LEVEL 3: Share your Final Analog Game Design

Kahina Morisset

University of Missouri

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Dr. Danielle Oprean

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Reenvisioned Game Title: Rainbow Fashion (the previous iteration was "Physics for a New World," and initially, the title was Ludwig)

My new title adds an artistic and intriguing element to invite players to think about how a prism and nature create rainbows and links physics phenomena with the beauty/fashion made by nature.

Overview

I borrowed from Ludwig's storytelling and aesthetics (Ludwig, n.d). as they provided a rich context for players. Stories can "give the game context meaning" (Schell, 2020, chapter 17) and provide more enjoyment to players. Shell (2020) asserted that with storyless abstract games, there is a risk that players do not engage in the gameplay experience.

My analog game narrative has Ludwig being curious about the planet's environment where they crashed their space shuttle. Ludwig has been exploring renewable energy sources. Among them, the light provided by the sun is intriguing, and Ludwig would like to learn more about it. Players will construct a rainbow to explain the phenomenon.

The reenvisioned version provides a supplemental analog game aimed at discovering the various colors of a rainbow and how it appears through a glass prism with different refraction of single-color rays. Linking Ludwig's gameplay with learning physics is promoted by connecting game elements with learning objectives.

Subject area and learning domain

The game explores physics phenomena related to renewable energy, focusing on studying light and its spectrum. Theoretically, seven colors were identified. Although observing the Indigo (between blue and violet) may be challenging, I have kept it in the game's objects to enrich the experience and align with the learning objectives.

Learning goal/objectives

The original game offered a partial view of the phenomenon with only three to five colors. In contrast, my analog game includes all seven colors. It deepens the player's understanding as they analyze the physics to understand how all parts come together using Snell-Descartes's law of refraction to place rays and construct a rainbow. The primary learning objective is "create a rainbow using single-color dispersed rays due to the refraction of light by a prism."

Prerequisites for this game relate to grade 6-8 "quantifying refraction" of the Physics curriculum, including understanding how the path of light ray changes when the index of a substance is changed, knowing how to draw the path of a light ray, and be able to solve Snell formula for one variable (NGSS 2013) as per MS-PS4-1, MS-PS4-2.

Finally, students will create a rainbow using the prism model provided and advance their learning path toward reaching the highest level of Bloom's revised taxonomy (Iowa State University et al., n.d.).

Game goal: discover a beautiful physics phenomenon and what a rainbow is made of

Form and material

- A deck of cards provides information about the refraction of a ray of light. Some cards are useful, others less, or not at all. Some cards provide abstract information (such as formulas), and others include factual data (like refraction angles). As per the learning objectives, students will have to use their judgment to analyze and evaluate the card content and further act on it (or not) to place a ray of light properly.

- A board shown on the Figure 1 below features a large prism in the context of Ludwig's environment with a white ray of light entering the prism at a specific incidence angle. Four boards are provided with various incidence angles. A (future) special board features a circle (this will provide players with a model of rain droplets to create real-world rainbows and having one reflection and two refractions to factor in).

