PORTAL 2

Thinking with Portals:

A post-mortem evaluation of Portal 2 for the XBOX 360

IDT545

Instructional Simulations and Games

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April, 2012

Abstract

Portal 2 is an excellent candidate for use as an educational tool in its commercial off the shelf (COTS) form and could be modified to accommodate specific learning objectives.

This paper covers the single player version of the Portal 2 for Xbox 360, a first person shooter/puzzle game. In this sci-fi theme game, the protagonist must utilize problem-solving and situational awareness to navigate a series of puzzles which increase in complexity and sophistication. This game has a learning level which aligns with the intellectual and cognitive skills on Gagné's learning taxonomy. Portal 2 offers some interesting opportunities as a learning environment, including applications for demonstrating and practicing with the scientific method, physics concepts and spatial acuity.

High concept

Insane AI's, perilous testing chambers and Portals - navigate complex puzzles to escape from the menacing Aperture Laboratories using only your wits, and Portals.

Overview

You must solve puzzles in the form of testing chambers in order to escape the Aperture Laboratories facilities which serve as your prison. Your only resources are a dual Portal device, the ability to pick up objects, your long-fall boots and Wheatley, your guide. Hazardous testing chambers, complex puzzles and deception awaits you as the maniacal GLaDOS returns for revenge.

Portal 2 is similar to the smash hit Portal but includes new features such as lasers, turrets, light-bridges, and more! With more elements to negotiate and a deeper story, Portal 2 is more complex and more fun!

Learner Characteristics

Seen through the eyes of Chell, the female protagonist from the original Portal, this game is played in the first person. However, the spirit of the game is closer to a 3D platformer as it requires the player to search for a way to exit using all three dimensions.

The Entertainment Software Rating Board (ESRB) rates the content of this game E10+ (everyone 10 and up) because it includes fantasy violence and mild language. All of the violence that the player inflicts is toward machines and MOST of the violence towards the player is implied or indirect. Combat is presented in a puzzle format. The player cannot inflict direct damage and must utilize Portals and any available environmental hazards, such as a Thermal Discouragement Beam, to defeat enemies. While most of the game is kid friendly, the dark humor will appeal to an older audience.

The game mechanics and level of strategy involved is geared toward an experienced gamer. The target learners are senior high school or college level, who has experience playing games 3D puzzle or First Person Shooter (FPS) games.

Interface design and interactivity

The interface is simple: There is no heads up display (HUD) save for the elliptical target reticule and the Portal indicators of dual Portal device. Controller interactions include shooting Portals, jumping, picking up objects, and crouching. (Fig. 1).

Fig. 1 - Portal 2 H.U.D

Game management includes pressing the start button to access the main menu to access save, load, and game options (Fig. 2). The game utilizes autosave which saves your progress after every chamber, chapter or other predetermined points during the game.

The player has two basic tools which is carried throughout the game: Long fall boots and the dual Portal device. The Portal device is not only for placing Portals, but also allows the player to pick up items. Other tools utilized throughout the game are limited to the level which is being played.

