Using Game Analytics to Measure Student Engagement/Retention for Engineering Education

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***Abstract*— The relative ubiquity of high powered mobile devices and increasing high speed connectivity offers new opportunities for educators. On the App stores, the freemium model has gained popularity to such an extent that the majority of games are now free to play. This type of business model depends on the ability to record, analyze and interpret analytics and metrics to finesse the user experience and plan future iterations of a product to ensure a high level of user retention and monetization. This paper explores the use of analytics in an educational context to measure student engagement and retention. A mobile version of the Circuit Warz project is introduced and demonstrates how engineering education can be completely reimagined to create immersive and highly engaging student learning experiences.**

***Index Terms*— Virtual Worlds; Engineering Education; Virtual Learning Environments; Game Based Learning.**

I. INTRODUCTION

Gamification is a term used to describe the application of video game mechanics to non-game processes in order to improve user engagement. This type of game based learning is increasingly been used in educational settings and is widely predicted to become mainstream in the next 3-5 years [1-3]. New business models for video games are emerging in the mobile market and on the App stores. The free-to-play approach allows the user to download and play a game for no upfront cost. For this approach to be financially viable for developers this business model depends on achieving large numbers of downloads and game installs with a monetization/conversion rate of 1-3% of users through in-app purchases. To achieve this revenue target the developer/game designer must be skilled in the effective use of game analytics and metrics to track user engagement and retention. This paper discusses a practical example of using game mechanics, analytics and metrics for educational and teaching purposes in the context of electrical and electronic engineering. It demonstrates how a commercial games engine e.g. Unity3D can be used to rapidly prototype simulations to teach advanced electronic/electrical circuit theory. A game based learning approach is used inside a 3D immersive game world where students must use their knowledge and understanding of the theory to bias a series of electronic circuits successfully to complete the game. The game is designed in such a way to ensure a high level of user engagement and replayability with the inclusion of analytics to measure engagement and retention. In this context this is defined as the number of return visits to the game by the student over set periods of time.

Section 2 of the paper discusses recent University of Ulster research in virtual worlds and serious games, section 3 looks at an extension to this research to create a cross platform Unity3D based version of the Circuit Warz game. Section 4 looks at how the game was successfully redesigned and ported to a range of mobiles devices and how analytics were used in this context to assess the level of student usage, engagement and retention. Section 5 concludes the paper.

II. GAME BASED LEARNING IN VIRTUAL WORLDS

Internet-based 3D virtual worlds are immersive environments which facilitate an advanced level of social networking where residents can explore and socialize by participating in individual and group activities [4]. The Serious Games & Virtual Worlds research team at the Intelligent Systems Research Center (ISRC), University of Ulster focus on the potential of virtual worlds and video games technologies for undergraduate/postgraduate teaching of electrical and electronic engineering related subjects [5]. In this context the Circuit Warz project was conceived with the overall objective to investigate if creating a compelling, engaging, immersive and competitive environment to teach electrical and electronic theory and principles would increase student engagement. The project was created using the OpenSim virtual world simulator integrated with the Moodle virtual learning environment and SLOODLE [6]. The game was a team based exercise where groups of students worked together collaboratively to compete competitively against other teams to complete a virtual assault course. In practice this was a series of electronic/electrical circuits (puzzles) which need to be solved (i.e. biased correctly) in order to complete the game and progress (Figures 1, 2 + 3).

