Impulse

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Abstract: Propel particles, avoiding destruction as you make your way to the goal. Take it fast, take it slow, just don't crash! *Impulse*, a blended-genre physics game designed for the web and mobile devices, is part of an NSF-funded research study to look for empirical evidence of learning fundamental high-school STEM content in games. We are using *Impulse* to test our assumption that we will be able to measure the development of players' tacit understanding of forces at a distance and Newton's Laws if we immerse them in a game where they must accurately predict Newtonian motion in order to succeed. As the game increases in difficulty through the introduction of additional particles and forces, players need to develop an increasingly sophisticated understanding about particles' behaviors in order to be able to predict their motions and safely navigate the player particle to the goal.

Introduction

Feeling Impulsive? Head for the goal, dodge obstacles in your way, and always remember, F = ma! Imagine you've been dropped in a sea of enemy particles. A bright light beckons in the distance. Your survival depends on your ability to avoid collisions and reach the safety of the goal before running out of energy. Figure out how the enemy particles behave and you just might make it out alive. Think you're up for the challenge?

Impulse is part of a larger suite of games being developed with support from the National Science Foundation to create games that teens (and the general public) like to play in their free-choice time, and are also designed to show empirical evidence of learning fundamental high-school STEM content. The research around these games focuses on the development and validation of a set of game-based assessments using an indwelling model of tacit learning that emerges through gameplay (Asbell-Clarke, Rowe, & Sylvan, 2013; Polanyi, 1966; Thomas & Brown, 2011).

About *Impulse*

Impulse is an immersive, blended-genre physics game designed for the web and mobile devices. Combining elements of puzzle, arcade, educational, and simulation games, *Impulse* places players in an N-body simulation of ambient particles obeying Newton's Laws (Figure 1). To advance, players must navigate their player particle (green) to the goal using a limited amount of energy. At each level, increasing numbers of "enemy" particles with different mass are introduced. Particles respond to the force of the impulse imparted by a player's tap or click, forces between particles (e.g., gravity), and elastic collisions between ambient particles. However, a collision between the player particle and any other particle results in an explosion and ends the game, sending the player back to a previous checkpoint.

Figure 1: *Impulse* game screen

Impulse requires the player to apply a force (an impulse) through a touch or click input. Players must use impulses to guide their particle to a goal without colliding with any other particles. Applying an impulse behind the particle will move it forward, while inserting an impulse in front of it will slow it down or make it travel backwards (relative to its initial direction of motion). However, every impulse requires energy, so players need to keep an eye on their energy bar and be strategic about where and when they create an impulse in order to have enough energy to

complete the level.

Early levels of *Impulse* are designed to teach players about the game and basic science concepts. Checkpoints unlock new levels as players master the skills needed to advance. Level 1 teaches the player about their interaction choices by including only the player particle and the goal. This lets them play as long as they like without fear of particle destruction, but also see how the particle moves away from the impulse, how the location of the impulse affects the resulting speed of the particle, and how energy drains from the energy bar with each move the player makes.

Enemy particles of different mass (indicated by color and size) are introduced at successive level checkpoints, as players learn that colliding with another particle results in a game-ending explosion, but other particles can collide with one another. They also see how particle collisions influence the speed and direction of the particles' motions and learn that they can move any particle with an impulse, not just the player particle. At each level, more particles are added to increase difficulty. As the number of particles grows, it also becomes more obvious to players that there is gravitational attraction between particles.

Impulse Design

Impulse was created by a joint team of game designers, scientists, and educators who are trying to make a marketable, free-choice game (to be played outside of school), while also studying how learning a scientific phenomenon in a game compares to learning it in a traditional or an inquiry-based science curriculum. While there are plenty of other games that include elements found in *Impulse*, our overall goals led us to focus the game's design on just one set of principles (Newton's Laws of motion), without complicating factors such as dynamically changing mass as seen in Hemisphere Games' *Osmos* (2009) or friction as would be experienced in a real-world gaming experience like billiards.

In *Impulse*, as players determine the best path to the goal, they need to "study" the behavior of particles in order to be able to predict their motion and avoid them. More specifically, players need to predict motions that can be described by Newton's First (an object in motion or at rest will stay in motion or at rest unless acted upon by a force) and Second (F = ma) Laws of Motion, and a conceptual understanding of Newton's Law of Gravitation (the gravitational attraction between two masses is proportional to the masses of the objects and inversely proportional to the square of the distance between the masses).

Show Us Your Game Face

Impulse was designed with data collection in mind. We are using the game to test our assumption that we will be able to measure emergent, implicit cognitive strategies when players are immersed in a game where they must accurately predict Newtonian motion in order to succeed (see Asbell-Clarke et al., 2013 for details). To study players' understanding of the concepts built into *Impulse*, we are collecting and analyzing click-data as well as Silverback recordings (Clearleft Ltd., 2013) that include screen-capture video of gameplay, video of players' faces, and audio (Figure 2).

Figure 2: Montage of teens' faces during gameplay

We use the recorded playtesting data to code strategic gameplay moves. With coded clicks as "ground truth," we then use educational data mining techniques to predict those strategic moves and describe how strategies evolve as players advance in the game (Asbell-Clarke et al., 2013; Romero et al., 2010).

References

Asbell-Clarke, J., Rowe, E., & Sylvan, E. (2013). *Working through Impulse: Assessment of Emergent Learning in a Physics Game*. Paper to be presented at the Games + Learning + Society (GLS) 9.0 Conference. Madison, WI.

Clearleft Ltd. (2013). Silverback: Guerilla usability testing software for designers and developers (Version 2.0) [Software]. Available at http://silverbackapp.com

Osmos [Video game]. (2009). Nelson, Canada: Hemisphere Games.

Polanyi, M. (1966). *The Tacit Dimension*. London: Routledge.

Romero, C., Ventura, S., Pechenizkiy, M., Baker, R.S.J.d. (Eds.) (2010). *Handbook of Educational Data Mining*. Boca Raton, FL: CRC Press.

Thomas, D., & Brown, J. S. (2011). *A New Culture of Learning: Cultivating the Imagination for a World of Constant Change*: Printed by CreateSpace.