This game I have created is called “Hypersphere”, it is tied to my second-year essay I am currently doing for the module MA262. The topic for the essay is “Quaternions and Rotations in 4-dimensions”, and this game is created to practice classifying different types of 4D- rotations you can apply to a Hypersphere which is a sphere in 4-diminesion. This is a social deduction game which is inspired by games like “Human Punishment: Social Deduction 2.0” and “Salem:1692”.

The goal of the game is simple; You must make sure you are in the last standing “team”. In this game, there are four different teams, represented by the different kinds of rotation there are in 4-dimension: The Identity, Simple Rotation, Double Rotation and Isoclinic Rotation. Each player is classified as a different rotation by their “Multiplication” Cards and “Rotation Angle” Cards. The reason I have chosen “Social Deduction” as the genre for my game is because it is shown that these types of game can allow students to be creative within the mechanics of the game. To engage with this creativity, students must first apply their understanding of the mechanics (Tilton:2019). This is why the core mechanics of the game is built so that the mechanics are the learning objective itself; Students cannot just be at the understanding level of Bloom’s Taxonomy but the apply level (Krathwohl 2002). Moreover, the analyse level of Bloom’s Taxonomy can also be seen, in the sense that for players to figure out what team other players are on, they must actively engage in gameplay, using existing information to analyse and find out their teammates.

As for why I have chosen this for my learning outcome, it is because of my second-year essay for the module MA262 Scientific Communication. In this essay we are tasked to research a mathematical topic which is not studied in second year and write about our findings. The topic I have chosen for this essay is “Quaternions and Rotations in 4-dimensions”, and part of this is to classify different types of rotation you can do to a hypersphere. This topic is very unintuitive in the sense that it is impossible for us to visualise what a 4D rotation look like, because we are a 3-dimensional being. And hence, the easiest way to understanding it really just to understand the mathematics of it and not to visualise it, which is a task requires understanding and practice. The goal of this learning outcome is to help anyone that is interested in this topic to understand, practice, apply or even analyse it.

But the challenges arise in how to incorporate all these different classifications into actual teams in the game. At the end, I went to the mathematical definitions for these classifications and incorporate them to the mechanics; Every 4D Rotation can be classified by looking at two orthogonal planes and their rotational angles. Each player can have two different cards that represents a rotational angle to decide what rotation they are. I have decided at the end to let two classifications to be the biggest oppositions to each other and the other two to be a smaller team that doesn’t necessary play into the conflict between the other two. Very intuitively, I have picked the classification with the most specific conditions to be the latter ones, namely the Identity and Isoclinic rotation. This is because for a rotation to be classified as an identity, both rotation angles must be 0 degrees, and for isoclinic rotation, both must be +/- of each other. Another issue then arises which is Double Rotation appears significantly more than Simple Rotation as Simple Rotation requires one angle to be 0

degrees. To solve this, I incorporate the multiplication card system at the end; Each player now will start with 2 Rotation Angle Cards and 2 Multiplication Cards, which the player will use them to create two pairs of cards consisting 1 Rotation Angle and 1 Multiplication card, then the player will multiple them to get a resulting number for the classification. The reason for this system is because there are now a set amount of multiplications which contain a fix number of cards that said "x0". This ensures that every game there will be at least one person who is a simple rotation or identity, and most of the time during my testing there is a similar amount of Simple Rotation and Double Rotation.

I have also decided to add more gameplay element other than just a social deduction game like "Werewolf". Each player is given few choices at their turn, and they are allowed to do one only per turn. These actions mostly use Operator Cubes, which is the only resource in the game. Players can buy and use cards from the open draw area or refresh the open draw area using operator cubes. I have chosen to use the open draw mechanics to reduce the randomness in the game, which enhances and provides more decision for players to make. But I also provided a "push for luck'' button, in the case the open draw area does not look good for you, and you desperately need to act this turn. But this action costs you 6 operator cubes which is a balance draw back.

In terms of card designs, the most basic design here is to allow the player to gain 3 operator cubes with the cost of 0 cubes, a straight upgrade to the basic action of gaining two which every player has accessed to each turn. There are of course cards that reveal players rotation angle cards, I have also decided to turn this into the life mechanic; Every player has two "lifes", and they are eliminated if both cards are revealed. Inspired by "Salem 1692", I have chosen to add cards like switches everyone's rotation angle cards clockwise or anticlockwise, but in a much frequent timing. This means that players are constantly changing teams and they will have more chance to think about other people's and their classifications. All the function cards are also named with a mathematical concept in mind to provide an understanding level for the student (Krathwohl 2002). For instance, the card "Eigenvalue Inspection", looks any one of the Rotation Angle Card in the game, it is named that because the Rotation angles are part of the eigenvalues of the rotation matrix.

The gametime for this game is around 20-30 mins, which is a decently fast-paced game. Every player only needs to make one decision in their turn, so there isn't a lot of waiting time between your current turn and next turn. This dramatically increase the flow of the time and hence increase engagement of the players (Csikszentmihalyi,1990). The game also contains not a lot of game components, 74 cards and 50 cubes, which makes the game more cost-efficient and easier to manage in a classroom setting. As for the aesthetics for the game, I envisioned it to have a geometrically complex looking visual to it, with different function cards have their corresponding mathematics drawn on it. This game also really benefits from a teacher assisting the game, since the core mechanics of the game might not be the most intuitive thing in first glance. Having a teacher making sure everyone got the right role at the start of the game is really helpful. Moreover, the teacher can also narrate the game

to check if the game has ended or not when someone is eliminated from the game, or the teacher can even just check it themselves.

As for future development possibilities, this game can be expanded in many ways, such as:

1. New function cards can be added to enhance variety of gameplay.
2. New special actions can be added other than just do card action, gain more cubes and refresh the market.
3. Isoclinic Rotations can also be classified as Left and Right Isoclinic, so perhaps there are potential gameplay elements I can expanded on using this.

There is also a possibility where I can implement technology to this tabletop game. This game requires a person checking endgame conditions when someone is eliminated. An app can be created where everyone can input the value of their rotation angle and multiplication cards, and the app can tell you has the game ended or not, which will increase the speed of the game without any person checking each condition one by one.

In conclusion, it was really challenge at first trying to incorporate such unintuitive learning objective into the mechanics itself, but I am very satisfied with the result of this game. But at the end, I only managed to playtest it myself to figure the optimal distribution for cards, how they affected the process of distributing teams in the game. If I had more time during this project, I would have organised playtests with multiple groups of people to get more feedback.

References

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