Galaxy Physics

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Overview

This game will teach concepts of physical sciences to middle school students. Players will create a character who cruises the galaxy in a spaceship, exploring and interacting. Sub games and puzzles challenge the learner and reward progress with points that allow the player to upgrade his or her spaceship and reach farther in the galaxy. The sub games would be embedded into the actual gameplay, teaching concepts of gravity, mass and force, as well as the scientific method, atomic theory, electromagnetism and cosmology.

Players will fly their spaceship from star system to star system, each themed with a challenge aligned with the California Science Framework. The gameplay will incorporate features from several genres: integrated puzzle environments such as Myst or Rhem , space trading such as Elite or Escape Velocity, simulations such as Celestia or Universe Sandbox, persistent universe MMORPGs such as Vendetta Online or EVE Online and classic educational titles such as Math Blaster and The Incredible Machine.

Instructional Objective

The game will focus on teaching concepts of physics, as outlined in the California Science Standards , leveled for Eighth and Ninth grade students.

The specific standard areas in particular are:

1. Heat and Thermodynamics
2. Motion and Force
3. The Atom and the Periodic Table
4. The Structure of Matter

5. Waves
6. Electric and Magnetic Phenomena
7. Conservation of Energy and Momentum
8. Density and Buoyancy

Learners

The game is designed for Eighth and Ninth grade students and could be adapted for other grade levels by changing the content.

Context of Use

The game could be played in the context of a class or as an additional independent study resource at home. The game could be played as a specific guided lesson by specifying which system a learner would experience, or as a free form independent course of study. By using missions that correspond to the equivalent science standard, instructors could tailor the experience for each student, or set it to sequentially match their lessons. The online universe would persist, however this would not be a MMORPG, the network would be used only for delivery of data to the client installed locally.

Scope

The game could be very large in scope, encompassing a different star system for each concept covered in the science standards. For example, the standard of "Heat moves in a predictable flow from warmer objects to cooler objects until all the objects are at the same temperature." would be represented by a world with several puzzles, the completion of which require the understanding of this principle. Successful completion of these puzzles will allow the player to refuel and upgrade their spaceships to reach other systems. Ideally, each puzzle world would take the average student 20-40 minutes to accomplish successfully. This would allow the game to be played in the context of a classroom lesson.

Object of the Game

The object of the game is to explore the galaxy, visiting star systems and completing the puzzles to receive rewards. These rewards will allow upgrades to the player's

spaceship, enabling access to other areas of the game. Providing the player's ship is able to reach the systems, the galaxy could be explored in a non linear fashion, and planets can be revisited after completion of their puzzles. The game would eventually end if all star systems were completed.

Competing Products

There are many stand alone, single subject games to teach physics concepts, and even websites organized around them. Sites like http://www.umapalata.com/home_en.asp and http://ed.fnal.gov/projects/labyrinth/games/index1.html have decent implementation, but each game is stand alone, or else joined together in a trivial way. There are a few sandbox style online physics games built in Flash like Incredibots and Fantastic Contraption, but while some of the content is similar, the presentation is not. While I could not find the equivalent of my concept for teaching physics, the closest I found was DimensionM, for teaching mathematics by TabulaDigital. In fact, though the gameplay is more action than puzzle based, it seems like a very good proof of concept.

Design Details

Universal Elements

The game will be designed to be 3D or pseudo-3D in a Japanese sci-fi animation style. Titles and cut scenes would be almost like a comic, which come to life with the player's selection. The universal game elements would include the character creation and spaceship modification areas, inventory, mission selection, and score screens. Most of the game would be first person P.O.V., through the effect of a comic book page. Even the 3D scenes would be rendered in a way to seem hand drawn. The following draft images model the graphic sense and feel.

