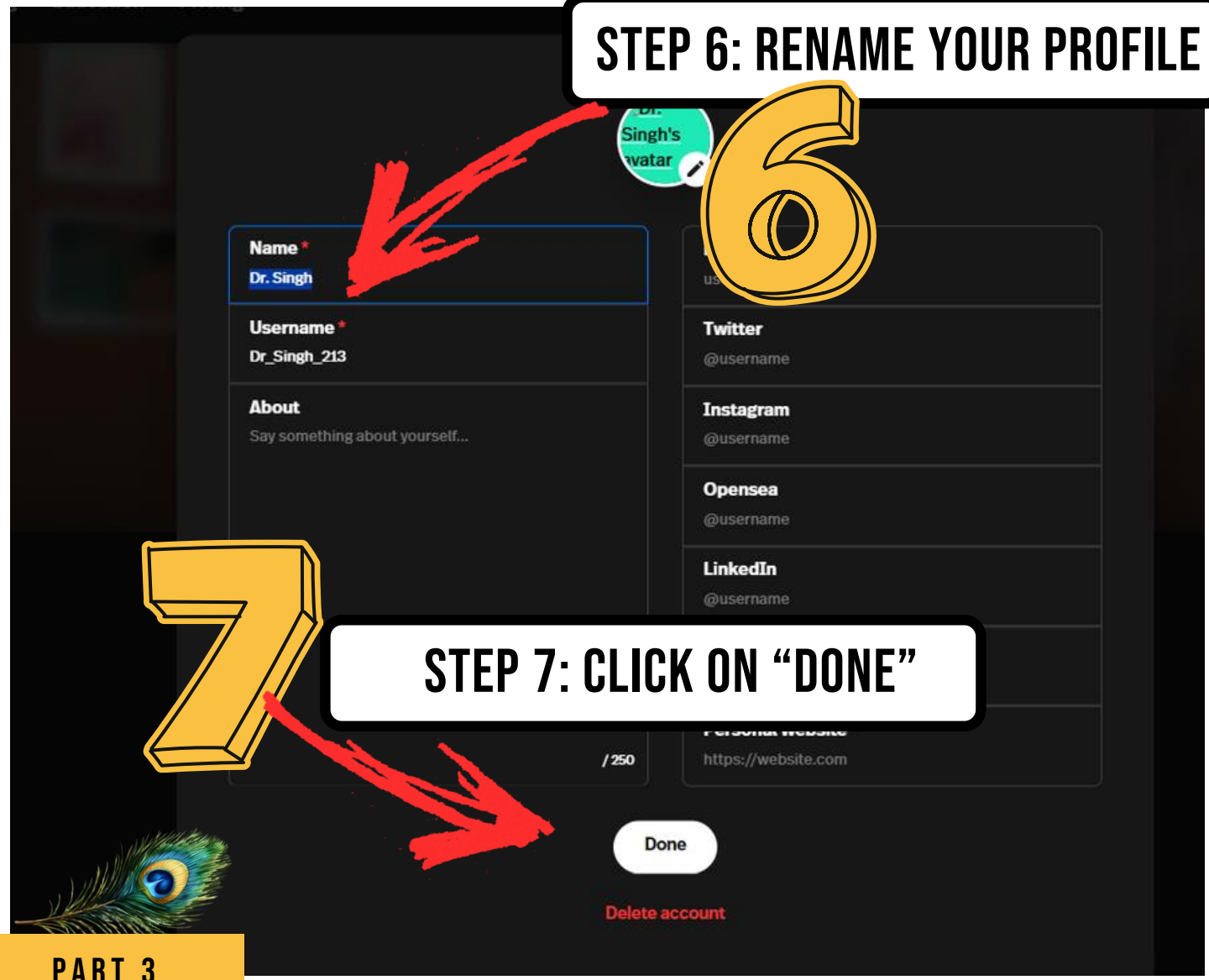
STEP 4: CLICK TO OPEN DROP DOWN MENU NEAR YOUR PROFILE

