The Ultimate Machine

Final Project Report

By

The Ultimate Team - # 13

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Introduction

This document is the description of The Ultimate Team's (Team #13) video game The Ultimate

Machine. The game is about building a machine, whether it is a remote-controlled plane, boat,

go-kart, or a combination of the three. It introduces physics principles to help the player learn

and build the best machine they can. Making "The Ultimate Machine" is judged by winning

races. Each race has different rules to emphasize different aspects of building the machine. For

example, one race might have a lot of obstacles in the way and require an agile machine so

emphasizing a light vehicle would be necessary. Although this paper focuses on the boat

building aspect of the game, it can be applied to any of the other machines. The game is

intended to introduce many physics properties and let the player experiment with them in a fun

setting.

Main Menu

The main menu of the game has four options: Story Mode, Sandbox Mode, Multi-Player/Online

Mode, and Options. Story Mode has four sub-options: Boat, Go-Kart, Plane, and Ultimate

Machine. The first three are immediately available while Ultimate Machine is unlocked once the

other three story modes are completed. Each story mode follows a progression in building a

steadily more complex machine of that type. Sandbox mode allows the player to build anything

they want with the parts they've unlocked. Multi-Player/Online Mode allows the user to work

together with others or compete against them. The Options menu is simply a necessary

component to help the user set up their game play experience by setting the difficulty and other

cosmetic options like volume of music or screen brightness.

Story Mode Character Creation

To engage in Story Mode, the player first chooses a sub-mode (Boat, Plane, Automobile, or Ultimate Machine). They can then choose their name, gender, and then build a custom character. The custom character will be built in a character creation mode that allows the user to shape their characters look. Properties such as facial features, height, weight, and clothing will all be editable.

Story Mode Introduction Video

Your character goes to an event (based on which mode was selected), sees the cool machines in action, gets excited, and decides to sign-up for the event. The kid is told that he must build one himself and is given a small kit with the necessary pieces. The character looks disappointed because he/she currently has no knowledge of building a machine. Then his/her grandfather says he'll help. The character is again excited and then the game play begins.

Story Mode Game Play

The following is a description of Story mode using the Boat sub option as an example. While the specific details between sub-modes may change, the principles behind it are the same.

Back in the garage of your house, your grandpa shows you a boat he made when he was a kid. Grandpa represents an iconic figure in the game that will provide you with general advice opposed to technicalities. He is a person who you can look up to and whose lifelong wisdom will be a guiding force in your project. After Grandpa shows you his boat, you put it in the test setup in the backyard and see that the boat doesn't go anywhere because there isn't a sail or motor, no method of propulsion. Grandpa takes it out of the water and attaches the propeller to the

front of the boat (an obvious mistake) and the boat goes in the wrong direction. You are supposed to correct him in build mode. This is intended to demonstrate that the user already knows how to do some of the basics and to motivate the user to continue playing with the machine. Once the propeller is attached, the boat goes back into test mode and you see the boat work. Then you see the boat go down the course and you learn how to race it in a tutorial mode.

Then, grandpa takes his boat away after you've gotten a start with it and tells you that you need to build your own boat with the kit you were given. You're given multiple types of pieces with different designs giving the player choices such as what the body looks like, how it's powered, etc.

When you sign up for events you are given a set of parts to build your boat. At earlier levels you'll start off where you are given pre-made parts. For example in the earlier levels you'll get pre-made sails, hulls, masts, rudders, stabilizers, etc. As you progress you'll be given more and more parts that you can use to build a more advanced boat. Later in the game you'll actually be able to customize and shape each part.

Also as you sign up for more and more race events there will be different challenges. For example, at easier levels you won't have to account for varying wind conditions; whereas the harder difficulties would require the player to compensate for this factor. On the easy level, the wind could be constant, requiring a simpler sail design. Another challenge within a race might be that your boat must carry a certain amount of weight. This would challenge a players understanding of buoyancy. By incorporating obstacles into later levels, players might have to

take into consideration the sturdiness of materials in their boat. In the beginning there may be no rocks, allowing the player to focus only on speed. As the players advances, the player would need to include a solid design to prevent the ship from sinking if hit or provide agile enough steering to avoid colliding with obstacles while still needing to build a boat that reaches the finish line first.

