Rocket Science in a Virtual World

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Rationale

As a partner college of the University of Greenwich, Bromley College runs Foundation Degrees in Software Development and Network Computing. As part the programme, students complete a major Software Development project in Years 1 and 2. The project theme for the academic year 2014-15 was Rocket Science, where students were required to produce a desktop program capable of modelling the flight of a single-stage rocket.

In education, virtual worlds provide unique learning opportunities for accurate/real contexts and activities for experiential learning, simulation, modelling of complex scenarios and social interaction that may not be experienced in other learning modalities (Atkinson, 2009).

As students' understanding of the mathematics, physics and technology relevant to rocketry may not be assumed from their prior compulsory education or experience, I decided that the affordances of a virtual world such as OpenSimpulator/SecondLife would be able to counter any deficit via an immersive learning experience.

The benefits to students have been twofold: first, in using the medium, they acquired the knowledge, understanding and competence to complete the task; second, they experienced the advantages of collaborative, virtual, social, synchronous communication afforded by the visual learning styles of the 3D environment.

A sense of historic realism was injected into the project by the inclusion of rocket models based on actual UK designs.

The virtual learning aspect for the project took place over a two-week period.

Target audience

The cohort was comprised of 26 post 18 students, within which group there were two students with statements for learning needs, one for dyslexia and the other for pervasive learning disorder.

Resources

Given the particular nature of the exercise, the students were provided with resources additional to the standard desktop setup, including the virtual world itself, running in Open Simulator V-0.8, and a suitable virtual word viewer.

Learning and Assessment

In completing the virtual world project, the students gained a working appreciation of the fundamentals of rocket technology and were able to calculate the flight profile of a single-stage model rocket, supported by the results of in-world formative assessment using chat logs and notecards, and by notecards only for summative assessment. (Please refer to the

Evaluation section for outcomes.) These tools are, I feel, consistent with items identified within the six sources of evidence and supporting documentation required by Yin (2003).

Learning space design

Virtual learning would be presented as a signposted, linear, walk-through workflow series of activities, from Orientation to Simulation, as shown below in Figure 1.

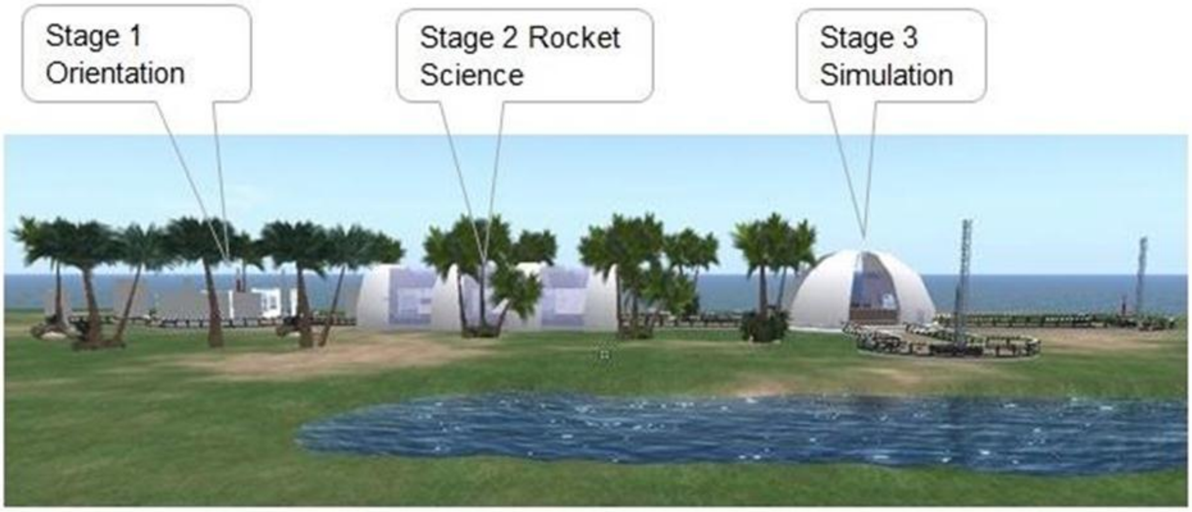


Figure 1: ‘ Only Rocket Science’ Learning Flow

Tutor’s role

The project began with a tutor-guided walk-through, after which students were able to plan and manage their own learning. Throughout the session, text chat logs, notecard feedback, reflection and questions using IM were reviewed.