STEP 5: CLICK ON THE PROFILE

5

STEP 6: RENAME YOUR PROFILE

6



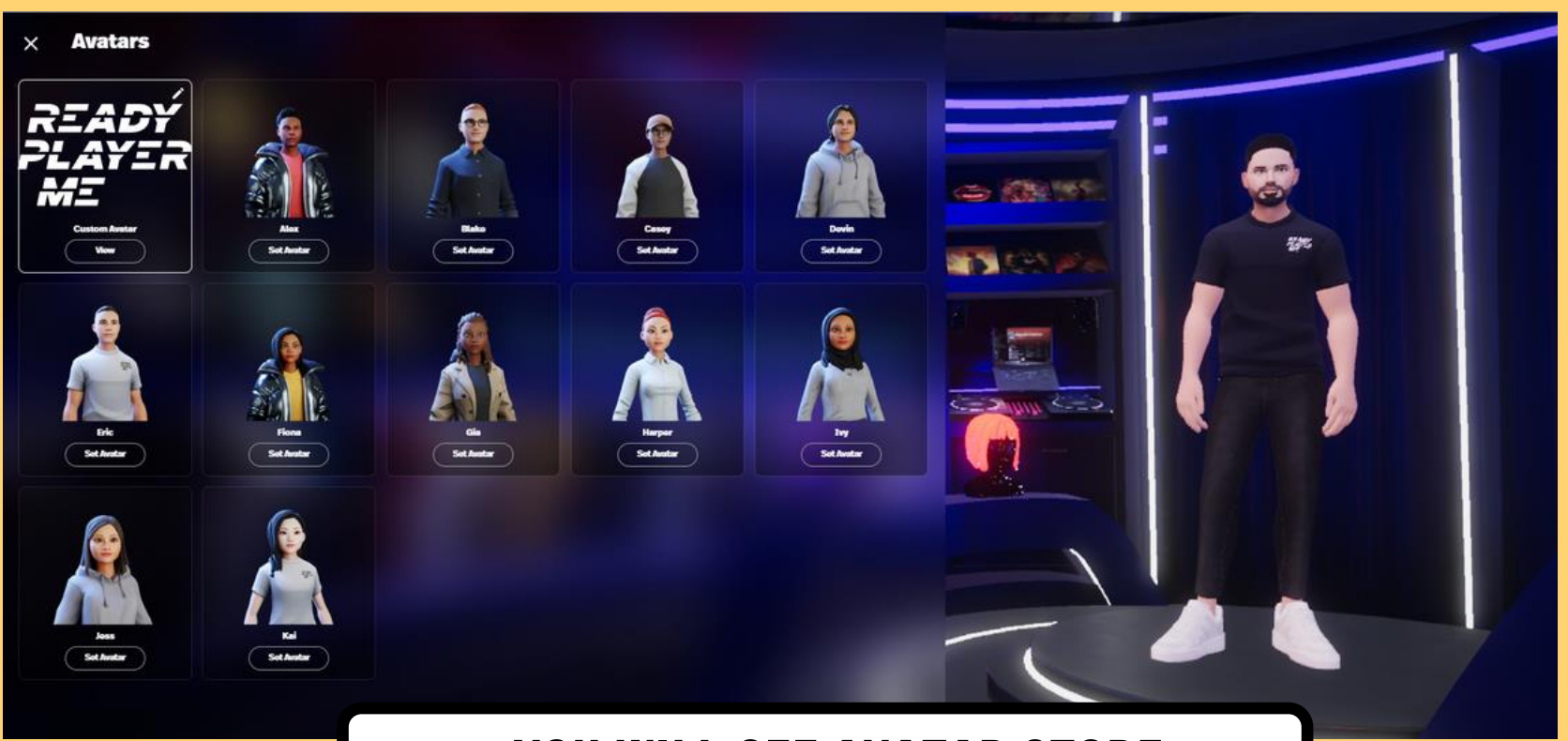