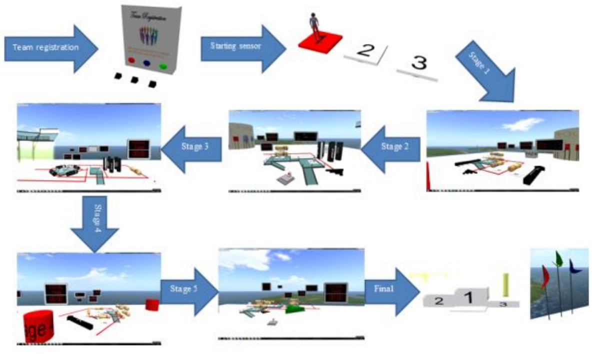

Figure 1. Circuit Warz virtual assault course

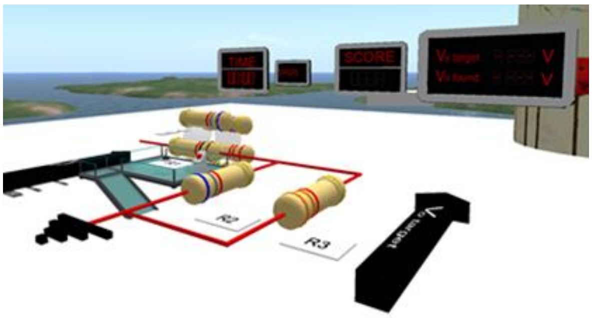

Figure 2. Series/parallel resistor circuit

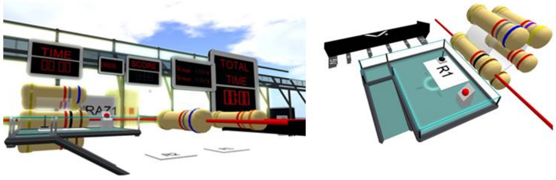

Figure 3. Calculate value of R1 with real time visualization of relative voltage drops

The initial evaluation process focused on user acceptance of this type of environment as teaching tools from both an educator and student perspective. The overall feedback was positive. However there were a number of shortcomings identified with the project particularly related to the use of the OpenSim platform e.g. installation and updating of the client software, networking/ports restrictions and lack of support for deployment in browsers and on mobile devices e.g. iPhone, iPad and Android platforms. On this basis it was decided to explore alternative technologies and platforms for game development and deployment.

III. CROSS PLATFORM APPLICATION DEVELOPMENT

To address the previous shortcomings the project was redesigned and repurposed for deployment using Unity3D, a cross platform game engine which allows the game to be easily ported to browsers and mobile devices. An additional two stages were added to the game creating seven increasing difficult levels for the student to complete. The game layer/client was integrated into the Moodle virtual learning environment and an underlying hardware infrastructure (Figure 4). Each stage of the game was modelled using Excel to determine/fine tune the core game play and determine the relative values of the components/formulas before the main development started (Figure 5).

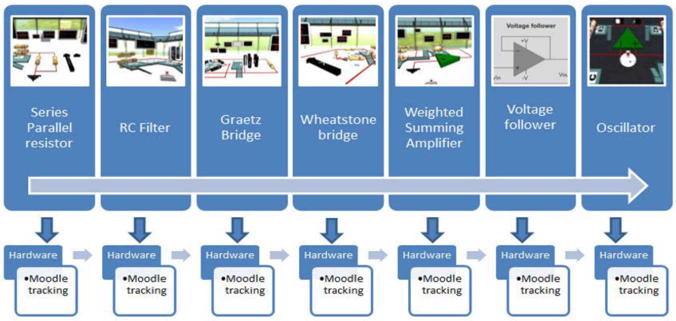

Figure 4. Seven stage game with hardware/virtual learning environment integration

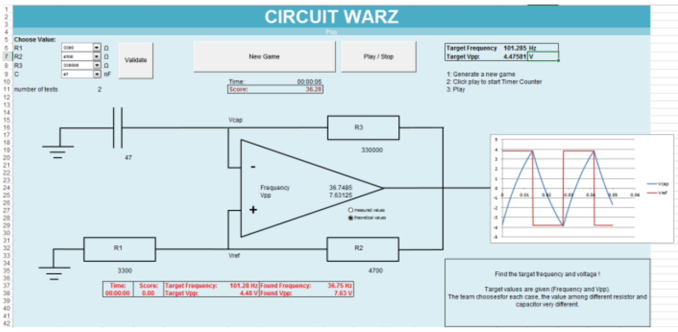

Figure 5. Level 7 oscillator circuit modelled in Excel

The physical layout of the circuit's was accurately recreated inside the Unity level editor (Figure 6). This element of the game design was important as the circuit layout and physical operation had to accurately reflect the constraints/requirements of the real world counterparts. Figure 6 shows screenshots from in-world game play (in this instance level 5, the weighted sum amplifier). Figure 7 shows the Unity3D client/game integrated into the Moodle virtual learning environment and linked to a range of test instrumentation and circuits/hardware.