In the testing mode, there will be tools you can use to test the boat. You can hook a diagnostic machine up to the boat which will let you analyze the boat you're building. The diagnostic machine is, in a sense, magical and essentially starts off telling you some basic things you can take into consideration such as speed, weight, drag, durability, buoyancy etc. As you advance the machine will tell you more and more about the properties of your boat, such as a sails depth/camber, engine thrust, flow resistance etc. This will allow the user to see numerically how different parts may affect the performance of their boat. The grandfather can then interpret some of the numbers if anything in particular stands out as being really good or really bad or where the player might want to improve their boat.

Whenever you add new pieces to the boat, it will give a brief explanation about what the part is and how it might affect your boat's performance. It will also talk about the various physics properties acting on that piece. For example when you add a sail, it'll tell you about how a sail works, the different types, materials, their size and weight etc. As you progress, you'll learn more and more physics properties that affect the performance of the sail such as its depth and camber.

Once the player decides they are ready to race, they go to their calendar and that shows them that the race day is upon them. At the race, the player's boat is inspected by the judges to make sure it meets the race specifications. If not, the player will be given a bit of time to fix it. This could mean shaving off or adding weight to the machine, making the boat longer or shorter, or meeting any other specification. The motivation to have initially followed the specifications is that by changing things on race day, you don't have the best materials available or a chance to really test your changes. Once the race begins, the player navigates their boat to the finish line, competing against computer controlled opponents. If the player wins, an awards ceremony is viewed and a trophy is awarded to the player. If the player loses, a few things happen. First, a video of their boat sinking is seen. Then, they also get a chance to see their competitors' boats and learn from them. Judges also provide information to the player as to how they could have improved their design.

The story mode is intended for a single player; however, it can also be played in Co-op mode with a friend. In Co-op mode, multiple players will work together to progress through the story and build vehicles. All of the players will be able to walk around in the garage and add parts to the vehicle at the same time. The only other difference between this and the regular story mode is that all of the players will race different copies of their vehicle; if one of them wins then they will advance in the story.

Sandbox Mode

In sandbox mode, the player will experiment with all the different design possibilities of boats, planes, and go-karts. The only parts that you will be able to use in sandbox mode will be parts that you have already unlocked in story mode, which will be determined by the number of

trophies that the player has unlocked in story mode. This is so the player will already know what the parts do and how they affect the machine. If we were to open up all the available parts in the game for players to freely use in sandbox mode, there would be parts that the player would not know how to use effectively. Story mode is where the main explanation of the physical aspects of all the parts that you can use in the sandbox.

After choosing Sandbox mode, you can create anything you want out of all the pieces that you have unlocked. For example, you can create a boat with a car engine in it if you'd like, or you could make a boat with wings on it. Sandbox lets you explore the building aspect of the game to the fullest extent. Sandbox mode is much different from Story Mode in that it gives the player a more freestyle feel to the game. It also gives the players the opportunity to go back and review some of the physical theories behind the parts that they already learned in Story Mode. The players learn from sandbox mode through an information box that pops up whenever you select a part. The information box explains in short sentences the physical theories behind the part and acts as a small refresh to the user. The information box will also host a button that takes the player to a more complete description of the physical properties of each piece and a more in depth look at the actual physics properties.

While making your machine, you can test it by hitting a "Test" button and dropping the machine into your test zone and letting it go. You will be able to control the machine that you build in test mode. After testing your machine and deciding that you like it and want to race it, you can save the machine and choose between any of the races that you have already completed or you can choose to create your own race.

In "Create a Race" mode, the player sets up all the conditions for the race. The player can choose the race surface, layout of the course, wind conditions, obstacles, the number of competitors, competitor difficulty, and intelligence level. The two options for Artificial Intelligence in the game are included in the game to better suit the player. "Competitor Difficulty" is how good of a racer the competitors are and the "Intelligence Level" is how smart the competitors were in making their machine based on the physical theories stressed in the game. Once done racing, the machine will be saved and can be accessed in Multi-player Mode or Sandbox Mode at any time for to be changed or raced again.