Potential hazards for the project

Technically, there might have been problems related to the availability to the students of suitable hardware, including broadband connection and graphics card compatibility. However, as the project was run during term time, students were able to make full use of college facilities.

‘Only Rocket Science’, Entry Point

At entry, the students were invited to accept a notecard explaining the learning sequence; then, as they moved on to subsequent stages, notecard dispenser boards prompted them to accept further notecards explaining the requirements of that particular stage. See Figure 2.

Figure 2: Entry Point

‘Only Rocket Science’, Stage 1 - Orientation

The learning aims for the stage are outlined in the notecard:

> You should become familiar with the following components and their use: nose cone, body, fins, parachute, shock cord, wadding, engine assembly
>
> The formula f=ma
>
> Understand engine coding, i.e. A8-3
>
> A - The Total Impulse (power measured in Newton-seconds). The class A engine value is 2.5
>
> 8 - The average thrust of the rocket engine during its burn time, also in Newton seconds
>
> 3 - Eject delay - the number of seconds following engine burnout until the parachute ejection charge fires
>
> You should also be familiar with the idea of initial engine weight and fuel weight, as we shall be using these values to determine average engine weight

‘Only Rocket Science’, Stage 2

This stage is made up of three tasks that cover Boost, Coast and Recovery phases of the rocket’s flight. The stages are presented as a signposted, linear, walk-through series of activities, carried out using similar workflows that are presented as: introduction notecard boards, exercise boards, calculator boards and a drop box. See Figure 3.

Figure 3: Boost, Coast and Recovery Phases

Example: Stage 2, Task 1 (The Boost Phase)

1: The notecard board (on the left in the Figure 4 image below) introduces the task, dispensing a notecard for the students to work through (using the in-world online calculator) the example calculations shown on the adjoining exercise board and to record their results.