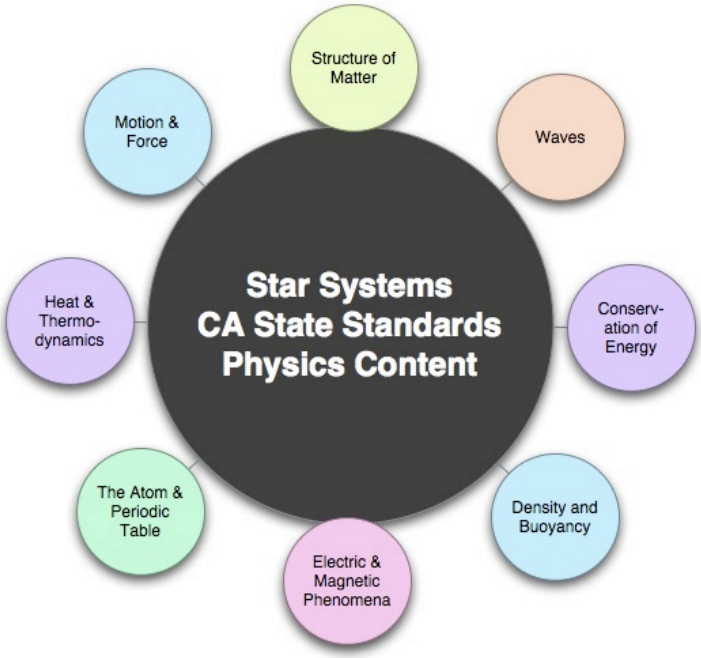
Title Screen:

Character creation screen:

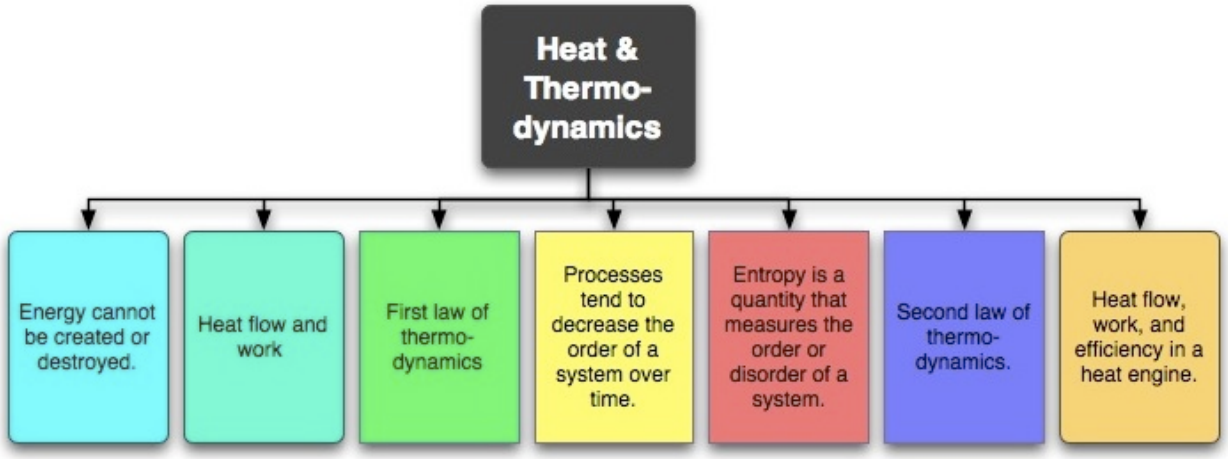
Navigation Screen:

Specific Elements

The galaxy is composed of systems, each dealing with a different topic in the standards.