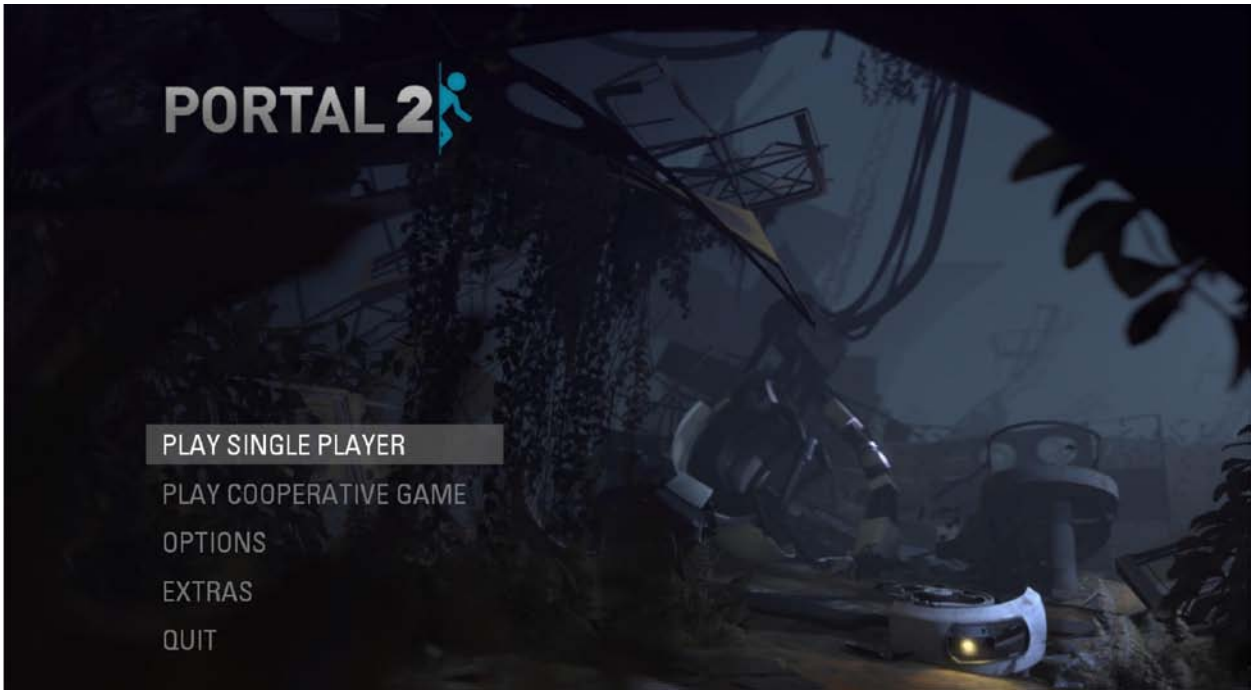

Fig. 2 - Portal 2 Main Menu

Gameplay/entertainment

The world of Portal 2 is designed around puzzles. Each chamber you enter is a puzzle which must be solved in order to navigate through the world and achieve your primary goal: Escape. Puzzles increase in complexity and in the combination of obstacles which the player is required to deal with. Each subsequent puzzle is more difficult, relying on mastery of the previous skill. For instance, one chamber will introduce a new element such as the Thermal Discouragement Beam. This allows the player to learn what the beam does and what it is used for. The next chamber will include other elements such as the Aperture Science Weighted Pivot Cube which allows the player to aim the beam to a switch to open doors. Subsequent chambers increase in the amount of previously mastered skills (Portals, switches, turrets, etc.) to build acumen in situated learning.

Strategies

Portal 2 encourages exploration and problem solving throughout the game. The player must figure out how reach the exit of the chamber. There are guides along the way help the player figure out a particular puzzle such as:

- Posters with icons visually highlighting particular hazards and/or elements.
- Wheatley guiding you through the guts of the facility
- A voice over the speakers describing a puzzle element or test.

These guides are placed to give the player some information to figure out what needs to happen to complete the puzzle; however, these sources will give unreliable or disinformation, so the player must use caution.

As in most games, everything that is usable in the game is required to solve a puzzle. There is little in the way of extraneous elements within the game with the exception of flavor text on the walls and commentary from GLaDOS, Wheatley and Aperture Laboratories founder, Cave Johnson.

Game Overview

Portal 2 continues the story of Chell, who was captured by Aperture Laboratories after the destruction GLaDOS. As Chell, you awaken in an unfamiliar room (Fig.3). A voice instructs you through some basic movements and actions which serve as the basic controls tutorial. The tutorial ends with you returning to sleep.

You are once again awakened but now the room is in a state of disrepair. It is unknown how much time has passed but the dilapidated state of the room and your body imprint on the bed indicates at least a few years. You are introduced to Wheatley, a “personality core” who wants to help you escape the run down facility. Wheatley serves as a pedagogical agent which guides and encourages you through prerequisite knowledge and skill building during the beginning of the game

A series of events leads you and Wheatley to find the Portal Gun and re-active GLaDOS, the rogue AI from the original Portal. GLaDOS, out for revenge for destroying her, drops you down a tube into the testing track for more testing.