Multi-player/Competition Mode

In Multi-Player/Competition Mode, players will all be given equal amounts and types of parts with which to build a specified type of vehicle in a limited amount of time. After the time is up, the players will all take their creations and race them against each other. This mode will be very similar to the Sandbox and Story modes, with the differences that the race opponents are other human players and that the player is given a limited amount of time to build an optimal vehicle. Players will be matched together based upon the number of trophies that they have unlocked in Story mode. This way, players will all have approximately the same skill level and number of parts unlocked.

Before the players are allowed to start building, they will be able to set different options for the game. These could include what parts that everyone will start with, the type of vehicle to be built, and the weather conditions for the race. After agreeing upon the match settings, the players will be able to construct their vehicles according to the rules of the match. As in the other modes, they will still be able to test their work and utilize the diagnostic tools; however,

due to the time constraints they will need to do the work with as little assistance as possible to maximize the amount of time working on building their machines.

In a gallery type page, players will be able to see all the machines uploaded by other players. This will reinforce the idea of community learning and show people all the different designs. There will be two options for each machine: to watch it race or to download it. Anyone will be allowed to watch a demo of it racing but only people that have unlocked all the pieces used by the boat can download it. This provides incentive to play the game and learn the concepts. Additionally, it prevents using pieces that the player doesn't understand the principles behind.

Graphics

Graphically, the game will be a 3-Dimensional game for the PC. The player is seen through a third person view. They navigate the area of play using the keyboard. The mouse is used to click and interact with the game world. Most of the world will revolve around your garage as the home base for constructing your machine. The backyard will be where your testing zone will be. When you are ready to race, the setting will change to a variety of different places.

Garage interaction will involve walking around the garage, choosing parts from the different parts buckets, putting them together at the workbench, and moving your machine to the testing zone. When a player goes to the workbench and chooses to start construction, they are taken to a screen that shows their machine at the center of the screen. From there, they can rotate and move their machine around and connect the pieces that they currently have in their inventory.

During races, players will control the vehicles that they entered into the race. The players will control the vehicles with the keyboard and mouse, and will view the race from a third person over the shoulder view of their craft. The finish line and or any race markers will be highlighted on the screen with an arrow that shows the players where to go. This feature can be turned off for more advanced racers.

In both the Competition and Co-op story modes, players will each play on different computers that are connected to the Internet. Split-screen play is not very feasible for our game because building requires using the mouse; meaning that only one player on a computer could build at a time. Thus, all multi-player game play will occur over the Internet with one player per computer.

Learning Outcomes

This game's target audience is middle to high school students. Whether it is integrated into the classroom alongside the concepts students are learning in class or simply played for fun, it will encourage students to further their understanding of these various physics concepts and see how they apply in real life situations. It is important to note that this game should not be used to test a student's knowledge but instead allow a student to experiment with these various concepts.

The story will help reinforce some of these learning outcomes. For example, from the beginning of the game, when grandpa attaches the propeller the wrong way, players will immediately be learning about propulsion. Through correcting the mistake, they will gain a basic understanding of how the forces and direction of the propeller contribute to the thrust of the boat. When entering the different races, players will have to take into account and note certain restrictions.

For example, one of the restrictions mentioned earlier was to build a boat that could carry a certain amount of weight. This will help players develop the understanding of buoyancy.

Much of the learning will also come from when they first earn or are given new parts. There will be a short video introduction for new parts in which the Grandpa comes on the screen and briefly explains the physics behind the parts and how to most effectively use them in their machines. After the first introduction to parts, this information will be given to the player in short summarizing sentences in an information box that pops up when you select the part in any game play mode.

Through building boats, airplanes, and go-karts, students will be able to learn about general concepts like force, energy, and gravity. It will also hit on topics like aerodynamics, hydrodynamics, weight distribution, combustion, friction and buoyancy. As mentioned earlier, by experimenting with the weight that their boats can support depending on the various parts that they use on the boat, they will be learning about buoyancy. Another thing they may have to take into account is the shapes of the different hulls, allowing them to learn about the basics of how the hull moves through the water, or hydrodynamics. Other concepts such as the physical/mechanical properties of the various parts will need to be taken into account when thinking about how sturdy their boat needs to be.