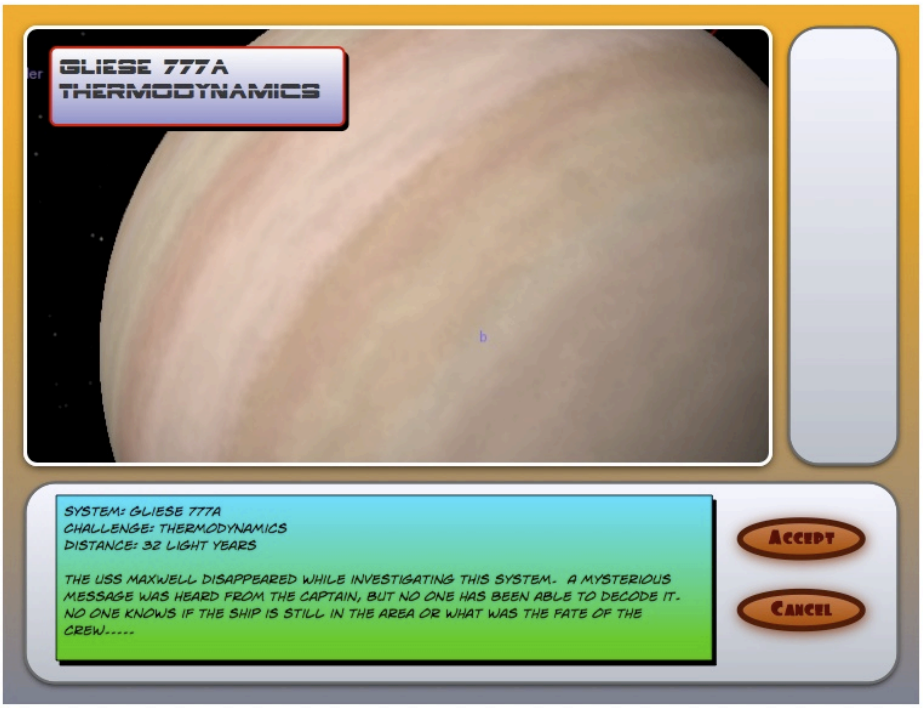


Each star system is themed around one content area. Within each star system are several planets or challenges, each corresponding to an individual standard. In our example, the system *Gliese 777a* deals with Heat and Thermodynamics. The standards covered would be:

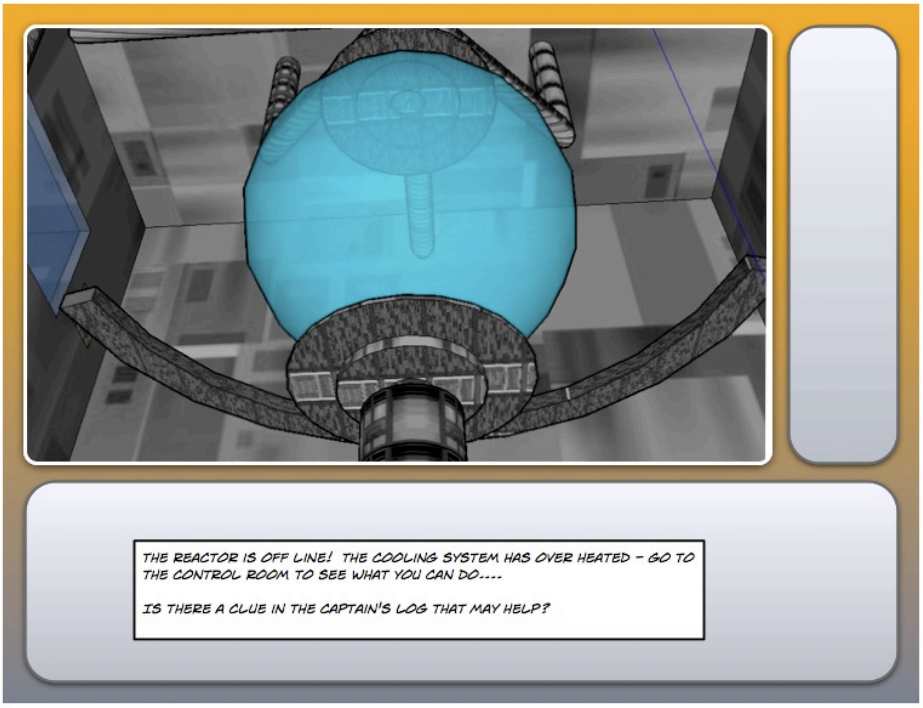


Of these standards, our example will focus on **Heat Flow and Work**. Heat moves in a predictable flow from warmer objects to cooler objects until all the objects are at the same temperature. The challenge in this system is shown as part of the navigation screen.