Fig. 3 - Waking up in an unfamiliar place

The first few chapters are dedicated to becoming familiar with basic controls and environment. These chapters begin to introduce hazards and testing elements which are used for

solving the puzzles required to advance through the game. The puzzles at this point of the game require you to evaluate your surroundings and generate a solution.

Wheatley appears from behind a panel in one of the testing chambers and helps you escape into the insides of Aperture Laboratories. During the escape, you and Wheatley sabotage both the turret manufacturing plant, the neurotoxin generator, and encounter GLaDOS (Fig. 4). Wheatley devises a plan to initiate a core transfer which will remove GLaDOS from the system and place Wheatley in control.

The boss battle with GLaDOS requires acumen of the evaluation and solution generation skills you have practiced up to this point. This difference between the first set of puzzles and the boss battle is that now the puzzle is live. Instead of a set puzzle with all of the elements placed for the player to utilize, GLaDOS will react to what the player does and use strategy to defeat the player. GLaDOS will actively try to stop you from defeating her by placing barriers and throwing you across the room.

Fig. 4 - Boss battle: GLaDOS

Once the core transfer is complete, Wheatley becomes insane with power and blames Chell for taking all the credit when he did all of the work. Wheatley connects the defeated GLaDOS to a potato battery and destroys the elevator as you try to escape.

You find yourself in an earlier version of the testing track which you must navigate through to find the exit to freedom. Along the way, you rescue GLaDOS from being eaten by a crow and take her with you (Fig.5). The old testing track introduces new testing elements for practice. The old test track also reveals the history of Aperture Laboratories including the origins of GLaDOS.

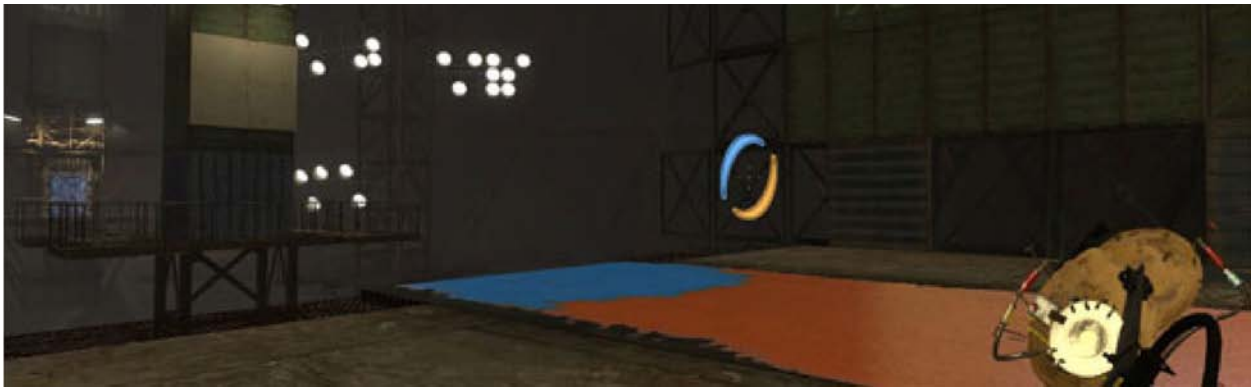

Fig. 5 - Navigating the old test chambers, GLaDOS in tow

As you and GLaDOS make your way back to the surface, you find that Wheatley has been busy creating new testing chambers. Wheatley has neglected to maintain the nuclear reactor that powers the facility and it has become unstable. While testing chambers that Wheatley has created are ill-formed and easily solved, he also has pulls some of the more sinister chambers from GLaDOS's collection.

After besting Wheatley's new test chambers, you and GLaDOS find a room with defective personality cores. GLaDOS creates a plan to add the cores to Wheatley, overloading the system with core corruption thereby forcing another core transfer. Once GLaDOS is in control again, the AI promises to set you free. Wheatley is ready for the plan and you must distract him long enough for GLaDOS to get the corrupt cores ready to attach them to Wheatley (Fig. 6).