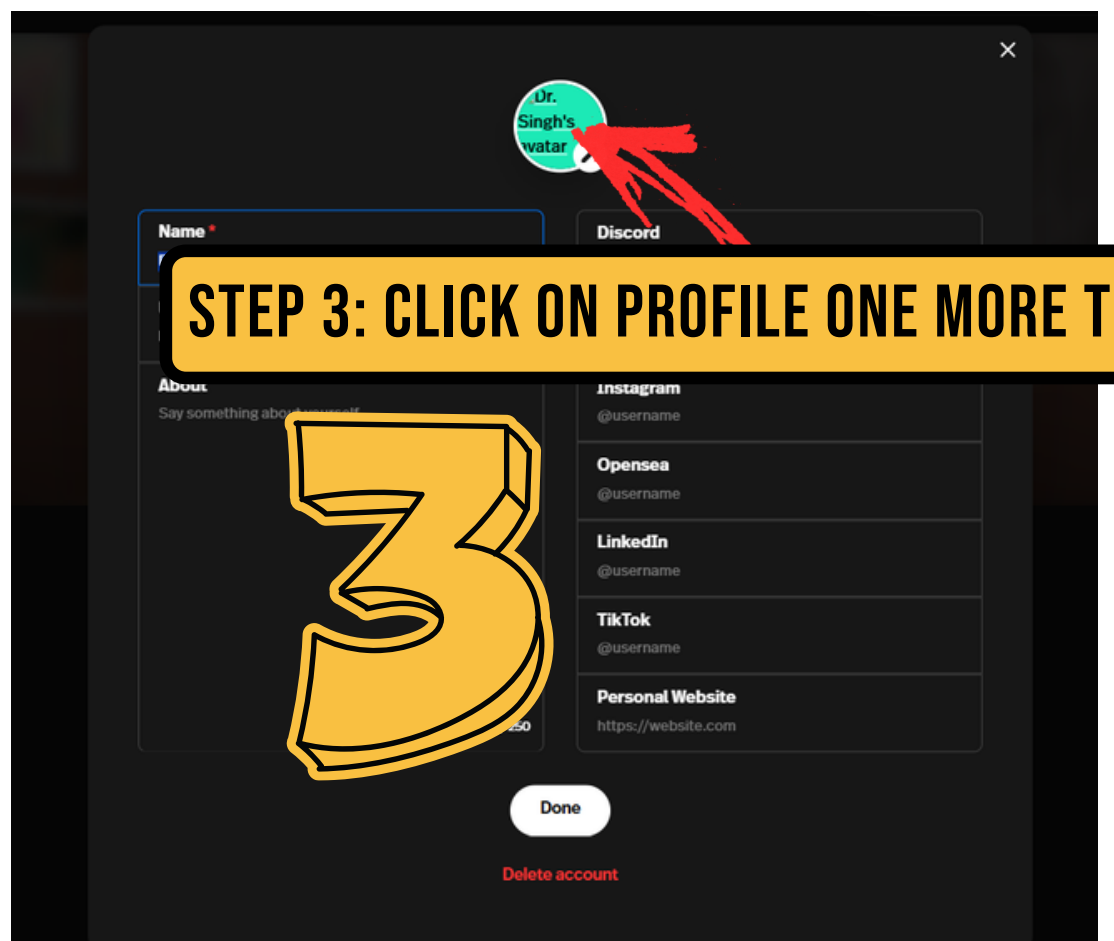
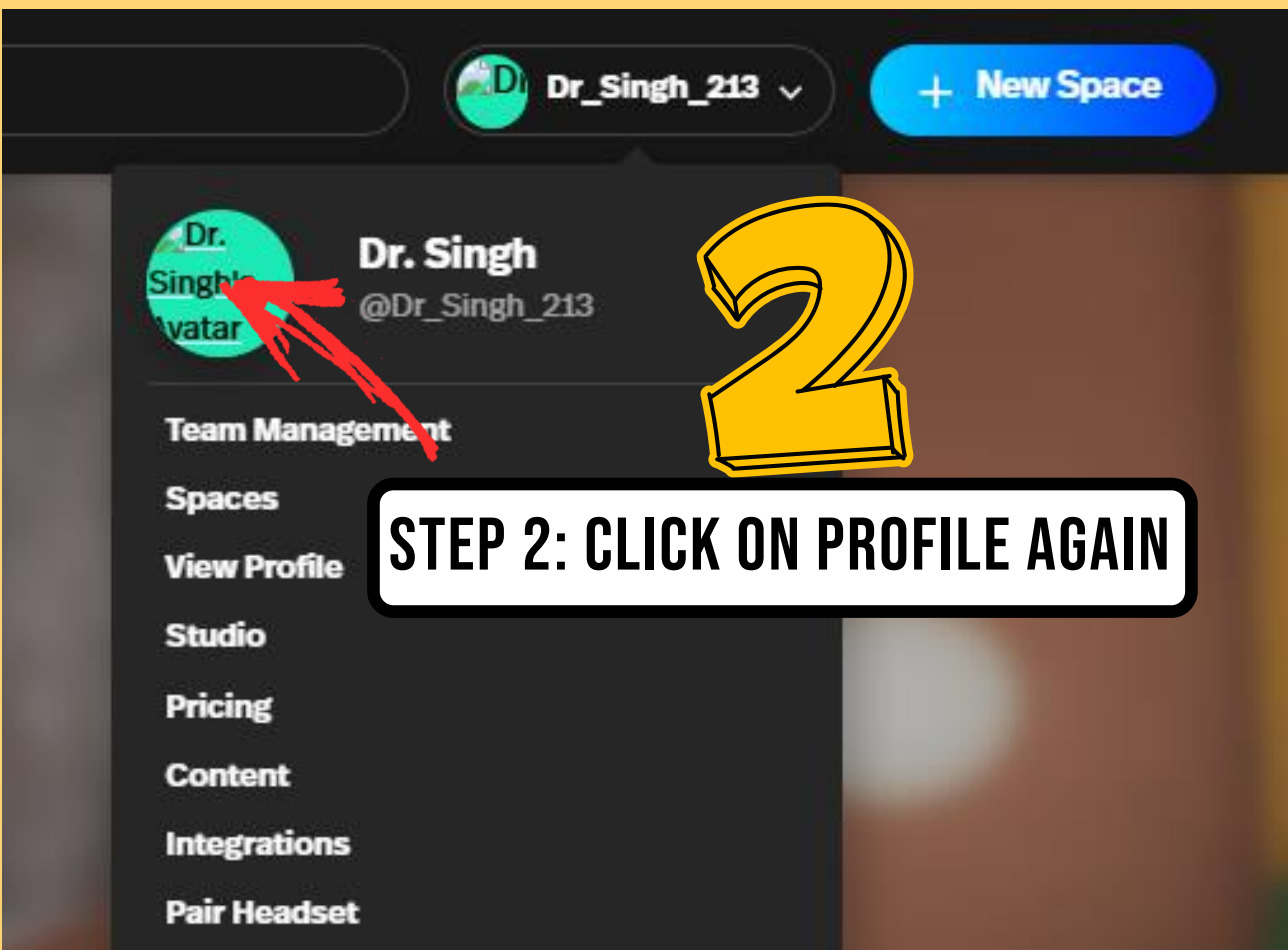
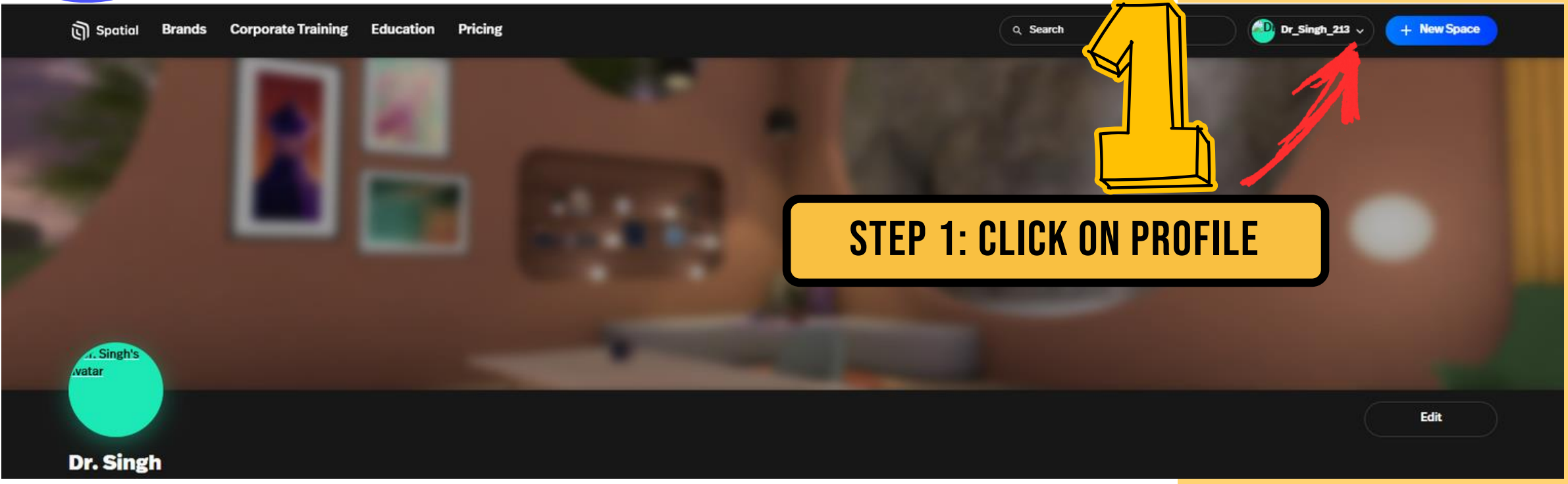
STEP 7: CLICK ON "DONE"