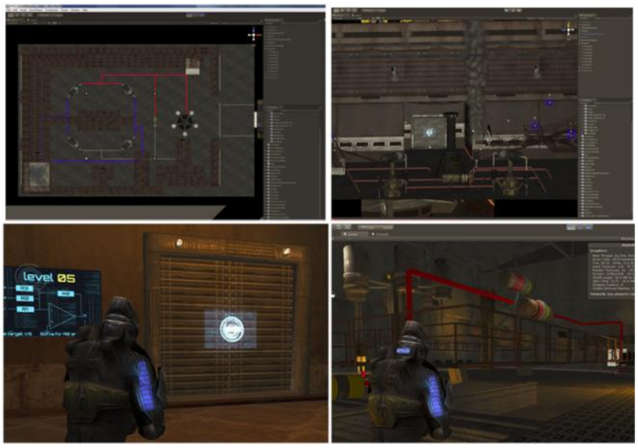

Figure 6. Theoretically correct physical layout of in-game and real world circuits in level 5

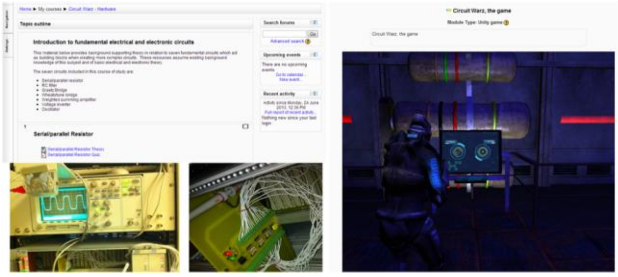

Figure 7. Game/Unity3D integrated with the Moodle learning environment and hardware

IV. PORTING TO MOBILE/INTEGRATING ANALTYICS

Using the Unity3D platform the Circuit Warz game was completely redesigned and optimized for deployment on mobile devices with touch capabilities. The character/game was redesigned using a first person perspective and viewpoint (Figures 8 and 9) which allowed the player to navigate the game world in a more intuitive and easy to use fashion.

Figure 8. First person perspective

Figure 9. Player navigating the first level (series/parallel circuit)

To engage the student the game had a simple and easy to understand back story. An alien ship is attacking the earth, there is an early defense system on a moon base with a giant laser system. The generator/laser is sabotaged by the aliens and the player must successfully complete and bias 7 increasingly difficult circuits against the clock to fix the laser and save the planet. The game can only be successfully completed by having a high level of understanding of the theory underpinning electrical and electronic circuit theory (Figures 10, 11, 12 and 13).

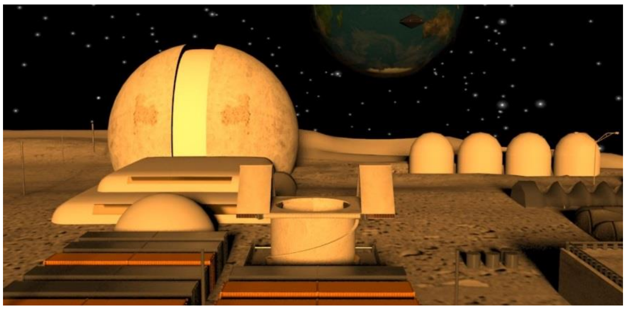

Figure 10. Circuit Warz setting

Figure 11. Faulty generator

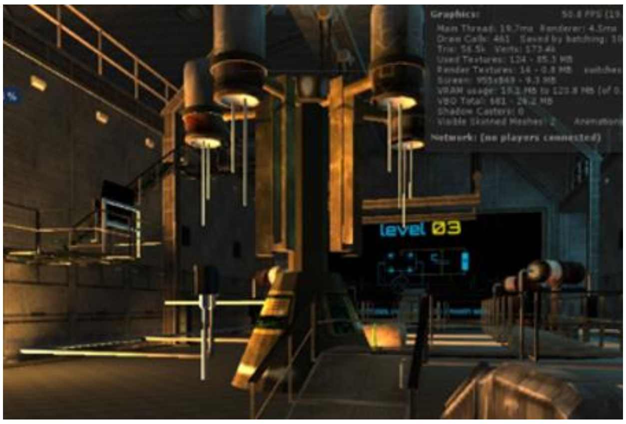

Figure 12. Level 3 Diode circuit

Figure 13. Level 6 Summing amplifier

The integration of game analytics software into the app allows the educator to track two main types of player actions inside the game. Core analytics measure standard metrics e.g. general usage in the form of daily active and monthly active users (Figure 14) and can be broken down with a high level of granularity e.g. time and length of sessions.