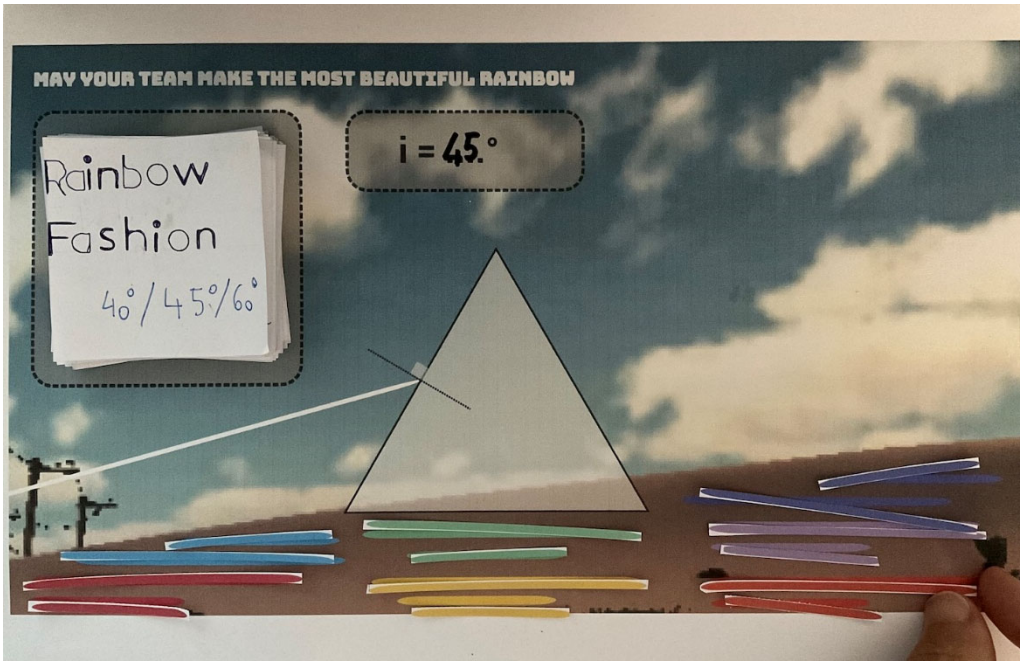

Figure 1: background board, deck of cards, rays of light

- There are 14x4= 56 pieces of cardboard with colored rays having two different sizes (longer and smaller). There are sufficient rays for playing four (4) games. Each game consumes fourteen (14) rays. See Figure 2.

Figure 2: box with all rays ready to play

- A couple of protractors (they are used to place the ray of light at a specific angle)
- Repositionable tape to fix rays at a specific place so each player can contribute to the rainbow construction.

Core dynamic: construct/build something new using resources

Kapp (2012) examined the game's core dynamics and classified them. Because I teach mathematics and physics in vocational high school and I want to use the analog game with my students, there are dynamics that I do not think are suitable. Dynamics such as forbidden acts, territory acquisition, and outwitting opponents do not align with our teaching philosophy. Others, like exploration and escape, may take too much time to play, considering our overall goal is to motivate students to catch up on abstract and theoretical concepts they have not digested from middle school. Our pedagogical approach provides a practical learning context so students can link theory with real-world applications.

In this context, the core dynamics of Construct/Build, creating something new from resources, is a good fit. A second core dynamic is in play with rewarding the player who correctly places the largest quantity of rays. This provides a race-to-finish other core dynamics with the overall goal of developing the rainbow.

According to Gonzalez, J. (2020, teachers could fail to reach higher levels of thinking. When designing with a creation in mind, I made sure I did not fall into this trap. The analog game asked that students create something novel and think about how to put pieces of information given by cards together to place the rays and form a rainbow with all its complexity.

New Mechanics

As per Zubek (2012), mechanics include game pieces, actions, and rules. For the analog game, players will get rays and cards from the deck or by trading with other players. They will place rays on the board at their turn. Each card provides physics facts and data

about the refraction/reflection of a ray of light, Snell-Descartes laws, refraction indices, and rainbow colors. Shuffling of the deck of cards during setup provides for some uncertainty as the "shuffled deck is a randomness generator" (Zubek, p. 61).

Moreover, the analog game contains new actions. For example, players can cooperate. Each player will do their part by placing rays in the correct position. Players also contribute together to create a rainbow with seven colors. The end result is the addition of all players' work and their cooperation. The game also supports competition by promoting individual thinking and achieving more ray placements than other players to receive the champion award.

Students must determine how to use a card and if that is possible. There are no incorrect facts to make the game enjoyable, but some cards are somewhat useless with vague or redundant information. However, some compelling cards provide the entire Snell formula and refraction indices. An astute player could move rays much faster using these if they are well-understood. This aspect targets Upton's heuristic of choice as described by Zubek, (2020). Players could "perceive a range of possible actions," enhancing the overall play experience.

As students develop the rainbow, ray after ray, they will have to use their judgment to evaluate rays' positions and could challenge another player's decision. A player who can prove a mistake occurred will gain in repositioning the ray. Identifying mistakes or making them will then include another Upton heuristic of "Consequence" as explained by Zubek (202). Actions have outcomes and, even if they are deferred, they will be attributed. As per feedback in the class discussion form our guide, the interaction where players can replace the rays with their own is interesting, and players can "work on one board better, it adds more competition" (Dr Oprean, 2022).

It is possible to envision a player taking a leadership position and guiding others to collaborate as a team beyond group cooperation. Players could discuss and figure out shortcuts to place rays and complete the construction faster.

At the end of the game, after all players have contributed to placing rays of light with seven different colors, they all verify the output: a rainbow with a full spectrum of light and colors adequately sequenced.