7

Use your real name to enter Math City



DIGITAL AVATAR CREATION



3

TEAM SELECTION

Avatars

In the avatar store, you will find different avatars to choose from.



TEAM 1 - BOY



Alex

Set Avatar

TEAM 2 - BOY



Blake

Set Avatar

1

2

TEAM 1 - GIRL



Fiona

Set Avatar

TEAM 2 - GIRL



Gia

Set Avatar

- Divide yourself into teams or groups.
- Each team should consist of 6-7 members.
- For easier recognition in virtual space, all group members should choose the same character.
- For example, all members of Team 1 must choose either Alex (Boy) or Fiona (Girl).
- Similarly, Team 2 members need to choose Blake (Boy) or Gia (Girl).
- Same for other teams



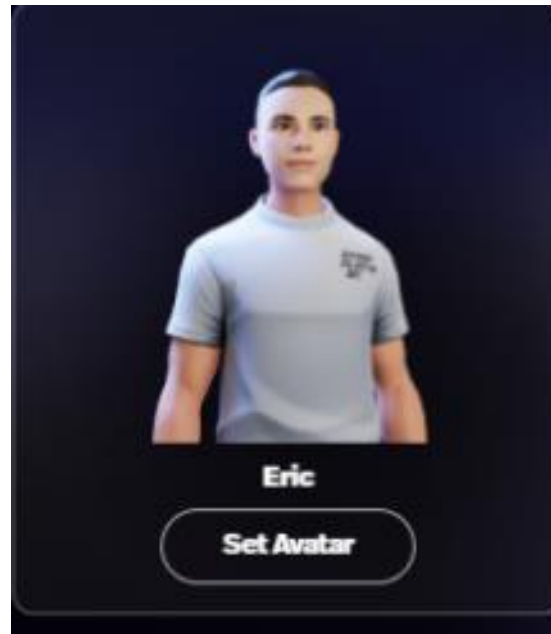
TEAM 3 - BOY



TEAM 4 - BOY



TEAM 5 - BOY



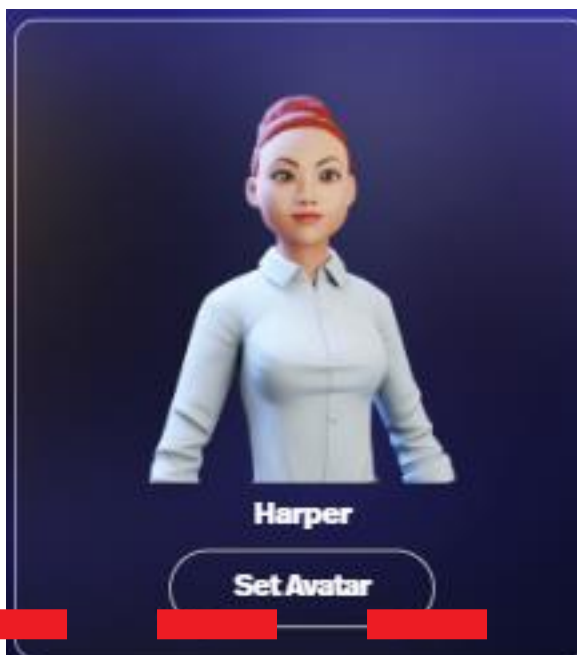
3

4

5

6

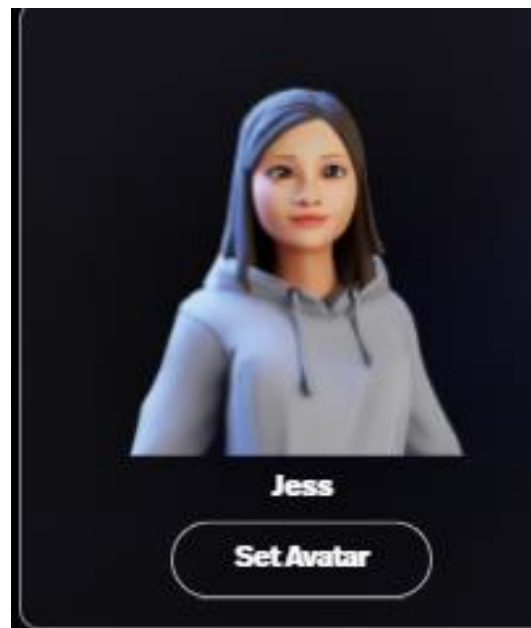
TEAM 3 - GIRL



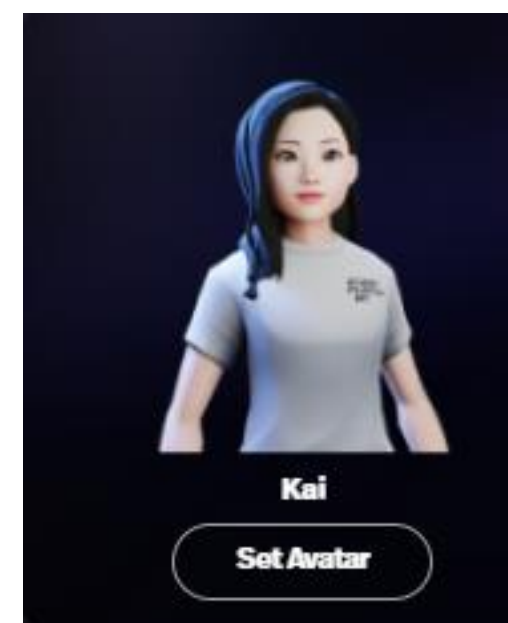
TEAM 4 - GIRL



TEAM 5 - GIRL



TEAM 6 - GIRL



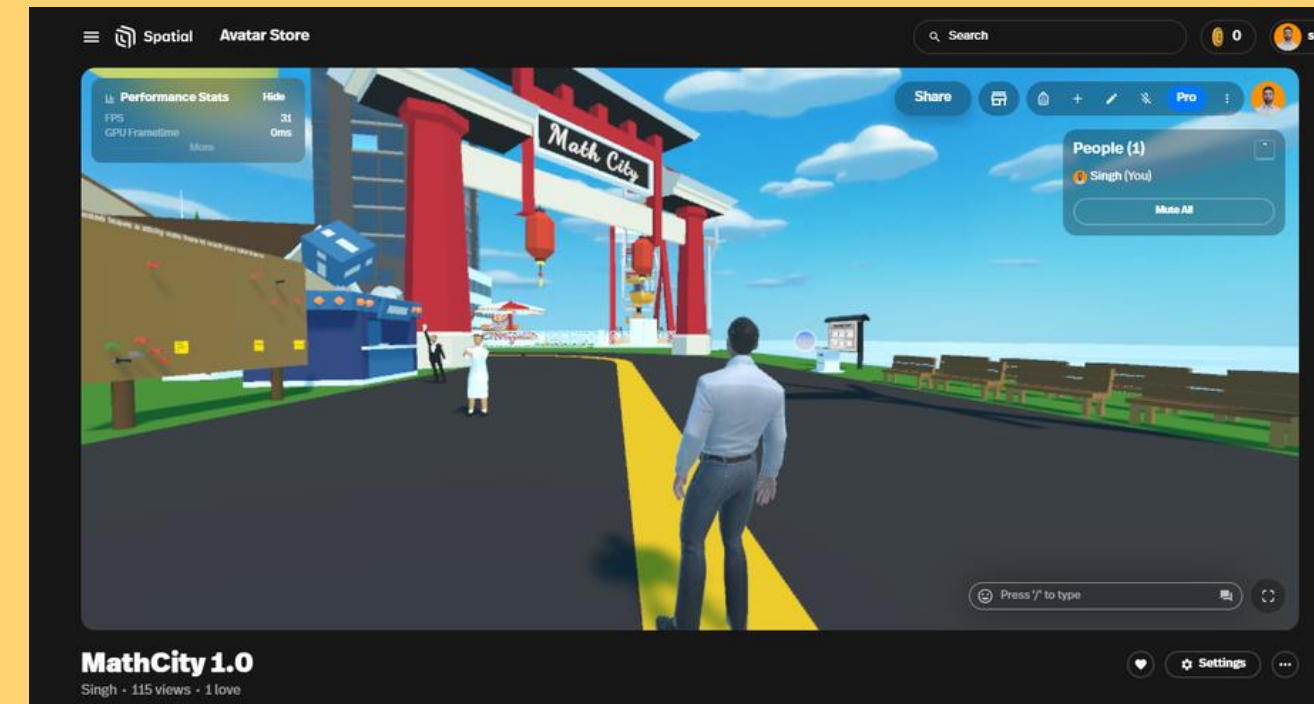
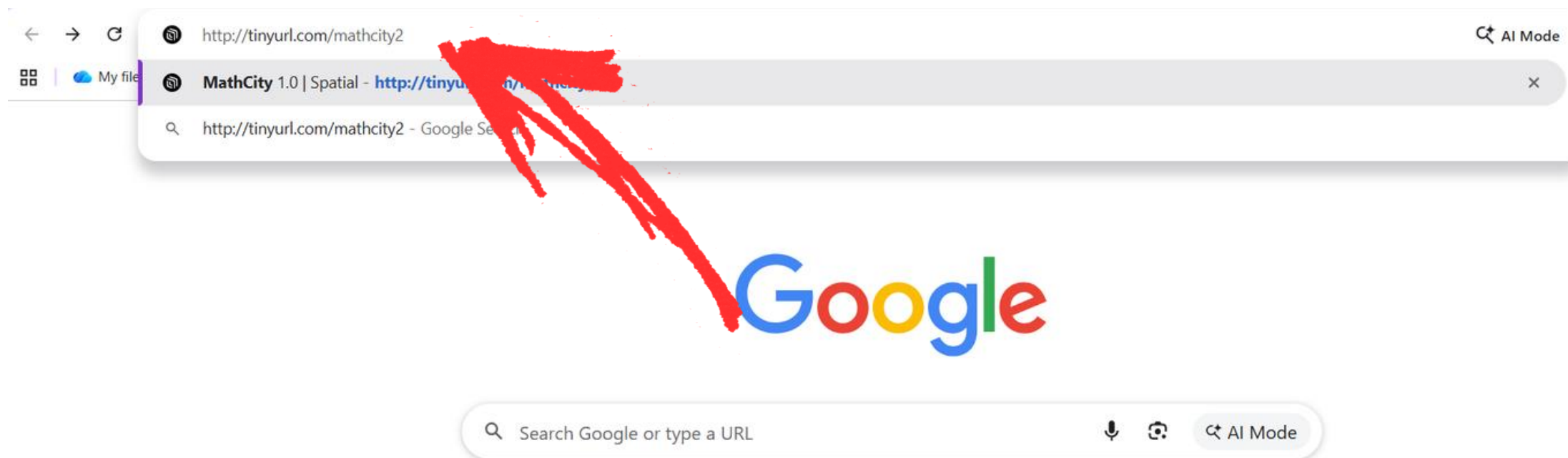
- Team 3 must choose either Caessy (Boy) or Harper (Girl).
- Team 4 members need to choose Devin (Boy) or Ivy (Girl).
- Team 5 members need to choose Eric (Boy) or Jess (Girl).
- Team 6 is Girls team only