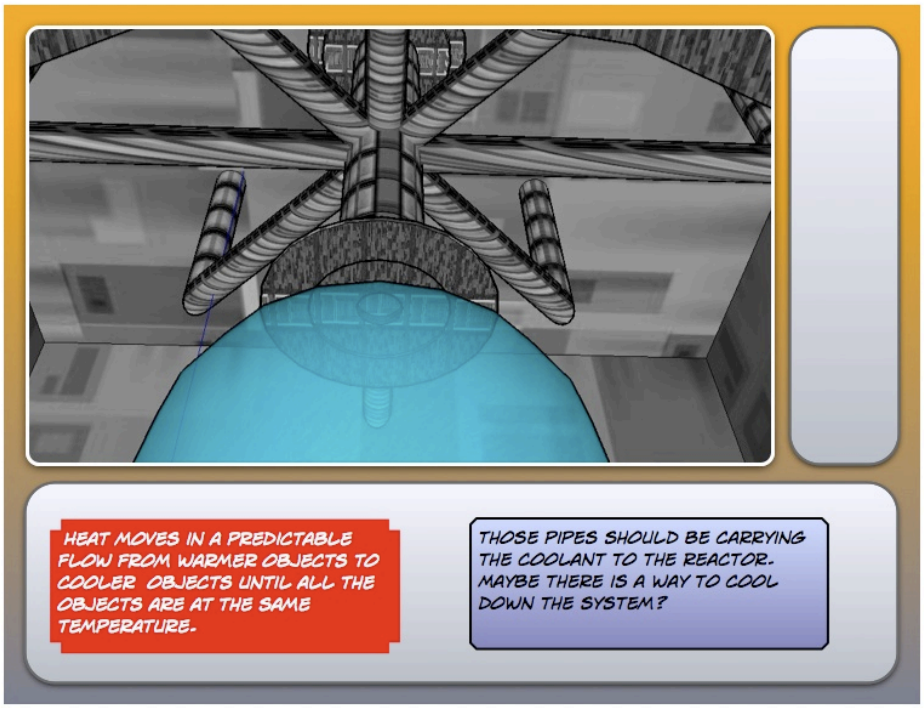
Navigation Screen:



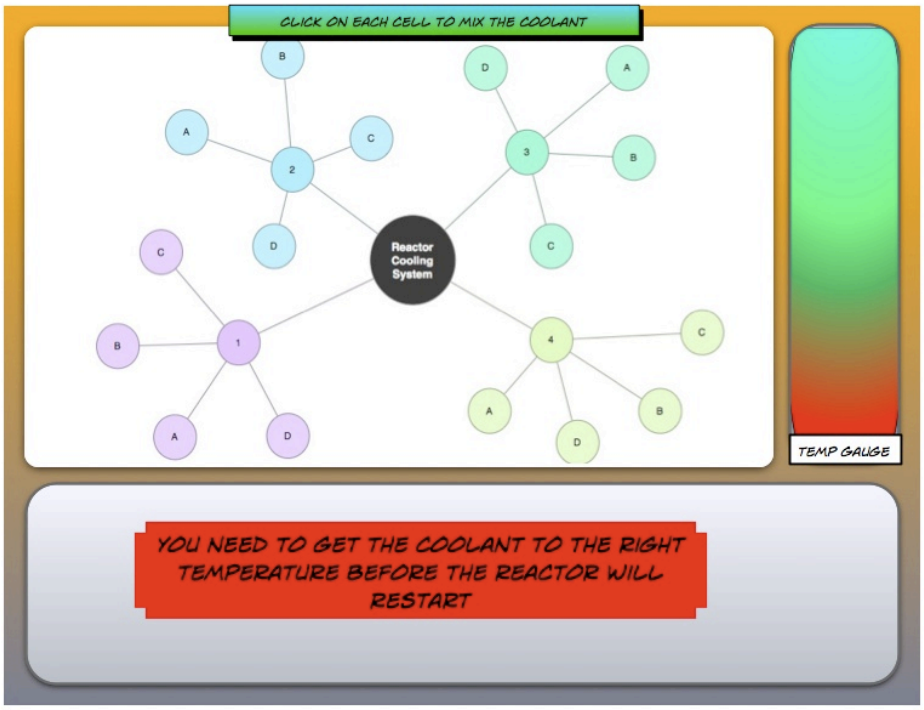
Since this planet's challenges are based upon heat flow, the solution to the puzzle will require the player's understanding of that principle.



