Game Inspired Tool Support for e-Learning Processes

Marie-Thérèse Charles, David Bustard and Michaela Black
University of Ulster, Coleraine, Northern Ireland
mcginnis-m@email.ulster.ac.uk
dw.bustard@ulster.ac.uk
mm.black@ulster.ac.uk

Abstract: Student engagement is crucial to the success of e-learning but is often difficult to achieve in practice. One significant factor is the quality of the learning content; also important, however, is the suitability of the process through which that material is studied. In recent years much research has been devoted to improving e-learning content but considerably less attention given to enhancing the associated e-learning process. This paper focuses on that process, considering in particular how student engagement might be improved using techniques common in digital games. The work is motivated by a belief that, with careful design, e-learning systems may be able to achieve the levels of engagement expected of digital games. In general, such games succeed by entertaining players, building on their natural curiosity and competitiveness to encourage them to continue to play. This paper supports a belief that by adopting some of the engagement techniques used in games, e-learning can become equally successful. In particular, the paper considers how the learning process might become a form of game that helps sustain continued study. Factors affecting engagement and elements of digital games that make them engaging are identified. A proposal for improving engagement is then outlined. The approach is to encourage student involvement by rewarding desirable behaviour, including the completion of optional challenges, and giving regular feedback on performance, measured against others in the same class. Feedback is provided through a web-based tool. The paper describes an exploratory assessment of both the tool and approach through action research. Results for two linked university modules teaching software development are presented. The results so far are very encouraging in that student engagement and performance have increased, especially at the weaker end of the class. Limitations of the approach are also outlined, together with an indication of future research plans.

Keywords: e-learning, digital games, engagement, feedback, action research

1. Introduction

In essence, *engagement* is the measure of a student's participation in a learning task. Skinner and Belmont (1993) explain this more fully by suggesting that those engaged "...*show sustained behavioural involvement in learning activities accompanied by a positive emotional tone. They select tasks at the border of their competencies, initiate action when given the opportunity, and exert intense effort and concentration in the implementation of learning tasks; they show generally positive emotions during ongoing action, including enthusiasm, optimism, curiosity, and interest*".

As might be expected, engagement is strongly related to achievement and dropout rates (Astin 1993, Harrison 2006, Trotter and Roberts 2006). Dropouts in e-learning are a particular concern, involving many complex issues (Martinez 2003, Tyler-Smith 2006). With a growing use of technology at all levels of education, leading to a blended approach to learning, the importance of improving engagement in e-learning has increased. The purpose of this paper is to consider how techniques used in computer games might be used to improve such engagement.

The overall situation is summarised graphically in Figure 1 as a *rich picture* (Lewis 1992). Rich pictures, often used in Soft Systems Methodology (Checkland 1999), help build and document a shared understanding of a situation of concern. The diagram in this case shows a class of students studying material through engagement in a structured teaching and learning process—which typically has to be covered to a schedule to meet assessment constraints. The process is supported formally by one or more teachers and/or tutors, together with computers connected to the internet. There is also informal support for the learning process from others in the same class group. The ticks emphasise the positive benefits to the process from these sources of support. On the negative side, the crossed swords identify two areas of concern: one is the limited availability of teachers/tutors and the other is the difficulty that students experience in engaging with the learning process. In the bottom section of the diagram it is suggested that the difficulty with engagement might be helped by adopting ideas from computer games.