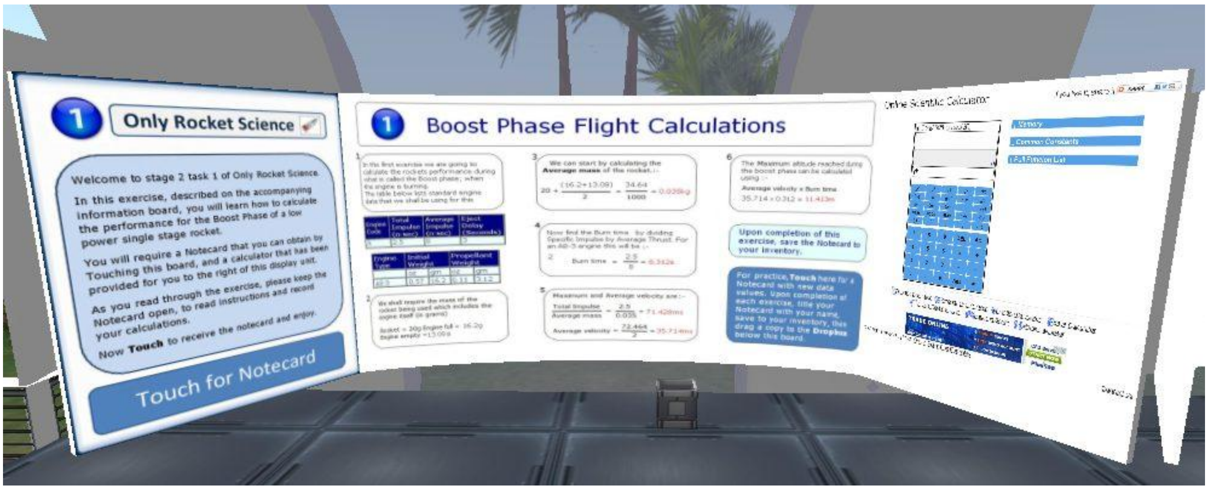


Figure 4: Boost Phase Notecard Dispenser

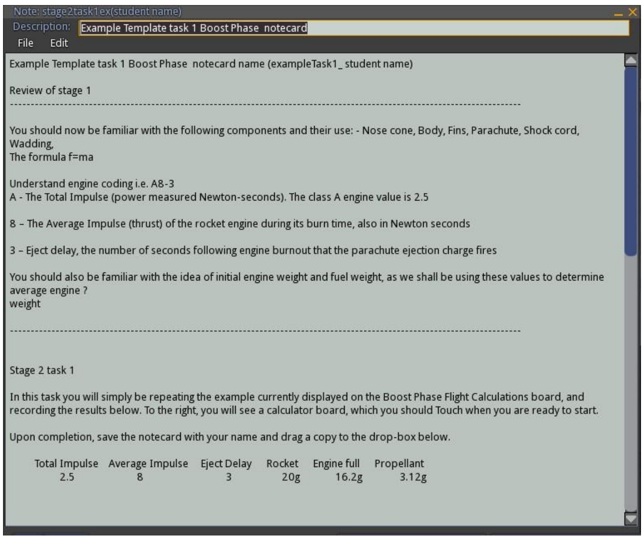
As this is a formative exercise, the students simply worked through the example shown on the board, reproducing results on their own notecard.

2: Upon completion, the notecard was named, saved to inventory and dragged to the drop-box.

3: The exercise board prompted students to take another notecard containing a new, un-worked, problem.

4: Upon completion, that notecard was named, saved to inventory and dragged to a drop-box for summative assessment.

Each notecard requests students to reflect on the learning experience. See Figure 5.


Note: stage2task1ex(student name)
Description: Example Template task 1 Boost Phase notecard
File Edit

Example Template task 1 Boost Phase notecard name (exampleTask1_ student name)

Review of stage 1

You should now be familiar with the following components and their use: - Nose cone, Body, Fins, Parachute, Shock cord, Wadding,
The formula f=ma

Understand engine coding i.e. A8-3
A - The Total Impulse (power measured Newton-seconds). The class A engine value is 2.5

8 – The Average Impulse (thrust) of the rocket engine during its burn time, also in Newton seconds

3 – Eject delay, the number of seconds following engine burnout that the parachute ejection charge fires

You should also be familiar with the idea of initial engine weight and fuel weight, as we shall be using these values to determine average engine ?
weight

Stage 2 task 1

In this task you will simply be repeating the example currently displayed on the Boost Phase Flight Calculations board, and recording the results below. To the right, you will see a calculator board, which you should Touch when you are ready to start.

Upon completion, save the notecard with your name and drag a copy to the drop-box below.

Total Impulse	Average Impulse	Eject Delay	Rocket	Engine full	Propellant
2.5	8	3	20g	16.2g	3.12g

Was the task made clear?
Did the Rocket Orientation exercise prepare you enough, or would you like to revisit?
The quality of the images on the display board was satisfactory.
Did you complete the task alone or with other students?
Was carrying out the actual exercise beneficial to your overall understanding?
How would you describe working with other avatars?
What did you like most? What least? How would you improve the learning stage?

Figure 5: Completed Notecard

Example: Stage 3 (The Simulation)

The final simulation stage draws the together the work of the previous stages. It presented the students with a full set of flight-profile calculations, dispensed once again from the notecard board. Upon completion, the notecard was saved and a copy dragged to the drop-box. Students could then check their results by launching a rocket: touching the green button at the centre of the launch console table produces a series of drop-down options prompting for input parameters, after which a soundscape introduces the countdown and launches the rocket. See Figure 6.

