

Using game-based learning to engage people with Physics: how successful could 'Junkyard Physics' be?

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Abstract

This small study was conducted with the aim of contributing to current theories on gamification and its ability to assist with the learning experience. Specifically, a prototype of a physics-based game (Junkyard Physics) was developed to teach the basic principles of forces. The resulting prototype was tested on lay people to determine if the game improved their level of understanding of the laws of physics. Testing was conducted via a questionnaire at the Develop conference in Brighton 2013. Results indicate that the game is a good way to engage people with physics, although it is acknowledged that with only one game level completed the learning outcomes were limited. The findings indicate that gamification is a valuable educational tool, which merits further research and development.

Key Words

gamification, physics, education

1. Introduction

Gamification has been shown to be beneficial in several fields such as employment, marketing, learning (Karl Kapp 2012), and to the educational process (de Freitas 2006). The process of learning is most effective when it contains elements which commonly exist within a gaming mechanic, such as rewards for achievements, leader boards and defined levels of difficulty. The aim of this study was to further examine the usefulness of games to the pedagogic process, specifically in the context of basic physics and assess if a new game 'Junkyard Physics' could potentially encourage young people, specifically girls, to engage with the subject.

In a recent survey the Institute of Education (IOE) – University London asked 5034 students whether they would consider studying physics after GCSE only 5% of girls and 13% of boys said they would strongly consider it (Institute of Education 2013). Craig Durham of the Institute of Materials, Minerals and Mining said “we desperately need more physics graduates” – (Craig Durham IOM3 2010). Considering the current numbers of students studying physics at the IOE, it does not appear that the UK will educate the number of physicists it needs and new ways need to be found to motivate and interest young people in the subject.

2. Literature review

2.1 Gamification

There has been recent research focused on the use of games for reasons other than pure entertainment. This research study was conducted first into the usefulness of gamification and secondly into the more specific concept of games in the learning process (Subrahmanyam & Greenfield, 1994).

Teaching is currently mostly instructor based, meaning someone is being taught by someone else. This way of teaching allows for real-time feedback to the person learning. The main downside of this type of teaching is that it depends upon the knowledge and skill of the person teaching. Conversely, computer-based teaching has the same level of knowledge no matter which computer the learner uses. However, real-time feedback cannot be provided.

Instructor- and computer-based teaching can be combined with gamification. If a game is created to teach, you get accurate knowledge and if a gamified layer is added, the learner can get instant feedback as they will only be able to progress through the game if they are correctly completing specific tasks (Gamification wiki).

Physics can be a difficult subject for people to learn. Gamification can be used as a learning tool for many subjects including physics (BBC 2013). Using games to teach physics allows players to view many experiments that cannot be easily demonstrated in the class room. For example pupils would not be allowed to attach a rocket to a ball to see how thrust works in a classroom setting. However, through gamification, this sort of experiment can be easily simulated.

2.2 Girls and Physics

Girls in school are statistically less likely to choose physics as an A-Level option. Only 5% of 5034 female pupils asked in a questionnaire said they would strongly consider taking physics as a subject after they turn 16 compared with 13% of boys. Research conducted by the IOE found that even if the testing scores are comparable to boys, girls are still less likely to choose physics. It did not ascertain why girls were not choosing physics and currently there

is no obvious solution to enable schools to get more girls into physics (Institute of Education 2013).

2.3 Girls and Games

According to the Entertainment Software Association (ESA), 45% of game players are female and 36% of games are played on a smartphone (Entertainment Software Association 2013). ESA's statistics show that females are increasingly playing games and more smartphone games are being sold. This means that girls will be able to access a fun game on the go or in school and learn valuable physics lessons. If girls start playing early in their lives it may spark an interest for them to take it further and study physics at GCSE, A-level or at university.

3. The Game

Junkyard Physics was developed by three female students at Kingston University. It is a physics game where impulse or thrust is added to a ball. The aim of the game is to pass through levels by hitting a button with the ball. In order to do this, players need to add the correct force, either impulse or thrust, or both, to the ball. The player then presses the play button to discover if they have succeeded. Once the button has been hit, there are question screens (figure 1) where the player is required to answer a question correctly to proceed to the next level.

Impulse is applied through the kick of a boot, as it is a one off application of force. In order to show thrust, a rocket is used. A rocket supplies a constant force, and is attached to the ball when thrust is needed. Players learn about both these forces as well as how gravity will affect the use of these forces by dragging the ball back to earth.



