Adopting the gamed-based learning software Racing Academy in engineering education: results from the University of Portsmouth and the University of Bath

Ya Huang[a], Richard Joiner[b], and Jos Darling[c*]

[a] *Department of Mechanical and Design Engineering, University of Portsmouth, Portsmouth, UK, PO1 3DJ*

[b] *Department of Psychology, University of Bath, Bath, UK, BA2 7AY*

[c] *Department of Mechanical Engineering, University of Bath, Bath, UK, BA2 7AY*

** Correspondent author: J.Darling@bath.ac.uk*

Following the implementation of the game-based learning software Racing Academy at the University of Bath, the software was adopted for the teaching of 160 year-one Mechanical Engineering students at the University of Portsmouth. 'Racing Academy' employs principles of engineering dynamics to simulate and display, in real time, a car drag race in which students modify their car from a menu of components. The aim was to complete a drag race in the minimum time, display the time histories of velocity and acceleration and interpret the results from an engineering perspective. The display of velocity and acceleration in real time was intended to make intuitive connections between physical observations and operations of integration and differentiation. Pre and post questionnaires measured students' experience of gaming and motivation towards Racing Academy and studying engineering.

1. Introduction

Engineering dynamics, taught as a common core for 160 Mechanical Engineering degree students in their first year at Portsmouth, has been perceived by many students as a demanding subject. The subject usually consists of one one-hour lecture and one thirty-minute tutorial (divided into smaller groups) each week. The conventional lab sessions for this unit only address a narrow range of topics which students found 'unexciting' and 'disconnected' to the lecture content. Recent changes to the technical support available in the department meant that changing these conventional lab exercises or adding lab sessions was unrealistic. Requirements for engineering courses are outlined in the UK SPEC (Engineering Council UK, 2010). To satisfy curriculum alignment defined by QAA (2006), elements of the current curriculum for engineering dynamics at Portsmouth required an update.

Recent case studies based on an engineering dynamics module that used computer games to support students learning highlighted the effectiveness of visualizing physical phenomenon using computer graphics and a social interface of learning (Joiner *et al*., 2007). At the University of Bath, the investigators employed a gaming software 'Racing Academy', which used principles of engineering dynamics to simulate and display on a computer, in real time, a car drag race. Students could then modify their car from a set menu of components (Darling *et al*., 2008). A work sheet was designed based on the software configuration that led students through the process of Racing Academy and pushed them into thinking about the science, rather than just the game playing. A lab report on how they improved their lap times was assessed. The 160 year-one Mechanical Engineering students were divided into groups of around 10 with academic staff assigned as tutors to each group. An online forum was opened to respond to queries about running the game as well as theories behind the game.

The primary aim of the project was to adapt the Racing Academy (RA) game-based learning interface at the University of Portsmouth so as to:

i. support students' learning in engineering dynamics

ii. enhance motivation of the subject

iii. evaluate the effectiveness of game-based learning.

This paper compares results collected at the University of Portsmouth and the University of Bath.

2. Racing Academy

The detailed learning objectives and specifications of Racing Academy are outlined by Darling *et al*. (2008) and Joiner *et al*. (2011).

The learning objectives of the Racing Academy exercise were:

- to understand the fundamental principles of dynamics
- to develop judgement in system design and modelling
- to use computer gaming software in an engineering context
- to work independently and as a team in a competitive environment.

Racing Academy uses a powerful physics engine to embody the principles of engineering dynamics to simulate and display in real time a drag race (Figure 1). In the race, students were able to change vehicle parameters by selecting i) engines, ii) tyres and iii) gearbox ratios from a set menu. In this way students could optimise their vehicle performance and get an intuitive understanding of the system dynamics that influence behaviour.