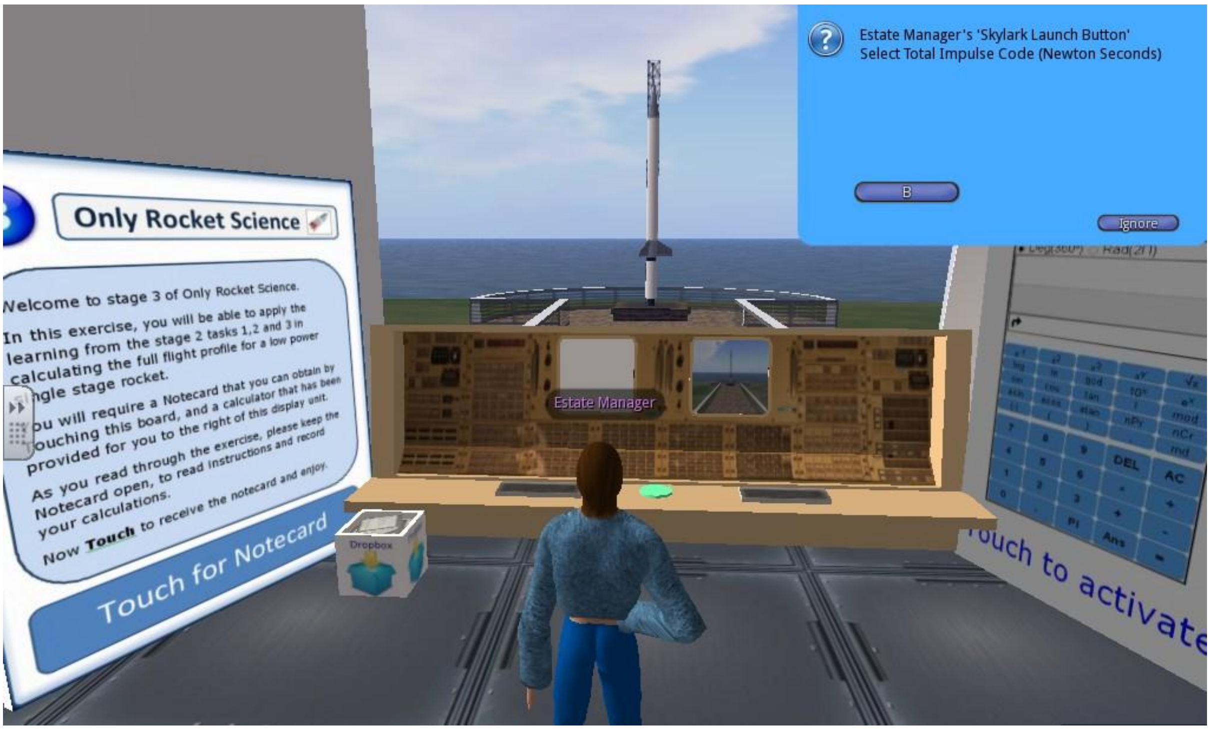


Figure 6: Rocket Simulation

Eventually, the rocket descends on a parachute return, shortly after which the calculated flight profile is displayed for comparison.

Theoretical underpinning (the learning space)

Since students inevitably experience a range of emotions during any eLearning session, comfort is considered important in leveraging affordances and capabilities. Findings from Saleeb and Dafoulas (2010) suggest that irritation and subsequent boredom become the most undesirable emotions and that colour plays an important role, with white and light-blue evoking the highest number of positive emotions, specifically comfort and consequent attentiveness.

Structural architecture and landscaping in the design were constrained to fall in line with the results from various research projects investigating the impact of a learning environment on learning itself (Saleeb and Dafoulas, 2010; Dickey, 2004). As a result, the build features large open areas to facilitate flying, the inclusion of water and greenery, landmarks, simple modern buildings with no over-decoration or imaginative enhancement, wide corridors to aid avatar movement and the arrangement of learning subspaces consistent with expected use.

Where buildings are used to accommodate an activity, the ratio of wall to window falls within the recommended 50:50 ratio recommended by Minocha and Reeves (2009). In general, avatar movement is significantly improved by using dynamic textures and rhythmically-repeated elements in paths (Bridges and Charitos, 2001) and avatar rotation is avoided, in order to improve ease of orientation and navigation in the space (Charitos, 1999). An apparent strong preference for good lighting led to open-topped buildings, without the imposition of ceilings; as circular buildings were also favoured, they have been deployed in two of the three sub-spaces.

Theoretical underpinning (pedagogy)

The learning space has been designed to support social constructivism as the driver in what is a highly-interactive and participatory environment. Students are able to test their ideas and understanding as they actively engage in real-time simulations and feedback, with tasks that encourage problem-solving and critical thinking (Roussou, 2015). The first task of Stage 2 promotes the construction of knowledge from prior experience of physics at Key Stage 3 or equivalent, drawing upon the individual's unique world experience consistent with the three general principles outlined by Dalgarno (2001) and supported and mediated by the Open Simulator virtual world.

As students are encouraged to collaborate and plan their own learning, I feel the review of the text chat session will reveal evidence of Cognitive, Teaching and Social presence in the emergence of a Community of Enquiry (Garrison *et al*, 2000) and that the shared, collaborative, goal-directed nature of the activity in turn induces Embodied Social Presence, drawing the participants into a higher level of cognitive engagement (Mennecket and Triplett, 2011). The immersive components of fidelity and adoption of design best practice in a collaborative social space are intended to leverage some or all of five dimensions of presence and co-presence that could lead to a flow, enjoyment, focus and concentration that combine to increase a positive attitude to learning (Choi *et al*, 2007).