To design this analog game, I started using some LM-GM frameworks (Arnab et al., 2015) to align the game and learning mechanics. For example, I designed the game so players have to pay attention and know their responsibility is engaged when correctly placing rays. To do so, I created a rule that others could challenge a ray placement, and there would be a penalty of one turn loss if they made a mistake. At the same time, I provided the incentive for players to evaluate other players' work and not just focus on their turn, as they could spot a mistake and get rewarded. I also think that trading cards and having a common goal could promote discussion and reflection and help some players to plan better and develop an effective strategy to build the rainbow. I would expect some players could figure out they have to use the refraction formula to place a ray properly and not have to wait for a card with all the angles data provided. Snell's law is provided in one of the cards (see figure 3) and can help a group cooperate or a player go faster by placing rays even if the card does not provide for explicit angles.

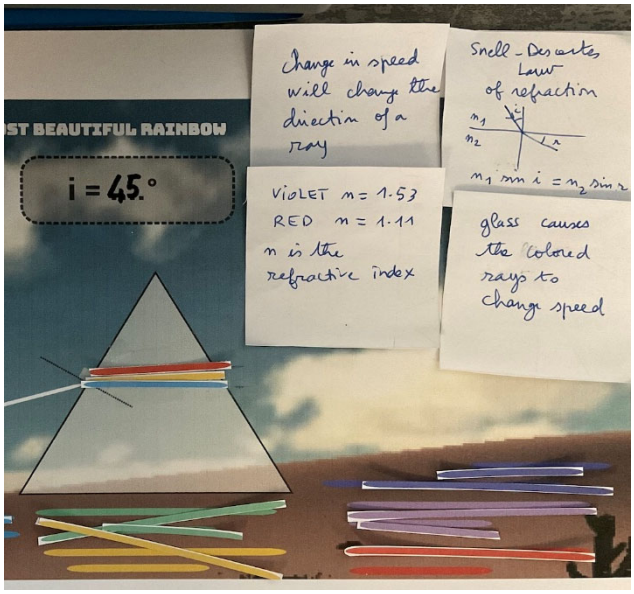

Figure 3: Snell law and refraction indices provide by cards

Ludwig digital game features one avatar, Ludwig, and control mechanics as defined by Zubek (2020, p. 56), allowing the player to move around. Ludwig plays a more passive role in the analog game, watching players construct the rainbow. Because the analog game has several players, I am still unsure how to better integrate Ludwig's role. In addition, the analog game does not provide direct feedback on how a player is doing. There is one point for each ray placed, but there is still uncertainty about whether the player has placed a ray correctly. At some point, there could be an indirect feedback and penalties for a mistake being made, reducing the number of points accumulated. See figure 4, and a new card picked questions the initial placement of a blue ray. It was incorrect as the player ignored some details about the change of substance and had to be replaced.

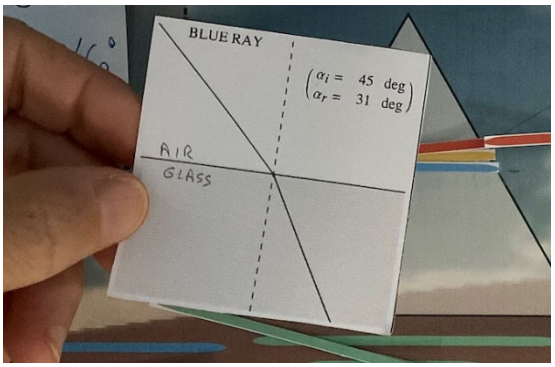

Figure 4: Blue Ray was not placed correctly before

Paper Prototype and Game Instructions

One of the course's sample level 3 projects is related to Ludwig and was quite rich in content. Although lots were happening on the board game, I could not figure out what higher-level learning objectives were in play. There are trivia cards, and players can earn pearls. Winners are the ones with the most pearls. It seems to reward knowledge and understanding.

In the same page, I enjoyed Carmen San Diego's How to play video. https://www.youtube.com/watch?v=cLBkDcMTpDA

I summarized it here to identify parts I could use it in my own set of instructions to structure and try not to not miss any elements.

Carmen Instruction Summary (not requested but for my own use later)

The setup is explained clearly what every player gets. Separating cards into decks, shuffling decks. What players do and do not do. Then it explains what players must do (actions) and how the matching core dynamic works with the cards. The video explains the other actions the players must take (taking notes, keeping track, and creating a journal). It is also important to memorize where the cards are. Then, the video describes the core loop and what players do at their turn: Roll the die, glance at a card, make notes, and put the card back face down. After players know all their cards, they can claim, “I have a warrant,” and then they flip the cards.