In-game experimentation (which will be aided by the magical diagnostic tool) will allow the student to mess around with these concepts to improve their understanding. All of these concepts will be reinforced when players start testing their machines. The magical diagnostic machine will show all the physics properties including hydro, buoyancy, propulsion, etc. which

were taken into account while building the boat. By grouping together all these physics concepts, players will be learning about how each of these physic properties coexist and relate with one another.

A more specific example of what a student will learn is the decision to use a sail while building a boat. Some concepts students may have been introduced in school are the basic understanding of surface area and force. The introduction to sails will tell them about how these concepts apply to the effectiveness of a sailboat in various conditions. Players will have to compare the forces on the sail in different wind conditions and directions. The key to choosing the most effective sail would be to see if the forces are consistently proportional to the difference in the surface area of the two sails. They will also have to determine if a sails depth or camber affects how well the wing went upwind. This would be done by applying what they learned in class/introductions, experimentation of different sails, and testing the sails with the diagnostic tool.

Beyond learning these specific physics concepts, players will also benefit from the use of science process and thinking skills. When learning about the different parts they will have to evaluate and sort different data according to the race guidelines. On top of this, players will have to demonstrate their understanding of physics concepts, principles and systems when building their machines in order to build the most effective machine.

Learning Theories

This game will employ the behavioral learning theory. We'll condition the players to want to improve their understanding of these various physics concepts and keep advancing their

projects through forms of positive and negative reinforcement. As far as positive reinforcement goes, following each race in the story mode the player will receive trophies and also unlock more advanced competitions and parts. When players don't do as well, they'll view in the races that their boats will sink losing their parts which will reinforce the players to rethink and redesign their boats. In order to improve though, they will get to see the competition's boats. This will allow the player to get ideas of how they can improve their boat. Then, back at the garage, they can incorporate things they saw at the race. They will be able to load their old designs so they can improve on it instead of having to start all over, but the option to completely start over will still be available. For each race, they will be able to retry as many times as they want before going back to the garage. This provides for the case when it wasn't the boat's design that was the real cause to losing but perhaps just a bad race.

Another prevalent learning theory is the Cognitive Theory. When each new type of part is unlocked and used, a basic tutorial on how it's used and what physics properties are most important to it. They will have to process this information that they are given and remember it for future races. This knowledge on each of the different parts will expand as you obtain and learn about more and more parts. This information is then always available in a little library in the player's home base, the garage. This will allow the player to review information which they may have forgotten or may not have fully understood.

Taking a look at it from a broader perspective, essentially the whole story mode and building process the player goes through would be considered a cognitive aspect of this game. The player is processing information they learn not only from the parts, but also through the testing of their machines. Using the diagnostics machine, they are able to see how different parts affect their

machine. This allows the player to interact with and learn from each part by trying out all the different parts that are available to them and finding out which one is most effective. As races are won, more and more physics properties are introduced, requiring the player to build on what they've learned from past races and deal with new and more complex problems.

The artificial intelligence within our game will also employs this cognitive learning theory. The artificial intelligence system within the game measures the performance of players and advances them through races accordingly. For example if a player just crushes all his competition in the first race he will be introduced to more different parts and physics concepts. Another instance where the game may advance is if a player manages to choose the most effective parts for their entire boat. The following races the player will enter there will be more race factors he will have to take into consideration. He may have to take into consideration stronger winds. They may have to carry a certain load. The race course may have more obstacles such as rocks or tighter turns a player must take into consideration.

Constructivist Theory is also prevalent in the game. The social aspect of the game, the Multi-Player/Online Mode, allows players to look at the designs of their competitors/peers in the "gallery". By downloading and interacting with others' designs, this allows players to improve on their own designs and make suggestions to help out others. With this distributed intelligence the players may find that there are flaws with even the winning designs.

Nothing enforces these learning theories. In other words, the entire game does give the freedom to potentially have the player just build the ultimate machine using trial and error. Even though a player may not take everything out of the game through just trial and error, a

player is still capturing the general concepts of how the physic interacts with the different parts. For example, by trial and error of different sails, the player will still be able to view which shapes or characteristics of sails are the most effective. Through trial and error of different hulls, a player will still be able to take out of the game how of how a certain shape or material is more hydrodynamic than another.