Instructional design constraints

From a study of the affordances of traditional Instruction design models, it appears that they in general do not offer precise guidance for the process of designing instruction in virtual world environments (Chen, 2010) and, further, that they tend to be process-oriented, static and linear, do not meet user expectations in a virtual world (Hodge and Collins, 2010; Chen *et al*, 2004) and are viewed by many as based upon outdated approaches to teaching and learning (Soto, 2013). Throughout Soto's (2013) study, which reviewed twenty-eight Instructional Design models, the ADDIE model, with its five phases of Analysis, Design, Development, Implementation and Evaluation, was found to be the most common Instructional Design process (75.4%) for virtual worlds.

Specifics to learning in a virtual world need to be introduced into any current Instruction Design model if it is to be of real use, something which appears to be addressed by the study's conclusion which states: "ADDIE process presents the necessary methods for guiding the design of elements needed for instruction in virtual world environments" (Soto, 2013, p.369). These may be summarised as:

1. Experience learning by solving a problem that may be encountered in a real-world situation.

2. Build on what students already know by adapting, modifying, and transforming the virtual world to construct new knowledge as well as to apply existing knowledge to new contexts/situations.

3. Interact in an immersive environment where knowledge is presented in an authentic context.

4. Transfer and apply the in-world learning to everyday life situations.

5. Work collaboratively to undertake tasks, exploring and negotiating with one another to complete the activities and reflecting on their learning along the way.

The second most popular Instructional Design (at 29.5%) proposes a more refined ten-stage system that I considered to be too detailed for my purposes (Dick *et al*, 2009).

Instruction strategy

The analysis component of the ADDIE model identifies the need for an instructional strategy and for this I selected Merrill's First Principles of Instruction. From research, there is convincing evidence that using First Principles of Instruction in education improves both student learning and satisfaction (Frick *et al*, 2007) by offering explicit guidance for assisting students in both their learning and development (Reigeluth, 1999). I felt that the provision of such guidance would readily accommodate outcome requirements and would fall very much within the scope of my own learning space design for social constructivism.

In reviewing the First Principles, I also felt that using laws of motion applied to real-world rocket vehicles and with real-time feedback, in a staged workflow process building to a complete solution (and drawing upon KS3 experience or equivalent combined with reflection and assessment from notecards) would work well with the Task/Problem-Centred strategy components of Activation, Demonstration, Application and Integration.

Evaluation

The virtual world work represented a maximum of 15% of the final assignment grade, giving a final average of 56.46%. During their sessions in the virtual world, students made 171 unique visits and logged 421 lines of conversational chat. Resource activity was logged using a MySQL database which recorded 1302 hits. In Appendix 1, I have included the results of a short post-project survey of students' impressions of using the virtual world for their learning activity.

Conclusion

This was an extremely worthwhile project which students enjoyed and from which they benefited as Appendix 1 demonstrates the affordances of a 3D virtual world proved to play an important part in the delivery of a specialist topic to a group of students from diverse backgrounds. I intend to develop my ideas for deploying this, a valuable emerging technology that has clearly encouraged and enhanced engagement, enthusiasm and collaboration in an educational setting.

Appendix 1

Using the virtual world was fun and exciting

Response	Average	Total
neither agree or disagree	7%	1
agree partially	47%	7
agree completely	47%	7
Total	100%	15/15

I would avoid classes using a virtual world in the future

Response	Average	Total
disagree completely	67%	10
disagree partially	20%	3
neither agree or disagree	13%	2
Total	100%	15/15

Working in a virtual world is an enriching experience

Response	Average	Total
disagree partially	7%	1
neither agree or disagree	7%	1
agree partially	47%	7
agree completely	40%	6
Total	100%	15/15

I experienced very few problems in using the virtual world

Response	Average	Total
disagree partially	7%	1
neither agree or disagree	13%	2
agree partially	33%	5
agree completely	47%	7
Total	100%	15/15

I often used the virtual world from home during my project

Response	Average	Total
disagree partially	7%	1
neither agree or disagree	20%	3
agree partially	27%	4
agree completely	47%	7
Total	100%	15/15

My classmates and I cooperated in completing assignment work in the virtual world

Response	Average	Total
disagree partially	7%	1
neither agree or disagree	27%	4
agree partially	13%	2
agree completely	53%	8
Total	100%	15/15

The virtual world was beneficial to my learning

Response	Average	Total
neither agree or disagree	7%	1
agree partially	40%	6
agree completely	53%	8
Total	100%	15/15

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Submission reference ISSN: 2044-0081