Figure 1. image showing the question screen

Tutorials explaining the different aspects of the game are provided to the players at necessary points. These take the form of an arc of motion, (figure 2) to show them where the ball will go when play is pressed. By using this on the tutorial levels the players could learn how the forces worked and how to use those forces to hit the button with the ball. Once the tutorial is complete, the arc of motion is removed, so that players are challenged to work out where the ball will go themselves.

Fun characters are incorporated within the game to make it more user friendly and to help with the learning experience. The “evil rabbit” prevents the player from moving forward by asking them questions and sticking its tongue out when the player fails a level. The “nice bunny” teaches the player how to play the game and imparts some basic knowledge of physics. It also gives a thumbs up and a wink when the player passes the level, to reinforce that the player had done well.

Rusty nuts are also collectable in the game. They are not required to complete the level, but add another challenge for the player to re-play levels and collect them all to fill a jar. They act much as stars do in similar games, however, rusty nuts gave more continuity to the theme.



Figure 2. image showing game play including the arc of motion

4. Testing Methods

Junkyard Physics was tested at the Develop conference held in Brighton July 2013. Data was gathered by means of a questionnaire with specific questions as well as a section for comments and suggestions.

The questionnaire asked people to rate their previous knowledge, learning experience of the game, gaming experience, whether the player thought this a good way to learn and

whether there was enough instruction within the game. The player was asked to mark between one and five, one being bad and five good.

People of varying ages and previous physics knowledge played the game and took the questionnaire. The questionnaire was only used at the Develop conference. At Women in Games and EuroGamer, an informal interview was undertaken to obtain general feedback on the game mechanics and the learning within the game.

The opinions of the sample players were processed with basic statistical techniques.

5. Results

Question (score out of 5)	Result – out of 30
Rate Your Previous Knowledge of Physics	No Knowledge – 1 (13%) 2 – 6 (20%) 3 – 10 (33.5%) 4 – 10 (33.5%) Stephen Hawking - 0
Rate Your Learning Experience	Learnt Nothing – 5 (17%) 2 – 10 (33%) 3 – 11 (37%) 4 – 4 (13%) Learnt a lot – 0
Rate Your Gaming Experience	Boring – 0 2 – 0 3 – 11 (37%) 4 – 13 (43%) Very fun – 6 (20%)
Rate Whether You Feel this is a Good Way to Learn	Not effective – 0 2 – 2 (7%) 3 – 5 (17%) 4 – 12 (40%) Very effective – 11 (36%)
Rate Whether the Instructions Were Enough for you to Succeed at the Game	Not enough – 3 (10%) 2 – 4 (13.5%) 3 – 4 (13.5%) 4 – 15 (50%) Plenty – 4 (13%)
Rate Whether the Characters within the Game Assisted with your Ability to Learn	Hardly noticed them – 7 (23%) 2 – 11 (37%) 3 – 3 (10%) 4 – 8 (27%) Noticed them a lot – 1 (3%)

Figure 3. the responses given to the questionnaire

6. Comments and Suggestions

Most of the verbal feedback was about the difficulty in learning the game mechanic. People found adding the force arrows a strange and backwards concept as games such as Angry Birds make the player pull back a sling-shot to affect the ball. Players often said: "Oh it's opposite to Angry Birds".

The in game characters were commented on by most players, once they had been pointed out. They were well liked but it was thought they should be bigger than they currently are and should be positioned on the left of the screen to pull the eye towards them.

Overall players found this a very fun and addictive game to play once the mechanic had been learnt. Most players believed this to be a good way to learn and with some more work the game could be a valuable teaching tool.

7. Conclusion

The findings agree with previous research (Karl Kapp 2012), that gamification is a valuable educational tool, which merits further research and development.

With respect to Junkyard Physics, the research showed that the game mechanic was hard to grasp, however, it was addictive once understood.

Future development of the game could be the development of a better tutorial and making the wording of the instructions clearer to make the game easy to understand. This would allow more emphasis to be put on the learning aspects, rather than players trying to work out how to play the game.

Junkyard Physics should undergo more development based on the feedback received and then be re-tested. New testing should be aimed specifically at girls before they choose their GCSE modules to see if the learning aspects of the game encourage them to learn physics. The current results are based solely on feedback given by both male and female players who were 18 or older. Further testing will prove if this game can make physics more appealing to girls. In addition, more evidence of the ability of Junkyard Physics to teach is needed, as people could only speculate that they believed this was a good way to learn. A way to remove speculation is to tailor the question screens to the anticipated learning outcomes. Recording the number of attempts it takes a player to complete a level would also give more useful feedback.

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