When players succeed with their Loot-Location match, they remove matched cards and replenish them. This part of the video resembles a tutorial, shows some events that could occur (Carmen card, invalid warrant), and teaches players what happens next. The game ends with a win when a player can claim a correct warrant for Carmen’s arrest. In the end, the video reminds players of the learning objective of working on their logical deduction skills.

My analog game set of instructions

- **Setup**
    - Everyone helps to set up and place all 14 rays onto the board's placeholders.
    - One set of cards is common to all games, and there are 3 different sets of cards for the other boards. The incidence angles provided are 40, 45, and 60.
    - Pick one board and measure and mark the incidence angle. Players could measure it with a protector or report directly an angle provided on the card set. (Two ways to do it provide means to verify and double-check together as they start the game and focus on completing the task.)
    - My prototype uses the 45-incidence angle. One player shuffles the 45-deck cards and puts them face down on the board.
    - Players pick two adjacent colors to start with.

- **How to Play - Core loop**
  - At a player's turn:
    - Pick a card from the deck or another player’s pile.
    - Read the card
    - Try to figure out if you can position a single-colored ray of light
    - If possible:
      - place the ray and tape it.
      - discard it in the “used cards” box. All players can review it.
    - If not found:
      - Place the card in front of you, face up. It means you are OK to trade it.
    - Before you end your turn, claim an incorrectly placed card. Get an additional 2-minutes to place it back correctly. The player that placed the ray incorrectly will pass his/her turn once.
    - End your turn (you may not have been able to place a ray), or stop playing if the 2-minutes bell has rung.
    - Next player sitting to the right plays next. (counterclockwise turns).

How to place a ray?

- Read a card's info and try to figure out if they help and if so, try to place a ray properly, with the right angles and location. There are 2 refractions so beware if you are dealing with the first air-> glass or the second one glass->air.
- You may place a ray or not. It is up to you. Write your initials on the rays you place. The more rays you place, the better chance you give to your group to win, and you could also win the champion’s title.

How to trade cards?

- All cards made visible by players that were not used can be picked or traded. Either pick or trade at your turn.

Are cards useful and accurate?

- Some are incredibly useful, but others are not. It would be best to consider ways to use the information to place a ray. Cards provide correct information, but depending on the context, they may not apply to your rays or might be too early to use.

What happens if a ray is not placed correctly?

- Another player can appropriately replace the ray. Initials are changed
- The owner of the wrongly placed ray loses and cannot play for one turn the first time it happens, 2 turns the second time, and so on...

End of Game

Players will have to place the rays at the right location and contribute to constructing a rainbow. Who wins? Once the rainbow is entirely made and 14 rays are placed, you all win as a group if the rainbow is successfully formed. There is also a super champion within the group, the player that has placed the greatest number of rays.

Discussing elements from Kapp's textbook Chapter 2

According to Kapp (2012), “game elements often contain advantages over traditionally presented learning content”. Because the learning objectives aimed to reach the higher levels of Bloom’s taxonomy, it was challenging to design game elements that would support this goal. I think that cooperation within a group is crucial as players can discuss and reflect together to achieve the game’s goal and recognize a champion amongst them that can help the group to thrive. Eventually, the best-functioning groups could become collaborating teams. However, if a group’s cooperation is not high, it does not prevent the game from ending. It might be less fun for players and invite all to reflect on their cooperative behavior. Another element contributing to the learning experience is figuring out what to do with a

card's information in a limited time. All players will have a fair chance to try out placing rays and could receive feedback for correct and incorrect moves from their peers. They are having a limited time per turn which allows for the game to move fast and hopefully encourages the contribution of all.

Other Credits not mentioned otherwise to create my prototype

All graphics and music tracks used in my prototype are licensed with Shutterstock except Ludwig's game images (my mentor game) as part of fair use for educational content, but not to be published elsewhere than this assignment.

I also used a Prezi Present template to develop my video presentation and Amazon Polly to create the text-to-speech audio.

Demonstration Video/PowerPoint PREZI present

My video presentation is available here:

https://prezi.com/view/rxehELeOZyofAh2X1acP/

You should hear a female presenter and a soundtrack in the background. Play and click on the items to advance the video or use the navigational arrow.

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