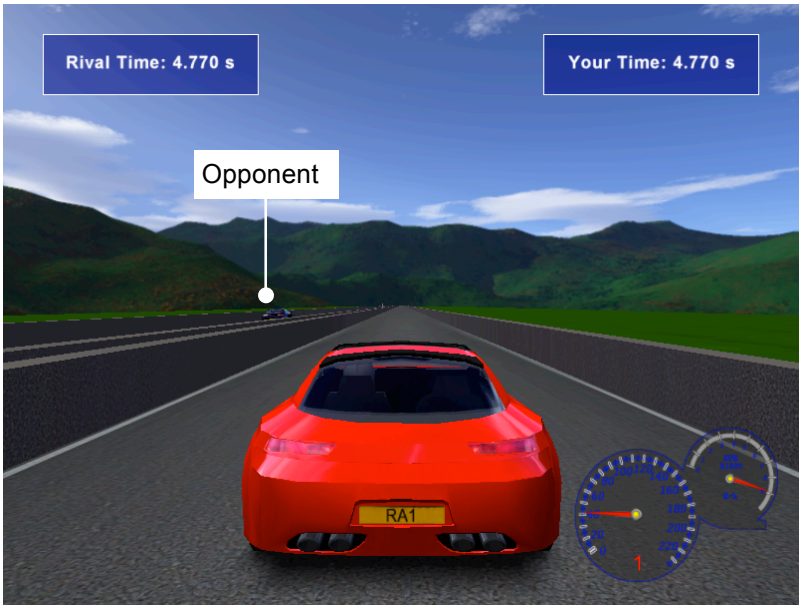

Figure 1 Racing Academy Screen During Race

In each of the three levels, the user needs to race and win against a software AI rival in order to progress. In order to illustrate the engineering dynamics taking place, the user can produce a number of different graphical output, including acceleration against time and speed against time. This way the user is encouraged to understand the engineering dynamics and use an iterative design process to optimise their vehicle.

3. Implementing Racing Academy into the Syllabus

This section specifies how Racing Academy was used at Portsmouth. The format was similar to that described by Joiner *et al*. (2011) from Bath so as to compare data from the two institutions.

3.1 Participants

At Portsmouth 118 students answered the pre questionnaire of computer gaming (110 males and 8 females, mean age 18.5 years, and standard deviation SD = 0.9), while 82 students (76 males and 6 females) answered the post questionnaire. The students were from the first year undergraduate course of Mechanical Engineering in the Department of Mechanical and Design Engineering at the University of Portsmouth, Portsmouth, England.

At Bath, 158 students (143 males and 15 females) participated in the study, with an average age of 18.5 years (SD = 0.9). They were from a first year undergraduate course in the Department of Mechanical Engineering at the University of Bath, Bath, England.

3.2 Procedure

While the structure of the Racing Academy exercise undertaken at the two institutions was similar, there were variations due to logistics and resources available. Both institutions used the same pre and post questionnaires (see Section 3.3), the same pre and post tests, and the same lab sheet to help students to complete a lab report. The programmes at the two institutions, in general, started with an introductory lecture, a pre questionnaire, then followed by different forms of tutorial sessions, and finally after submission of the lab report a post questionnaire.

3.3 Materials

At Portsmouth, the students answered a pre questionnaire before playing the game, and a post questionnaire after playing the game. The two questionnaires were the same, measuring experience with digital games and motivation towards RA and studying engineering. The post questionnaire included questions regarding how much Racing Academy was used, and how motivating the students found playing RA.

Details of questionnaires and analysis were provided by Joiner *et al*. (2011).

The pre questionnaire measured students' experience of playing digital games. They were asked how frequently they played digital games during the week, how frequently they played at the weekend, and what type of digital games they played.

In both the pre and post questionnaires, three different aspects of motivation towards engineering were assessed. These were enjoyment of engineering, perceived competence in engineering and how important engineering was to them personally. Students answered the questions using a five point Likert scale ranging from strongly disagree to extremely agree.

In the post questionnaire we assessed how motivating the students found playing RA by measuring how much they enjoyed playing RA, how good they were at playing RA, how much effort they put into playing RA, and how valuable playing RA was. The students answered it using a five point Likert scales, ranging from 1 strongly disagree to 5 extremely agree.