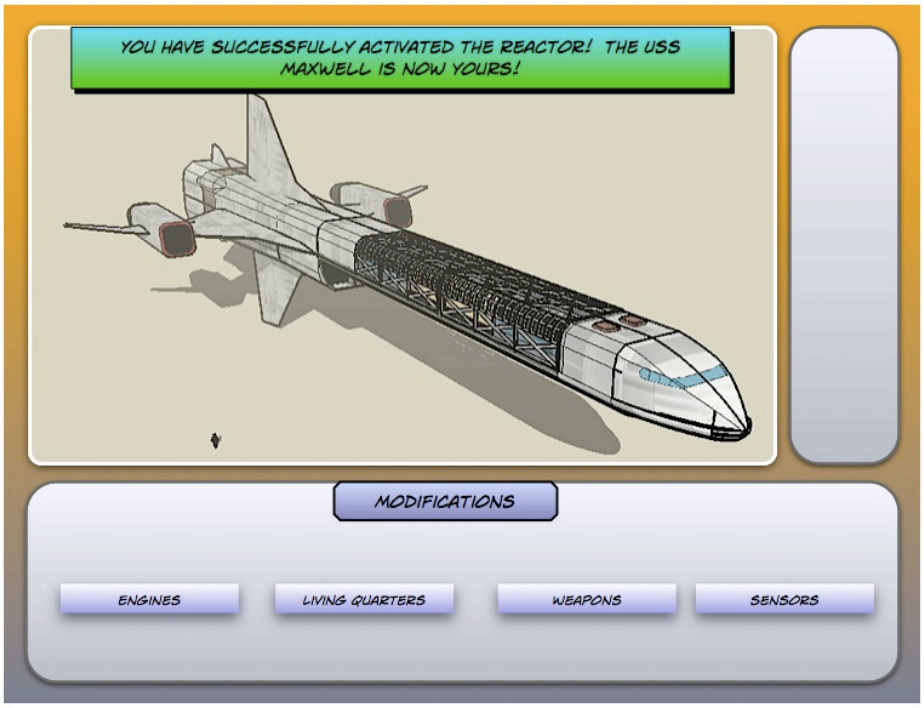
The 3D environment is designed with the puzzle in mind. In this case, the reactor models the principle of heat flow.



Players must mix the hotter fluid with cooler until the target temperature is reached by routing it correctly through the reactor pipes.



The game rewards successful efforts with items and power ups. These rewards will unlock further sections of the game and motivate players by allowing a level of customization.



The player could then leave that star system, or else try the remaining challenges in the content area. This could be a setting controlled by a teacher as well, forcing a more linear gameplay, or directing certain students to specific content.

Technical Elements

Since the environment would be three dimensional, the game would be authored in Unity3D. Alternatively, since the game has an anime design feel to it, it would be possible to develop it in a pseudo-3D environment using Flash. The game would be multi-platform, another advantage of the Unity and Flash tools. Graphics and sounds would be in formats that could be imported into Flash or Unity.

Players create their characters and then modify their spaceships using the rewards from completing the puzzles in each star system. The game would require a sign in and would track the status of each player accordingly: Character attributes and modifications, Inventory (of reward items and puzzle keys), Ship attributes and

modification, Systems visited and scores (based upon time to complete) and total score and game time.

Motivational Issues

The game will use much of the familiar experiences of adventure games to motivate the learner, such as customization and modification of one's character, rewards and special inventory items when certain puzzles are completed and tracking of score through out the campaign. The integrated lessons in the context of the environment will be designed to appeal to a student's curiosity, and challenge him or her based upon the selected science standard.