4

ENTER MATH CITY

Enter the following code in the browser to enter Math City

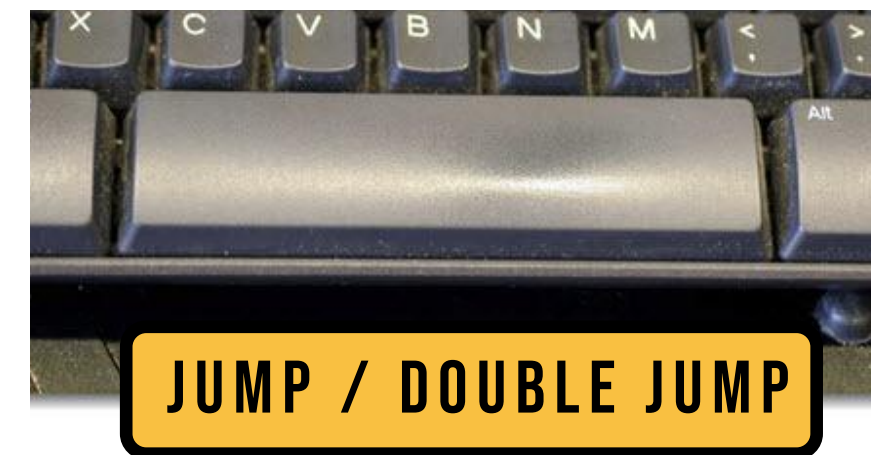
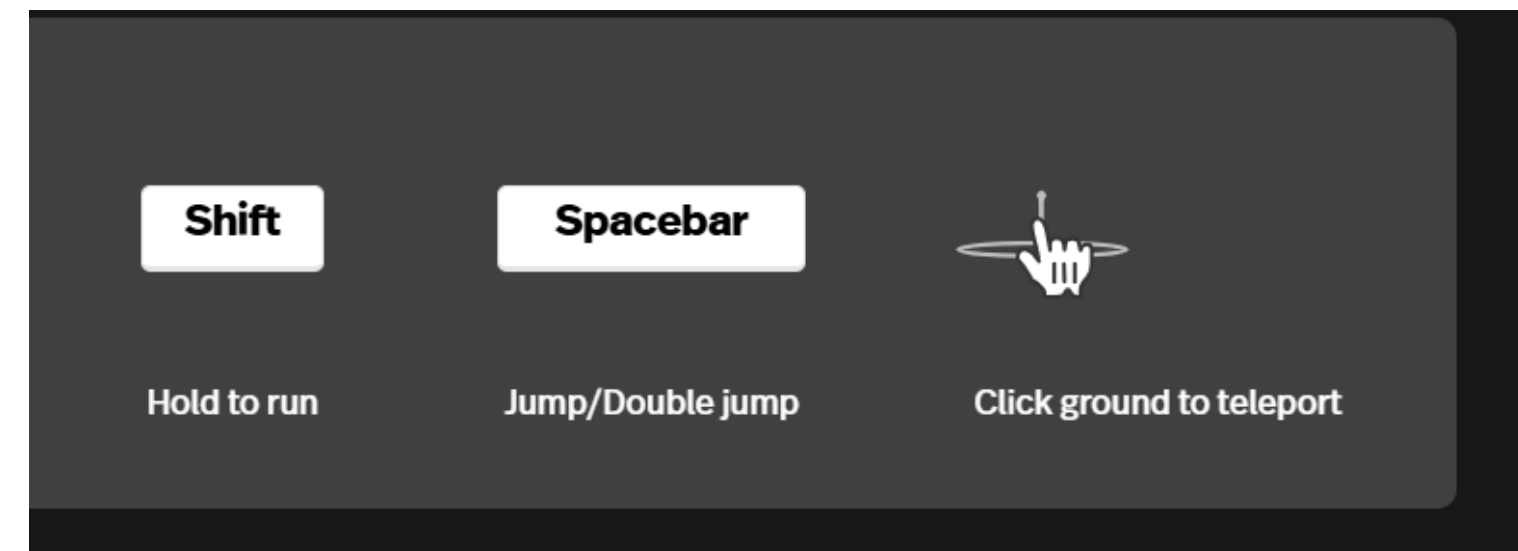
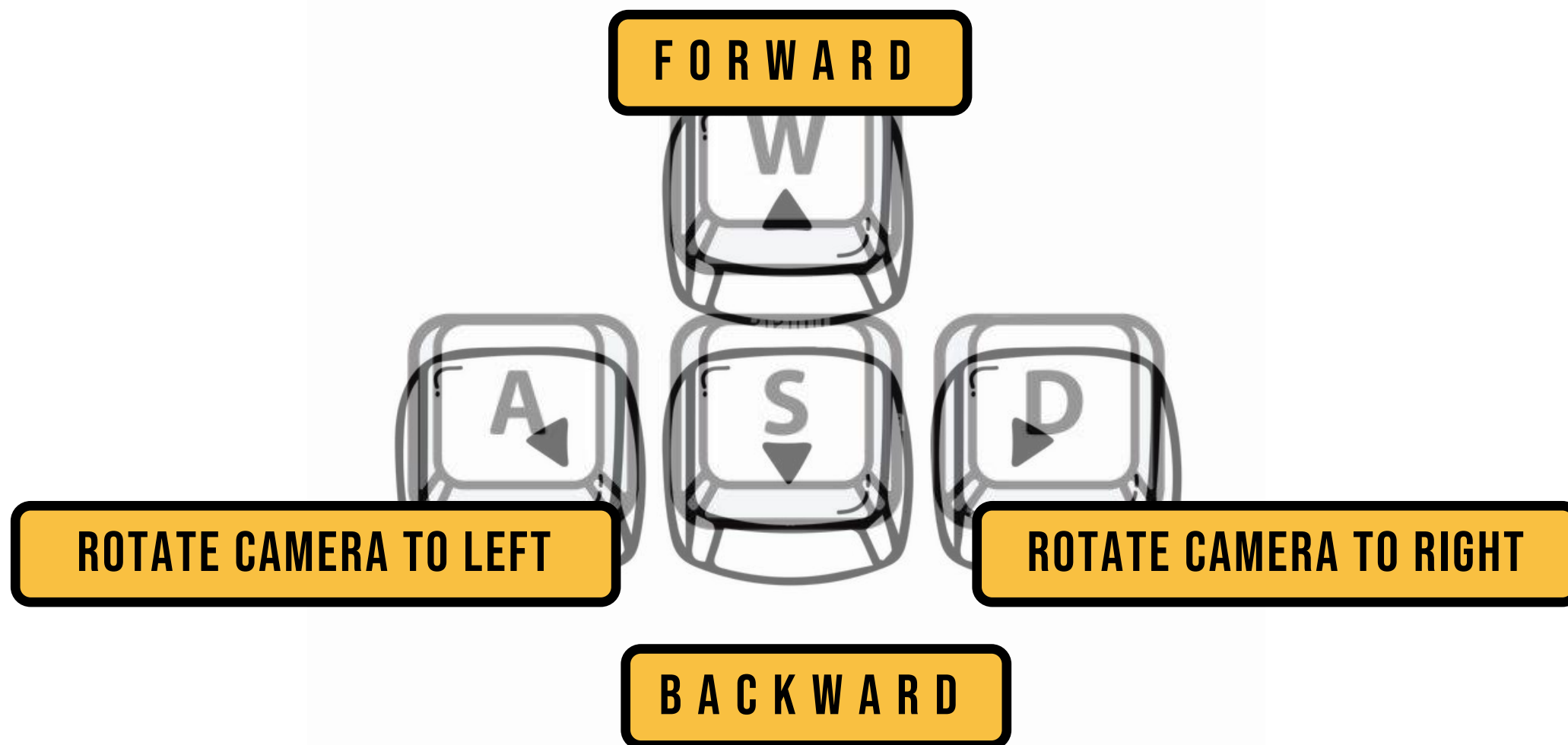
<http://tinyurl.com/mathcity2>