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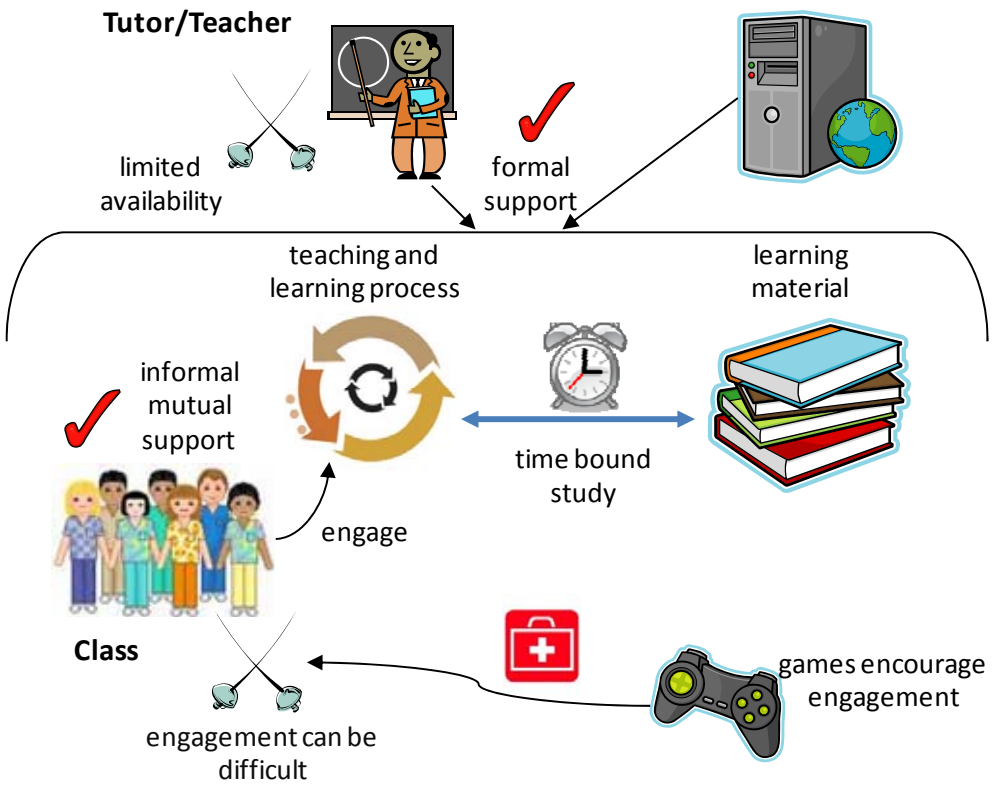

Figure 1: Rich picture of games supported blended learning

Computer games are known to be highly engaging. The inherent rule-bound structure of a game immerses a player in a temporary world in which challenges build up skills and knowledge to help achieve specific goals. As this is essentially a learning process (Gee 2005, Prensky 2006), many believe that games ideas could be used in e-learning to improve engagement (Cordova and Lepper 1996, Jonassen and Land 2000, Ricci *et al*. 1996, Squire and Jenkins 2004). That is the motivation for the work described in this paper.

Games ideas can be used in both the learning process and the design of learning materials. Work in this area has tended to focus on learning content (McFarlane *et al*. 2002) but the learning process is equally important. Indeed, improvements to the process can be more influential because, by being largely independent of content, such ideas can be used in a wide range of contexts. Section 2 of this paper examines engagement in the teaching and learning process in more detail and identifies the engaging aspects of games that might support that process. Section 3 then outlines the design of a process game. Experiences with using this process and associated tool are discussed in Section 4. Plans for further development of the approach are indicated in the conclusions.

2. Supporting engagement with games techniques

This section examines the factors associated with engagement as a first step towards identifying improvement. One well established model of the constituent elements of engagement is that developed for the National Survey of Student Engagement (NSSE), which began in 2000. The purpose of the survey is to gather information annually on engagement across four-year colleges and universities in the USA and Canada. In 2000, 276 institutions were involved, rising each year to 774 in 2008. The rationale for their work (NSSE 2008) is that "...*the time and energy students devote to educationally purposeful activities is the single best predictor of their learning and personal development*... [so] *those institutions that more fully engage their students in the variety of activities that contribute to valued outcomes of college can claim to be of higher quality compared with other colleges and universities where students are less engaged*".

NSSE currently bases its engagement benchmark on five main indicators, assessed through 42 questions. The indicators are:

- Level of Academic Challenge, as "challenging intellectual and creative work is central to student learning and collegiate quality. Colleges and universities promote high levels of student

achievement by emphasizing the importance of academic effort and setting high expectations for student performance".