Using Keller's ARCS model, this would translate to:
1. **Attention**: Graphics and gameplay will focus attention; the anime style story is also very popular with the targeted age group.
2. **Relevance**: The embedded puzzles that challenge the learner are integral to the story and success, the content is not "tacked on" so to speak. This puts the game character's success in line with the learner's ability to absorb the lesson.
3. **Confidence**: By breaking the content into missions that mirror the individual science standards, each lesson is a small enough challenge as to not overwhelm the learner.
4. **Satisfaction**: The reward system is also integral to the storyline and not just an arbitrary trophy case. The player can earn relevant upgrades and unlock special features with each success.

Design Process

I knew that I wanted to use my board game concept in some way for the my eGame project. This game was based upon the electromagnetic spectrum, allowing the player to move up and down the spectrum answering questions and collecting points. While doing research for that project, I came across the following image on the Chandra X-Ray observatory website:

Reflecting upon this image gave me the idea of a space based character game, like the "space trading" games of Elite or EVE Online. Each star system would cover a different science area, and incorporate the standards in the design of each world. This also allowed my design to incorporate content from the entire physics curriculum, and the genre of space simulation seemed a perfect fit to teach concepts of gravity, force, energy, light and electromagnetism. Since I am also an avid fan of adventure and puzzle games, I thought it would be a great idea to have the environment of each planet actually embody the principle being taught, such as the worlds in Myst or Riven.

I played with a few ideas and pitched my rough concept to Dr. Dodge. His recommendation was to rough out the game world, but focus on one specific game section for the document. This was sage advice, since the project would prove to be a lot of work, even within those limits.

I started with consulting the California Science Framework to see how best to break up the content. I decided to focus on physical sciences, and this mapped to 8th grade, as well as some content from 9-12.

I proceeded to research if there were any other similar games, but all I could find online was a math based world game called DimensionM. This was more action based than

puzzle based, but it did share the elements of a persistent world that embodied the content.

I chose the thermodynamic content since I thought it would be the easiest one to model. Perhaps there was a puzzle in my unconscious memory from some adventure game that I had played in the past, but the idea of pipes and coolant seemed an obvious way for the world to embody the content.

I also chose a Japanese animation style for the graphics, thinking that it would appeal to the target age group. An added benefit would be the lower technical requirements as opposed to a more photo realistic rendering engine, also allowing 2D cut scenes if 3D development would prove too expensive. Thematically, this style also matched the plot of a space-faring game. Finally, it was my hope that by intentionally adopting such a style, the game graphics would not appear as dated in a few years.

Since this was supposed to be an anime style experience, I built the mock ups in Comic Life, a comic creator program for the Mac. The actual models in the frames were rendered in Google SketchUp. The models came from the 3D Warehouse, a publicly accessible repository of user created content. The models used were:

Sci Fi Reactor by zazwaz
SpaceShip Interior by drake
Starship Bay Windows by haz
Anime FIG by FIG-X
Robbie Robbie(omotchama) by COSEDIMARCO
Transporter Intercept by Snipperbes

Planet and space imagery was generated in Celestia, an open source space simulator. Charts and other graphics were made in OmniGrafflePro.

I posted the draft game design document on the wiki and received positive feedback, as well as some very constructive suggestions. I tightened the description to reflect that this unit is more appropriate to 8th and 9th grade science standards, rather than just "middle school." Another good comment was that to advance the game there should be

puzzles based upon multiple standards, that require knowledge from more than one area. This would be a good way to extend the gameplay for more advanced learners.

I have built a few little HyperCard and HyperStudio games over the years, so I entered this project thinking that experience would give me a head start on the process. But attempting something of this size was categorically different, and I underestimated the amount of design and planning that was necessary. When designing the puzzles and the world, it was a challenge to stay on the objective. I really see the need for truly story boarding something like this, and without that logical plan it would very quickly devolve into a mess, an expensive one if I were the developer.

I am very impressed by the level of work done by my peers in this class, and I think there are several excellent ideas. I do not know if that translates into marketability, but I would enjoy playing many of the games I reviewed. I hope that my effort would be in that company.

References

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Ong, F, & Lundin, J (Eds.). (2004). *Kindergarten through grade twelve science framework for California public schools.* Sacramento, CA: California Department of Education

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