once you're in the math city

Get yourself familiar with the avatar movements in the virtual world.

AVATAR MOVEMENT



— *journey to earn*

MATH CITY BADGE



- Talk to the receptionist near the Math City entrance to get general instructions.
- Complete different quests designed in Math City to qualify for the final quest.
- The different non-playing characters (NPCs) in Math City will provide the instructions for completing these quests.
- In the final quest, you need to run in the Amusement park to find random 3D objects.
- Interact with the random 3D shapes to answer questions and earn the prestigious Maths Scientist Badge.
- Get a screenshot of the Maths Scientist badge and upload it to the portal







TEAM *selection*



COLLABORATIVE LEARNING



CHOOSE YOUR TEAM AND
FILL UP THE INFORMATION
BY CLICKING ON THE
PORTAL


TEAM 1 (ALEX - FIONA TEAM)	Team Selfie	Screenshot of Math City Badge	Have you completed the survey? Yes / No
 			

TEAM 2 (BLAKE - GIA TEAM)	SCREENSHOT OF TEAM SELFIE	Screenshot of Math City Badge	Have you completed the survey? Yes / No
 			

TEAM 3 (CESSY HARAPER TEAM)	Team Selfie	Screenshot of Math City Badge	Have you completed the survey? Yes/ No
 			

TEAM 4 (Devin -Ivy Team)	Team Selfie	Screenshot of Math City Badge	Have you completed the survey? Yes/No
 			

TEAM 5 (Eric - Jess Team)	Team Selfie	Screenshot of Math City Badge	Have you completed the survey? Yes/No
 			

TEAM 6 (Girls only team)	Team Selfie	Screenshot of Math City Badge	Have you completed the survey? Yes/No
			