Learning Principles

The transfer principle applies to our game because each race will incorporate physics properties from past races. The user will be expected to continue applying what they've learned from past races to future races. While new factors are introduced with each new race, past principles continue to be very important and cannot be forgotten. An example of this is how a hull affects the weight of the boat. While that fact will not be explicitly covered in future races, it is still an important factor in how the boat performs. (Gee, 142)

Another principle which applies directly to how we set up the game is the "Material Intelligence Principle". All the physics properties are directly incorporated in the different parts and tools that you are provided. A good example where the "thinking, problem solving, and knowledge are 'stored' in a tool" would be our magical diagnostic testing machine described earlier. The machine tells the user the specific physics properties they should focus in on while trying to build their boat which demonstrate the boats performance. Using these basic diagnostic tests, the players are allowed to use their own thinking with the results of the diagnostic to build the best boat. (Gee, 110)

A third learning theory which our game really tries to focus in on is the bottom-up basic skills principle. The more you play the game the more resources you're given. As you're knowledge of physics expands, you're given more opportunities to create the more advanced boats. As you get more and more parts, you have more choice. This keeps the player from feeling too overwhelmed with material that they haven't been introduced to before and allows the player to progressively build up their knowledge. (Gee, 142)

Motivation

The game includes various individual motivations as mentioned in the Malone & Lepper article. In order to keep the challenge level continuously optimal to keep the player motivated he or she is able to choose the difficulty level between Easy, Intermediate, and Hard. For students that are good at physics topics before starting the game, know how to use the parts at an advanced level, and are annihilating the competition in the early levels, the game is able to diagnose this and take the player to later levels and more advanced topics. Also, if possible, a pre-play test would be given to all students to further asses the material that they know vs. the material that they are unfamiliar with. Then, after figuring out what the students know, the game places the student players at an appropriate starting point to ensure that the player is continuously playing the game at an optimal level of difficulty. (Malone & Lepper, 231)

The players are continually challenged and motivated with goals. There are many goals in the game, including short term goals like unlocking new parts, new races, new challenges, and advancing the story line. Learning physics is also a motivational goal in this game, although it is more of a long term goal because in order to advance and build the fastest machines the player

must learn how to use physical theories to place parts in the most effective places. (Malone & Lepper, 231)

The outcomes are often uncertain depending on how well the player is able to use the parts to build a successful and properly functioning creation. The gamer receives performance feedback after the race which then motivates him or her to create another new, exciting, and more advanced product. This game will prompt the cognitive curiosity of the player, which will motivate them to learn how different vehicle parts work, as well as why they work that way. Control also plays a large role in the game wherein the player has the ability to make a series of choices such as which parts to use and how to assemble these parts. The task will ultimately result in a powerful effect after the player completes a race and sees his or her progress, success, or perhaps failure. (Malone & Lepper, 231)