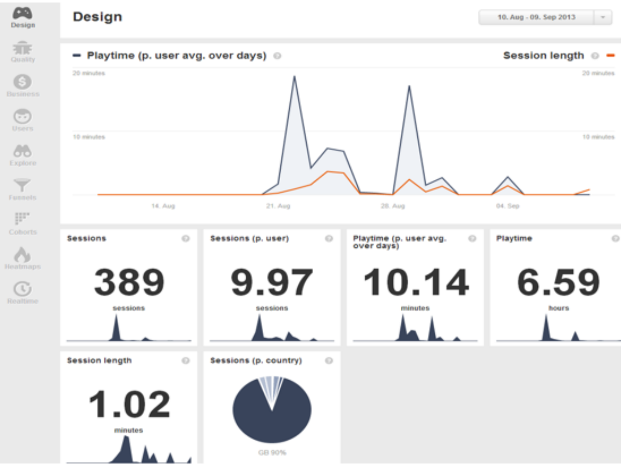

Figure 14. Game analytics dashboard showing app usage

From an educators perspective the use of custom measurements along with funnels and cohorts inside the game analytics platform (Figure 15 and 16) is more interesting as it allows the exploration of the usage data to determine user retention. Custom measurements are used to check how many levels the user completes. This can be cross referenced using funnels and cohorts e.g. how many users who completed level 1 went onto level 7 and returned regularly to the game over a period of months.

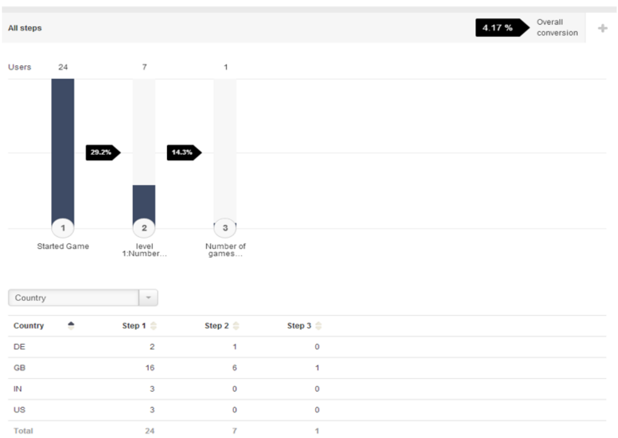

Figure 15. Funnels allow the cross referencing of data

As the game design evolves the use of analytics would allow the educator to also check the impact on usage and retention changes to the game caused e.g. changing the relative difficulty of a level and adding or removing features.

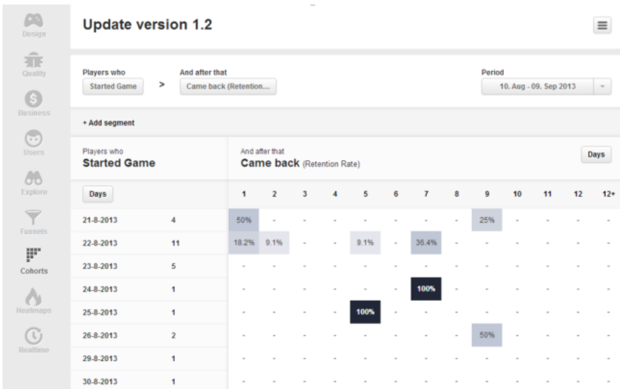

Figure 16. Cohorts allow the educator to check retention

V. CONCLUSION

This paper provided a brief overview of ongoing research at the Intelligent Systems Research Center, University of Ulster, Northern Ireland into the use of virtual worlds/games and virtual learning environments for teaching. The Circuit Warz project was introduced and a number of complex, highly interactive and engaging simulations described which make effective use of game play mechanics to engage students. This approach potentially offers a new engaging and highly interactive way to teach engineering related material. This is an ongoing project and the mobile version of the game has just been completed and is been optimized prior to release on the app stores. The final paper would extend on the material presented here and will include much more detail and depth of discussion and include actual usage figures and analytics from student usage.

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