4. Results at Portsmouth and Bath

4.1 Gaming behaviours and preferences

Age started playing

Table 1 Age students started playing video games

Age group	Number of students		Percentage of students	
	Port	Bath	Port	Bath
>5	7	1	6.1%	0.6 %
5-7	34	6	29.8%	3.8%
8-10	43	43	37.7%	27.2%
11-13	14	58	12.3%	36.7%
14-16	9	40	7.9%	25.3%
<16	4	7	3.5%	4.4%
Null	3	3	2.6%	1.9%

Students were asked when they first began to play video games in order to measure their playing history. Approximately 36% of students started playing video games under the age of 7 and less than 4% of students had not started playing videogames until after they were 16. The majority of students from Portsmouth started between the ages of 5 and 10, with the most common age group being between 8 and 10. Students from Bath appeared to start gaming at an older age, the most common category being between 11-13. Table 1 shows a breakdown of the different age ranges.

Frequency and breadth measures

Most students play games once to several times a week, but only play racing games less than once a week if at all. Table 2 shows a complete breakdown of how often students play video games in general. There are slight differences between the Bath and Portsmouth cohorts although these may be attributed to the surveys being undertaken during different years. For instance, Portsmouth students who completed the survey most recently were more likely to play games on their mobile phones, using a technology that has only recently become widely available.

Table 2 Frequency of playing video games (Portsmouth, Bath)

Number of students	Video games		Racing games		Play on computer		Play on mobile	
	Port	Bath	Port	Bath	Port	Bath	Port	Bath
Never	11	0	32	1	31	0	35	0
Less than once a week	22	28	55	64	37	131	35	131
Once a week	17	64	15	70	18	15	17	19
Several times a week	47	50	13	20	23	8	18	6
Daily	13	23	2	4	5	8	4	11

Breadth measures

In order to further examine the breadth of video game play, students were asked the types of games they played. The results are summarised in Table 3. The most popular category amongst the Portsmouth cohort appeared to be Action games (90/118), followed by Sports (67/118) and then Puzzle games (61/118). Role play game (RPG) scored the lowest (39/118). These results were more or less mirrored in the Bath cohort.

Table 3 Type of Games Played (Portsmouth, Bath)

Types of games	Number of students	
	Port	Bath
Action	90	120
Adventure	48	48
Fighting	50	58
Puzzle	61	65
RPG	39	41
Simulation games	47	65
Sports	67	94
Strategy	58	89

Depth measure

The questionnaire took a measure of how long students spend playing games, to establish the depth of game playing. During the week, a gaming session seemed to last approximately 1 hour (SD=1.02).

4.2 Engineering identity

Both the pre and post questionnaires contained a measure of how important engineering is in a student's life. This measure had 3 subscales.

i. How much they enjoyed studying engineering.

ii. How important engineering was to the students' own self identity.

iii. How competent they were at engineering.

The mean measures of enjoyment, identity and perceived competence from the pre and post questionnaires are reported in Table 4.

The scores for Portsmouth students are all above three before they played RA and remained unchanged after they have played RA. Thus playing RA had neither a positive nor a negative impact on how important engineering was in a student's life. The only significant difference in the Bath cohort was that RA appeared to have significant influence on how important engineering was to the student's own self identity. This may be attributed to the timing of the RA activity at Bath that took place during their second week at University during a period when the students were beginning to engage with engineering for the first time.

Table 4 Pre and post questionnaires of engineering identify (Portsmouth, Bath)

	Pre				Post			
	Port		Bath		Port		Bath	
	M	SD	M	SD	M	SD	M	SD
Enjoyment	4.2	0.4	4.2	0.4	4.3	0.4	4.1	0.4
Identity	4.3	0.5	3.0	0.5	4.2	0.5	4.0	0.5
Perceived Competence	3.8	0.5	3.6	0.5	3.9	0.5	3.6	0.5

4.3 Frequency of playing RA

The post questionnaire asked students about how frequently they used RA. Over half of the Portsmouth students (54%) played RA several times a week or more, while over 86% of the Bath students played the game to the same extent. Table 5 shows a summary.