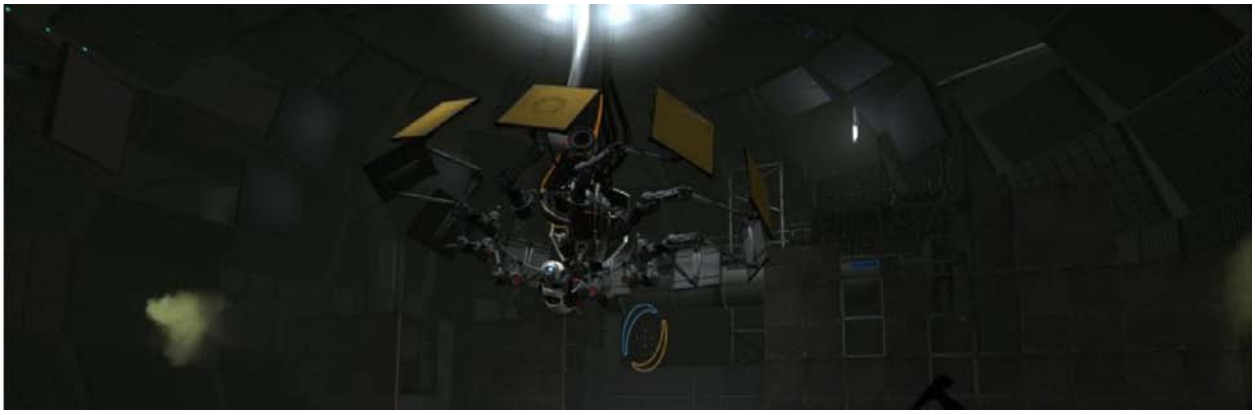

Fig.6 - The final showdown

The final battle requires you to quickly assess the situation and react accordingly. In addition elements from previous tests, new elements are introduced during this battle. The skills of evaluation and solution generation are again required to learn how these elements work together or against each other to defeat Wheatley. The battle is also timed as a reactor core will melt down in six minutes.

Successful completion of the final battle shows a very entertaining final cut scene and completion of the story which leads to the cooperative version of the game not covered in this paper.

iGrid

The interactivity Grid or iGrid as described by Hung and Van Eck is used to categorize a game based on the number and frequency of interactive choices the player can make. The iGrid will not give us a detailed map of every choice throughout a specific game, but is used as an indicator when selecting a game for use as a learning tool.

The iGrid is contains 6 different categories which generally align with different gameplay types:

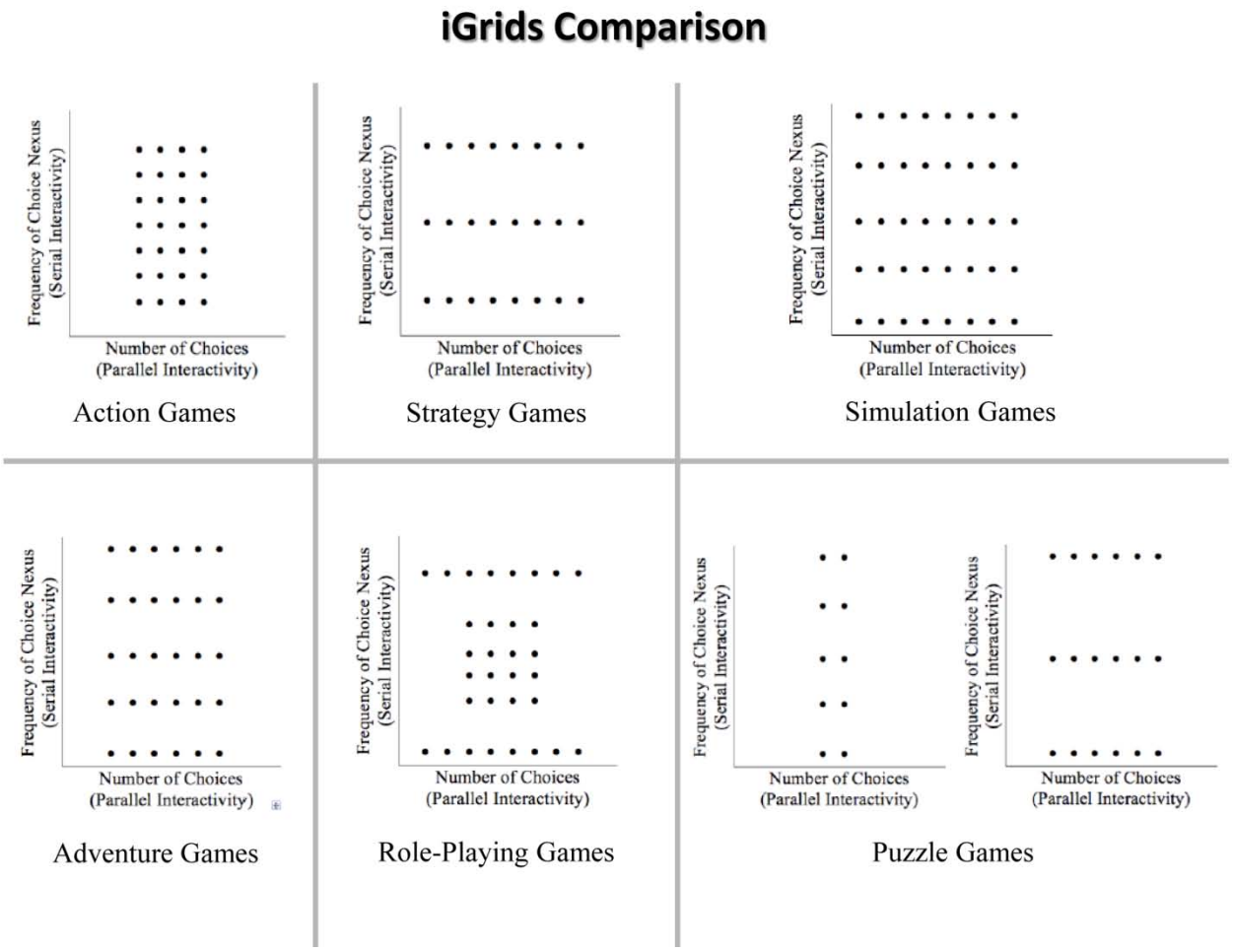

Fig. 7 - iGrid comparisons

Portal 2 falls in the puzzle category (Fig. 7), due to the fact that most of the choices a player makes depend on the available testing elements in a particular puzzle (lasers, gels, switches, etc). Most of the game is on a rail, meaning that the player's choice of where to go and what to do is limited by the game: you can only do puzzles in the order the game dictates. The only choices the player are allowed to make is during the puzzles and boss fights, but these are limited by the goal for the game. While these decisions are not explicitly offered, it is up to the player to figure out what the rules of the puzzle or boss fight is and how to successfully complete the goal.

Portal 2 falls in the logical problem category of Jonassen's typology of problems because each test chamber uses only a few of the total available testing elements. This in turn, dictates the rules for solving the puzzle. In each of the chambers, all of the testing elements are required for the solution. As an example, if there is a chamber which has a laser, a switch, and a Aperture Science Aerial Faith Plate, all three will be required to solve the test chamber. This knowledge is a part of the strategy that the player uses throughout the game.

It can also be argued that Portal 2 is a strategic performance problem as well. The player must look at all of the elements in a test chamber and figure out the solution, but they must also be able to make adjustments while solving the puzzle. This requires the player to have and develop skills in spatial acuity and problem solving, as issues, obstacles and new information which will affect the outcome of a test chamber can appear during game play.

Instructional/Learning Factors

Portal 2 emphasizes two categories of Gagné's learning taxonomy: Intellectual skills and cognitive skills. Mastery of these skills is required for the player to advance in game.

Intellectual skills are developed by the necessity to discriminate, define and categorize concrete concepts in the form of puzzle elements (i.e. the Thermal Discouragement Beam). The player must then use these concepts to create both rules and high-order rules (using Portals to direct the Thermal Discouragement Beam).