- Active and Collaborative Learning, as "students learn more when they are intensely involved in their education and are asked to think about and apply what they are learning in different settings. Collaborating with others in solving problems or mastering difficult material prepares students to deal with the messy, unscripted problems they will encounter daily during and after college".
- Student Interaction with Faculty, as "students see first-hand how experts think about and solve practical problems by interacting with faculty members inside and outside the classroom. As a result, their teachers become role models, mentors, and guides for continuous, life-long learning".
- Enriching Educational Experiences, as "complementary learning opportunities inside and outside the classroom augment the academic program".
- Supportive Campus Environment, as "students perform better and are more satisfied at colleges that are committed to their success and cultivate positive working and social relations among different groups on campus".

These factors cover both technical and personal development, across a full educational programme, and include wide interaction with the environment. Other researchers have identified more detailed factors, some of which elaborate or complement the points above, including:

- *Challenging tasks*: tasks should continually and appropriately challenge students to stimulate engaged learning. If a task is too simple it becomes boring and if too difficult, can be frustrating. Tasks must increase in difficulty as students improve to ensure they stay engaged in the process (Quinn 2005, Wang and Kang 2006).
- *Affiliation with others*: the learning task requires collaboration amongst students. Collaboration is perceived to promote engaged learning experiences (Allen 2003, Schlechty 1997, Wang and Kang 2006).
- *Identity and roles*: being a member of a community has a strong motivational influence on an individual's identity with their peers, and much research emphasises the importance of the social factors of learning engagement (Rosenberg 2001).
- *Focused goals*: students should be aware of or discover which outcomes they need to achieve. This can be accomplished by defining a clear set of compelling goals that relate to the learning objectives (Quinn 2005). Also, allowing students to set their own goals could help increase motivation and further immerse them in the learning process (Wang and Kang 2006).
- *Protection from adverse consequences*: students should receive *feedback* on their work throughout the process, which informs them of their progress towards the learning goals (Allen 2003, Schlechty 1997, Wang and Kang 2006).
- *Clear and compelling standards*: the standards for assessing performance should be clear and are important to students (Schlechty 1997).
- *Authenticity*: the work should be significant and relevant to the lives of students and something with which they can identify (Allen 2003, Rosenberg 2001, Wang and Kang 2006).
- *Affirmation of progress*: student performance should be observed by persons other than the teacher as this public review helps add meaning to the completed tasks (Schlechty 1997).
- *Choice*: students should be provided with choice in the ways of doing the work and the methods of presentation. Choice increases engagement by giving the student control over their learning experiences (Wang and Kang 2006).

This list can be further refined by identifying key elements of game design that promote an effective learning experience (Cordova 1996, Garris *et al*. 2002, Malone and Lepper 1987, Rieber 1996). A significant overlap is to be expected but considering the factors from a different perspective helps clarify their meaning and give insights into how improved engagement might be achieved.

- *Fun*: This is an essential engagement factor in games but isn't typically given much prominence in education. Anyone directly involved, however, knows of the positive impact that 'fun' can have on engagement. Koster (2004) goes further and argues that "*fun is just another word for learning*", implying that effective learning is inherently enjoyable.
- *Conflict:* This is an alternative way to think about 'challenge' in education. Conflict is an intrinsic element in game systems and occurs routinely as a player pursues goals. Some goals may be

achieved with ease while others require a higher level of skill that has to be developed (Salen and Zimmerman 2003). The struggle of players to complete these goals, either in opposition or collaboratively, encourages engagement by building on their natural competitive drive.