Table 5 Frequency of playing RA (Portsmouth, Bath)

	Number of students play RA		Percentage of students play RA	
	Port	Bath	Port	Bath
Never	3	1	3.8%	0.7%
Less than once a week	33	20	41.8%	13.5%
Once a week	37	99	46.8%	66.9%
Several times a week	5	17	6.3%	11.5%
Daily	1	11	1.3%	7.4%

4.4 Motivation of playing RA

The post questionnaire contained measures of how motivating students found Racing Academy. There were four subscales.

i. How enjoyable students found Racing Academy.

ii. How competent they felt playing Racing Academy.

iii. How much effort they put into playing Racing Academy.

iv. How valuable Racing Academy was in their study.

Table 6 shows the impact Racing Academy had on student's motivation. The students from Portsmouth scored 3.6 on the measure of enjoyment suggesting they enjoyed playing RA. They felt competent, and thought that it was worth putting the effort into the game and that it was a valuable experience. Bath students were generally less keen on the RA experience than their counterparts at Portsmouth.

Table 6 Motivation of playing RA (Portsmouth, Bath)

	Port		Bath	
	M	SD	M	SD
Enjoyment	3.6	0.5	3.4	0.5
Competent	3.6	0.5	3.4	0.6
Effort	3.8	0.6	3.1	0.7
Value	3.6	0.5	3.1	0.6

4.5 Perceived success of playing RA

Table 7 shows a breakdown of how successful the students thought Racing Academy was at supporting their learning. The majority of students thought the implementation of Racing Academy was either a little bit successful or quite successful. Interestingly, a few students from Bath thought that Racing Academy was not successful at supporting their learning.

Table 7 Perceived Success (Portsmouth, Bath)

How successful	Number of students play RA		Percentage of students play RA	
	Port	Bath	Port	Bath
Not at all	0	8	0.0%	5.4%
A little bit	17	71	21.3%	47.9%
Quite	50	66	62.5%	44.6%
Very	13	3	16.3%	2.0%

5. Conclusions

The Racing Academy project at Portsmouth clearly met and extended requirements specified by the Engineering Council UK (2010) and the QAA (2006) in terms of engineering knowledge and teaching and assessment methods.

Pre and post questionnaires that assessed motivation and perceived success showed a positive response from the students from both Portsmouth and Bath to Racing Academy. Informal feedback from students and the lab report results indicated that the comprehensive

supporting materials provided a 'safe' learning environment. Future development of online gaming communities could further improve the engagement of the large group of students.

References

Engineering Council UK, UK Spec (2010). http://www.engc.org.uk/ukspec (14-03-2011).

Joiner, R, Iacovides, J, Darling, J, Drew, B, Owen, M, Gavin, C, & Clibbery, S (2007). Racing Academy: A preliminary evaluation of an online racing car simulation game for supporting students learning of engineering. EARLI 2007, the 12th Biennial Conference for Research on Learning and Instruction, Hungarian Academy of Sciences, Budapest, Hungary.

Joiner, R, Iacovides, J, Owen, M, Gavin, C, Clibbery, S, Darling, J, Drew, B (2011). Digital Games, Gender and Learning in engineering: Do females benefit as much as males? Journal of Science Education and Technology. Volume 20 (2), pp178-185.

Darling, J, Drew, B, Joiner, R, Lacovides, R and Gavin, C (2008). Game-Based Learning in Engineering. Innovation, Good Practice and Research in Engineering Education (EE2008), P070. www.engsc.ac.uk/downloads/scholarart/ee2008/p070-darling.pdf (14-03-2011)

Quality Assurance Agency for Higher Education (2006). Subject Benchmark Statement – Engineering, QAA114. Retrieved in May 2010 from http://www.qaa.ac.uk/academicinfrastructure/benchmark/statements/