Cognitive skills are also a major requirement of the game in that the player must create a method for finding the correct solution to the puzzles. Portal 2 will not give you any hints as to the solution of a puzzle other than the help listed in the strategies section above, therefore a method to identifying objectives, hazards, possible solutions and implications is required to successfully navigate the puzzles.

Adaptation for instructional use

Suitable instructional topics for Portal 2 would include practice using the Scientific Method and spatial acuity training. There is also an opportunity to adapt the game to illustrate some concepts in physics.

Scientific method

The Scientific Method would be a great topic to use Portal 2 as a learning intervention. The game can be used in its unmodified format after a teacher lectures on the scientific method. A level would be presented to the entire class with some basic background of the level and the objective. Students would then be instructed to design a solution on paper and play out their

solutions in game. Results would be recorded, reflected on and revised until a successful solution has been found.

Concepts in physics

Games lend themselves well to illustrating and modeling theoretical physics concepts and Portal 2 has already made a start. These are a few ways in which Portal 2 can be used to be used as tool for demonstrating and practicing concepts in physics.

Demonstration

Portal 2 could be used as a tool for visually demonstrating complex physics concepts use as the Einstein-Rosen Bridge (wormholes), which could be demonstrated using the Dual Portal Device as presented in the game. The instructor would give a lecture describing the concept and theories associated with the concept. The instructor would then show the class the concept in-game while expanding on the topic to include implications and how they would work in real life as opposed to how they work in the game. The COTS version of the game will only really work for demonstrating this one concept. Other concepts would require the game to be modified.

Worked Examples

The instructor could utilize the COTS version of Portal 2 to create worked examples. The last half of the game introduces three different gels including Propulsion Gel.
The Propulsion gel, produced by Aperture Laboratories to accelerate objects. During game play, player can use the propulsion gel to cover an area such as a ramp. As the player moves up the ramp, the propulsion gel will accelerate and launch them. This strategy is used in several parts of the game where it is required to cross very long open gaps.

A worked example for can be created for a physics class utilizing the propulsion gel and ramps: The instructor will choose a level from the COTS version of Portal which has both the propulsion gel and a ramp. The objective of the learner will be to calculate the players' trajectory and predict where they will land. Since the game offers no indication of speed, the learners will need to figure out how to calculate the speed, angle of the ramp, and specify that will affect their trajectory.

This can be presented as a real-world application where the technical information has not been included. The learners will create a worksheet to identify and calculate all of information which will affect the player's trajectory. In game, the learners will have to find ways to get all of the information (i.e. angle of ramp). The learners will then calculate the trajectory and predict where they will land on paper. The students will launch Chell in the game to see if their prediction was correct. If the calculations were incorrect, they will need to go back to the game and figure out what was incorrect or missing and refine their calculations until they are correct.

While the model of worked examples will work using the COTS version of Portal 2, custom levels may be better suited. Customs levels would add a level of control to the experiments by the instructor. Speed, angle, etc. could be adjusted as required by the instructor. This would also ensure that instructor has all of the correct information to calculate the correct trajectory.

Measurement tools could be created for capturing specific numbers, including Laser Tape Measure and an Accelerometer. These numbers could then be input into an in-game worksheet and the trajectory placed into a field which would show a target at the predicted landing site. The learners would not be able to use the ramp until the trajectory and prediction was input into the system. Once trajectory has been input, the ramp and gel would be accessible and the learner

could launch Chell to check their results. If the learner was incorrect in their predictions, they would start again. After three attempts, a pedagogical agent would assist in their efforts by listing things to check or miscalculated. The agents would not give them information but guide them to figure it out themselves. If their prediction is correct, the learner would progress to the next practice or the simulation would end and a screen would show their results, including their calculations and the attempts they made.

Considerations

In order for Portal 2 to be used as an instruction strategy for teaching concepts in physics, we must determine if the games physics are accurate. If the game physics are not analogous to the real world, the teacher will have to provide interventions which offset this gap, such as:

1. Modifying the game to align the physics with the real-world.
2. Provide a scenario in which the game physics is related, for example, another planet.
3. Include a disclaimer that the game is for demonstration only and does NOT reflect real-world application.