The multi-player mode also utilizes the interpersonal motivations mentioned in the Malone & Lepper article. Since the players will be playing against other people, such as their friends, they will be more motivated to play the game in order to be more competitive. Particularly, players will be motivated by competition when playing the multi-player mode with their friends. In order to get better at the game to be able to consistently beat their friends, players will be motivated to experiment more in their game play to try and discover new strategies with which to beat their friends. Also, this will motivate them to learn the physics behind the game, so that they will be able to more effectively compete with friends. (Malone & Lepper, 242)
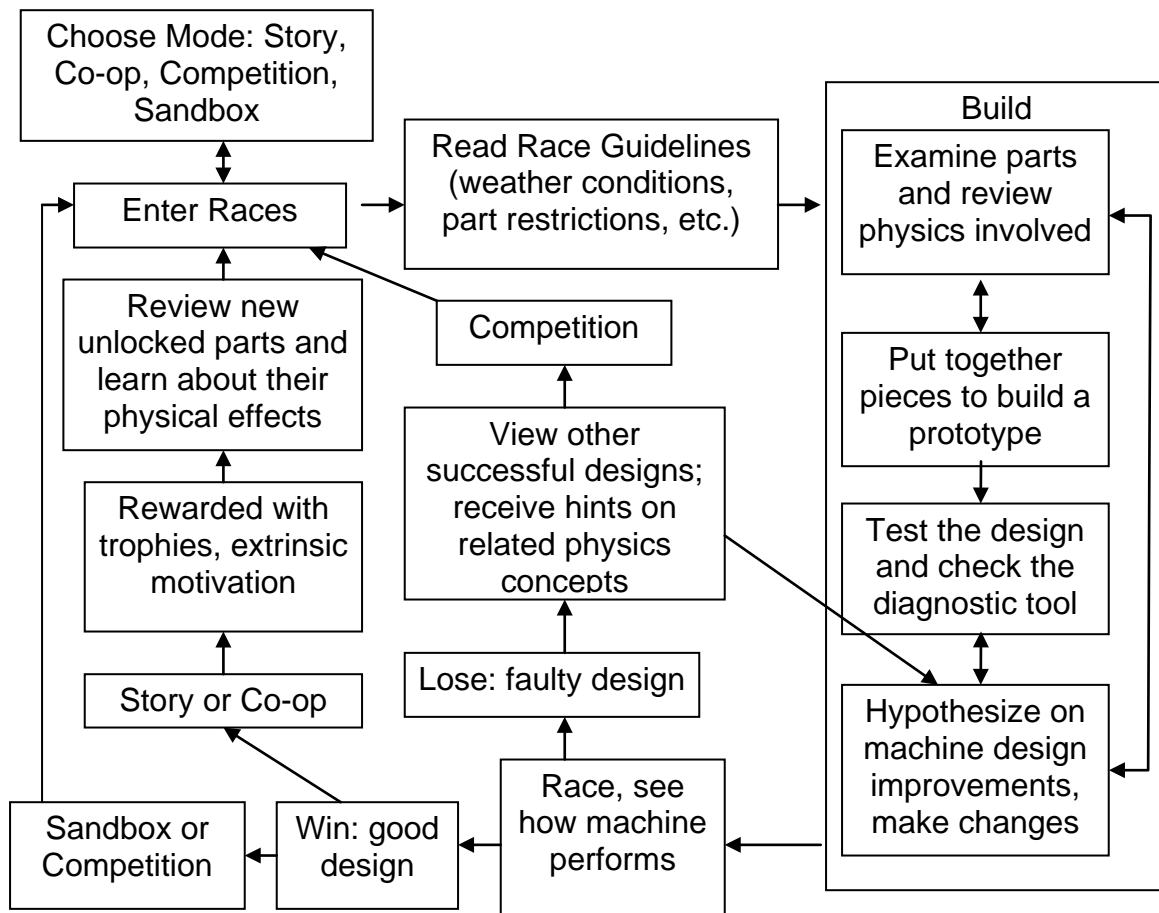
Logic Model

Our logic model starts with the player able to choose the type of game play mode: Story, Co-op, Sandbox, or Competition mode. After choosing the mode, the player can then begin a race, or back out and choose a different mode. After selecting a race, the player will be briefed on the requirements and guidelines of the race, such as what the weather will be like, the length of the race, and how many parts the player can use. After choosing a race and reviewing the conditions, the player will be sent into the garage for the build mode of the game. Throughout the build mode, the player will be able to examine the available parts and review their physical properties. Initially, the player will build a prototype that he or she believes may be successful, going back and forth between the machine and the parts review as necessary. After building this first version, the player will be allowed to take their creation and test it in action. Additionally, the player can utilize the diagnostic tool, which will give potentially useful numerical information about the machine. After testing the vehicle, the player will have the necessary information to form a hypothesis on how to make any improvements on the machine. After making these changes, and returning to the parts information as necessary, the player will be able to test the vehicle once again, and repeat the process as necessary.

Once the player believes that he or she has a winning design, the player can exit the build mode and enter the race mode. After racing the vehicle, the player may lose. If the player loses, their vehicle design was probably flawed. In order to assist the player, he or she will be given some tips or hints about how to better improve the design. With this information in mind, the player will return to the build mode and will need to reform a hypothesis on how to improve the design. The exception to this is that in competition mode, the player will instead return to the race screen, as players only get one attempt per race in competition mode. After repeating the

cycle of forming hypotheses and testing the vehicle, the player will be able to race again, as many times as necessary.