let's learn together

TEAM SELECTION PORTAL

COLLABORATIVE LEARNING

Click on the
portal to enter
your team
information





PART D

MATH CITY BADGE & QUESTIONNAIRE



 *receive*

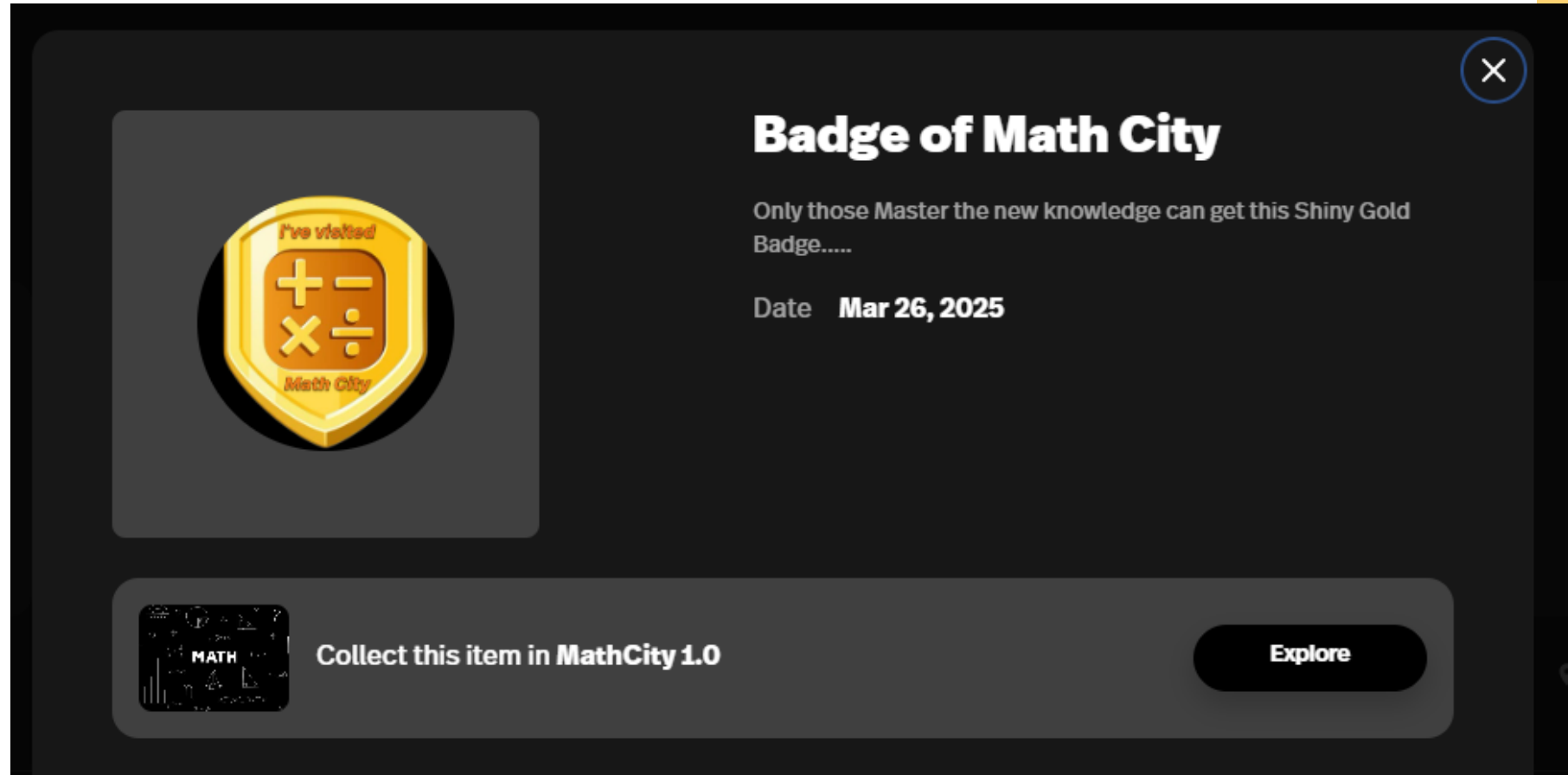
THE MATH CITY BADGE

- Interact with the non-playing characters (NPCs) in the Museum to get general instructions.
- Complete different items of the quest in Math City.
- Check your knowledge at the end to receive The Cardium Souvenir.
- Upload the screenshot of Souvnierr and complete a survey to receive the real souvenir

BADGE

receive

THE MATH CITY BADGE



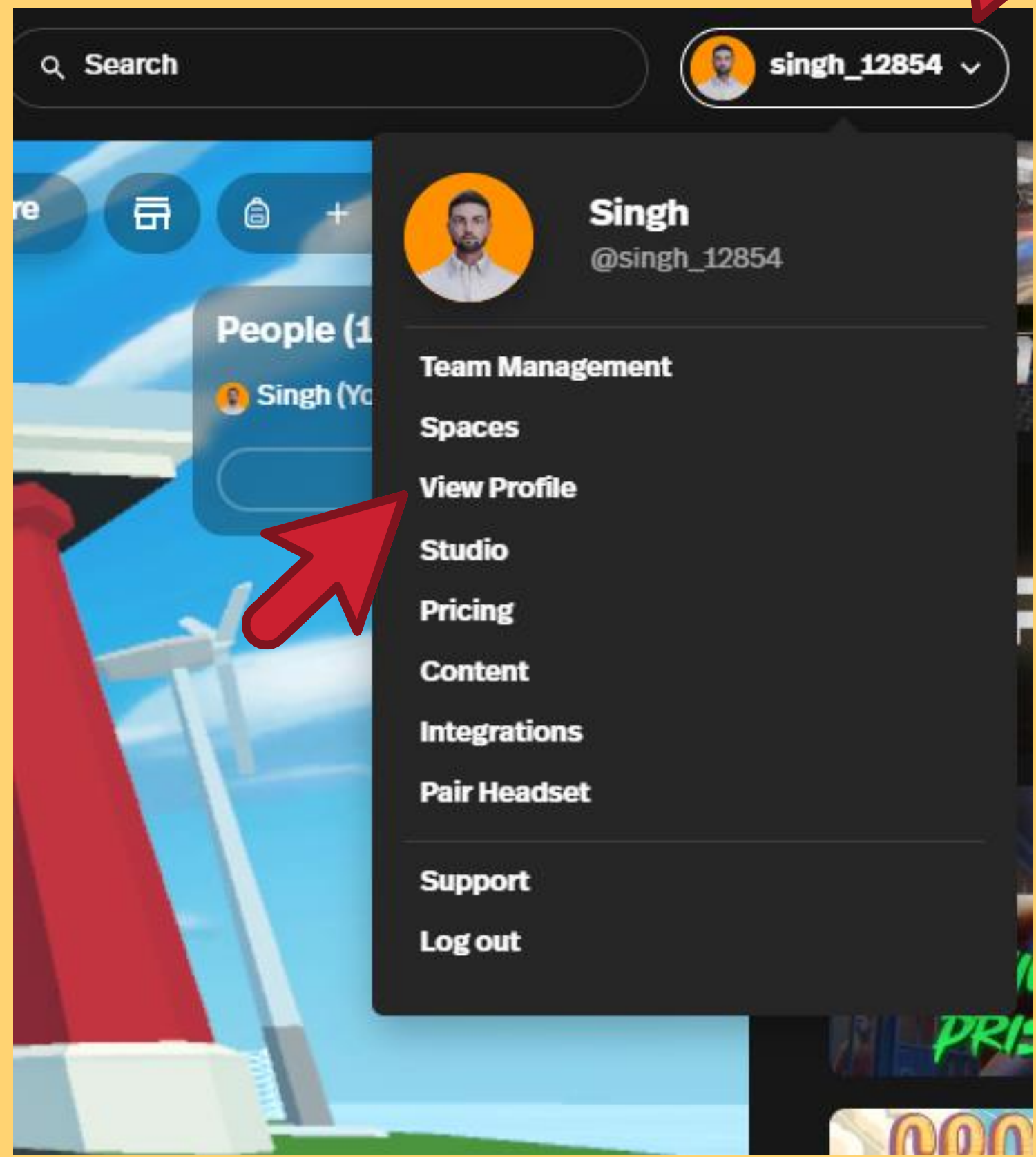
Badge of Math City

Only those Master the new knowledge can get this Shiny Gold Badge.....

Date **Mar 26, 2025**

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BADGE



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- Integrations
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- Support
- Log out

complete QUESTIONNAIRE



Questions Responses Settings

Overall Experience

Answer some simple questions based on your overall experience in Metaverse platform Math City

1. What's your overall feedback about the Metaverse platform—Math City?
Short answer text

2. Which part of the Metaverse Platform do you like most?
Short answer text

Thank you for attending our session. Please take a few minutes to complete the following survey. Your valuable feedback will help us improve our activities in future. Participants can present the completion page at the Redemption & Souvenir Counter (Block B1) to redeem a souvenir.

Survey QR Code