Spatial Acuity Training

A Spatial Acuity Training module could be developed for use in professions which require accurate navigation through highly confusing environments such as a doctor performing laparoscopy surgery or an emergency response team (ERT) in a burning building. Portal 2's game mechanics creates a world where finding and reaching the goal requires the player to think about the level as more than just a standard 3D environment. Normally in 3D worlds, a player uses real-life methods of navigating a space, walking, jumping, climbing, etc.

Portal 2 introduces a device which creates a “doorway” which enables the player to enter a door in one place and exit anywhere an exit door is placed. This mechanic makes the game environment malleable and forces the player to think about 3D space from different perspectives. As the player gains experience with the dual Portal device, they quickly learn that they do not have to walk to another section of an area when they can use Portals to get there quicker.

While the technology to physically build a Dual Portal Device is a few years beyond actual production for emergency response teams, Spatial Acuity development is of immediate benefit. Portal 2 requires the player to make a mental map of the area to navigate so when they travel through the Portal, they will 1) be able to identify where they will exit and 2) quickly reorient themselves to their surrounding once they have traveled through the Portal.
ERTs (police, firefighters, etc) are required to be able to navigate terrain filled with hazards. These professionals require the acumen to identify their surroundings, hazards and goals to safely reach their target. A simulated experience would allow ERTs to practice and increase spatial acuity in controlled environments where obstacles and hazards could be added and manipulated to the requirements the particular profession.

Simulations for ERTs could be implemented in two different ways:

1. Virtual Simulation: Members of the ERT would play Portal 2 as it is presented in its COTS form. This allows a financially viable and quickly implemented solution to practice spacial reorientation and environmental problem solving.
2. Presented as true simulation: Environments found in real life situations of the ERT would need be created. This solution would require significant redesign of the game. The dual Portal device would have to be replaced with tools in the ERT

tool kit (axe, firehouse, ladders, ropes). The physical game environment would be redesigned so that area could be solved with these tools.

3. Medical training: Doctors could benefit from the COTs form of Portal 2 to practice and build spatial acuity for use in working with computer-aided surgery tools, such as in laparoscopy surgery. These surgery tools are teleoperated and have the "feel" of playing a video game and require a surgeon to be able to infer what they are seeing on a 2D screen as a 3D position in space. Using Portal 2 as a device for practice, they would hone the spatial acuity and fine motor skills they require in a safe and controlled environment.

Overall rating

Portal 2 is a good candidate for use as an educational tool. The COTS version of the game leads itself to some applications for worked examples and demonstration of concepts as described in the Concepts in Physics section. These examples and demonstrations offer good visual and entertaining resources for use in an introduction to physics educational environment and introduction to the scientific method. The COTS version of Portal 2 can also be used for spatial acuity training for doctors and emergency response teams. In addition, modified versions of the game are recommended for effective simulations for doctors and emergency response teams to practice experience-based situational training.

In order to use Portal 2 in an educational setting, the instructor should be aware of the specific chambers of each chapter. This will allow the instructor to make informed decisions as to which chambers to use to demonstrate the required concepts or goals and at which level these chambers perform. An instructor's guide should be created for reference to the chambers and include a list of elements, strategies for solving the puzzle, and highlighted concepts.

This game is a lot of fun but recommended for more adept videogame players as it requires a certain amount of prior knowledge in first person shooter/problem solving genres which will cause novice gamers a higher level of cognitive load and longer amounts of play time.

Future Research

Portal 2 is rich with topics for research which could not be explored in this paper. Research could be conducted on cognitive load while a player solves puzzle chambers could give some good insight on the effects of intrinsic cognitive load. Researchers could track players as they solve the puzzle chambers to explore factors in motivational, engagement and flow.

Valve, the company which produced Portal 2, is working on a Portal 2 puzzle creator which will allow players to create and play their own puzzles. The puzzle creator is a very interesting tool which could be used to explore the instructional opportunities of learning by design (LBD). Learning by design is the instructional theory in which the learning objectives are achieved by having the learners create a project.

References

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Media Resources

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