If playing in Story or Co-op mode, after winning the race, the player will first be given an extrinsic reward: a new trophy for their trophy case. After spending time in the trophy room, the player will be shown any new parts that have been unlocked, along with a brief explanation on their use and physical properties. After learning about the new parts, the player will return to the enter races screen and be able to choose another race to begin. If in Competition or Sandbox mode, the player will not unlock anything but will instead return directly to the races screen.

Choose Mode: Story, Co-op, Competition, Sandbox

Enter Races

Read Race Guidelines (weather conditions, part restrictions, etc.)

Build
Examine parts and review physics involved

Review new unlocked parts and learn about their physical effects

Competition

Put together pieces to build a prototype

Rewarded with trophies, extrinsic motivation

View other successful designs; receive hints on related physics concepts

Test the design and check the diagnostic tool

Story or Co-op

Lose: faulty design

Hypothesize on machine design improvements, make changes

Sandbox or Competition

Win: good design

Race, see how machine performs

Cheats

By incorporating cheats into our game, this will allow the game to accommodate players' skill levels. For example, a teacher could add race restrictions to help challenge a player who is easily mastering the physics concepts. On the other hand a teacher could remove restrictions to help those who are having troubles and need to focus on just the basic concepts. Here is an example of some cheat codes that we can add:

- A code to unlock parts.

- A code to change race day conditions

- A code to make your boat faster/stronger/more agile/better for a race

- A code to change race restrictions just for you.

- A code to unlock Ultimate Machine Mode

Our definition of cheating is to gain advantage over other players by means outside of regular game play.

Research/Evaluation Plan

The game will have a few methods of evaluation. By collecting the information that the diagnostics machine gives the player, we will be able to see if the player is steadily improving the design of the machine. The data can be analyzed by anyone interested to see almost exactly what the player has done to build their machine. On top of that, it will be obvious if the players are becoming familiar with the physics principles based on if they are progressing through the game. This is a viable method of observing because as the game progresses, more physics principles are introduced and become important to winning races. So, if we see the player continuing to win races, it will either be because they've found a way to cheat the system or they are using the principles they've learned to build the best machine.

In addition to in-game data collection, a post play test could be given by the teacher. This test could be generated individually for each player based on how far they've progressed in the game or the same test could be given to everyone. The customized test allows each player to be tested on just the principles they have learned about and should know. Giving everyone the same test would evaluate both the players and the game. If everyone is expected to know everything on the test, the test becomes more of an evaluation of how well the game teaches certain principles. Both options provide unique testing outcomes and would provide valuable information to the research team. These post play tests, in conjunction with the test given before ever playing the game will help researchers, parents, and teachers understand what the game has helped the students learn and where the game may have fallen short.

At the end of game play, the students should be asked to actually build a machine as a final class project. They should be given the choice of go-kart, boat, or plane and split into groups. From there, they are free to build their machine as they please. Then, after being given a set amount of time to complete their machine, they should get to race them against other people in the class. This activity allows them to really put their knowledge to the test. Possibly more importantly, it allows them to work in actual teams to combine ideas and learn from each other. Finally, a report on their design decisions should be submitted to the teacher. The report should include a detailed description of every part they used including why they used it, quoting the specific physics principles. They should also indicate what they could have done to improve their design if they didn't do well in competing against their classmates.

After game play, an educator could ask a series of questions directed at the students about what they have learned. This will help the players to realize their learning potential in the game and will allow the educators to see the purpose and educational value of the game.

1. Given three options for a type of sail to use, which one would you choose and why?

2. How does the principle of aerodynamics fit in with your final design?

3. After the race, what tools did you use to improve your design, and why?

4. In "Create a Race" mode, how did you decide which conditions to choose and why?

Conclusion

Our game, The Ultimate Machine, will encourage people to learn physics in order to build the best machine they can. It will be entertaining because of all the components described above. Engaging your friends and peers in races with designs you are personally responsible for is a powerful motivator. The game strives to make it easy to pick up and start designing a good machine right away and encourages the player to master the properties through tinkering with parts and design.

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