- *Structure*: The 'rule bound', 'goal oriented' structure of games contributes to an engaging experience (Bjork and Holopainen 2005, Gee 2005, Rabin 2005, diSessa 2000). As in education, goals, sub-goals and required levels of achievement need to be clear, relevant and appropriate.
- *Identity*: A player usually has a visual representation of themselves within a game system. Gee (2003) describes this as a "projective visual identity". This may be selected by the player or personally developed by them. Gee (2003) suggests this identity deepens personal investment in the game and encourages players to interact and engage to a greater extent through the projected character. Currently, there is no directly equivalent mechanism in education but students do develop specific role within a peer group.
- *Feedback*: As in education, feedback in games is important in providing players with timely and relevant information on their progress towards goals and identifying their level of achievement so far. Progress within the game will often be summarised in a map, and achievement indicated though ongoing game statistics, measuring attributes such as player skill, strength and health.
- *Social*: When players interact within a game environment there is social interaction at two levels: (i) *internally*, though interaction of game characters; and (ii) *externally*, as the players communicate to exchange information, share experiences, or compete to make progress with the game (Salen and Zimmerman 2003). Much educational and social research highlights the importance of such social interactions in the learning process (Rudd *et al*. 2006).

The next section, building on these aspects of game design that promote engagement, outlines an approach to the development of a process game that is intended to improve engagement in a programme of study. In principle, the approach should be relevant to study at any academic level but the initial focus and subsequent experimental work described is in third level education.

3. The teaching and learning process game

The most obvious difference between the list of relevant engagement factors in education and the one for games, as outlined in Section 2, is the absence of 'fun' in the education list. One obvious way to improve engagement, therefore, is to introduce a game into the general teaching and learning process. What is less obvious, however, is the form that such a game should take to ensure that it is played with sufficient enthusiasm to enhance student performance. Potentially, for example, the game might be resented by the students, and ignored. Because of this concern, it was decided to approach the design of the game cautiously, in stages. In the first stage, the focus was on group work, with the expectation that groups would be more likely than individuals to take part in a game. As a further safeguard, the game was presented as an 'experiment', with participation made optional and ample opportunity given for critical feedback.

The general strategy was to create a game in which points were offered for desirable behaviour, which would include, for example, attendance at lectures, lab classes and tutorials. Desirable behaviour is obviously important for student success but interesting optional challenges are also necessary. Examples here include answering questions in tutorials, asking questions in lectures and making a presentation to the class on a relevant technical topic.

Groups were allowed to give themselves names to establish a game identity, and feedback was provided each week through an update of group scores. As an 'affirmation of progress' these scores were displayed openly on a plasma display in a public area.

The group approach was sufficiently successful to move confidently to the second stage of introducing engagement strategies from games, namely to encourage students individually. For this stage, a feedback tool was developed to present each student with an ongoing report of their performance. The results from these experiments are described in the next section.

4. Experience with the teaching and learning engagement game

Experimental use of the engagement game focused on two consecutive first year Java programming modules: *Software Development* 1 (COM158C1) and *Software Development* 2 (COM164C2). Both ran for 12 weeks, in consecutive seminars from September to December 2007 and January to May 2008, respectively. The modules operated identically in 2006-07, without the game, so direct

comparisons of student behaviour and performance could be made. Students were briefed about the game at the beginning of the year and all chose to participate.

4.1 Semester 1: the process game with groups

In the first semester, the experiment was designed around relatively large groups of students. Specifically, 64 students were allocated to 8 groups, selected to have a reasonably even distribution of ability, based on entry level qualifications. The main objective of the first experiment was to see if the students would participate in the game and, if so, determine the impact on both their behaviour and academic performance. The semester was divided into two halves: a simple introductory game ran from weeks 1-5, which helped familiarise the students with the various elements of the game, as summarised in Table 1. These were introduced as the rules of the game. The game leader board was reset during week 6 and the game continued throughout the remaining 5 weeks of the semester.

Table 1: Rules for game 1

Element	Score	Possible Points
Attendance	10 Points for each of the lectures, lab class and tutorial	200
Contribution to tutorial	10 Points for every question answered correctly (Maximum of 10 points per student per tutorial)	50
Outstanding work	10 Points awarded at lecturer's discretion	50
Online Revision Quizzes	10 Points awarded for each quiz a student completes successfully; further attempts not rewarded with points but the student who obtains the highest score on their first attempt awarded a further 20 points	210
Group Assignment	25 Points group mark 15 Points individual mark	40
Exam Questions	10 Points awarded to each question completed by group, max of 2 questions per group	20
Group Presentations	20 Points awarded for a presentation, max of 2 presentations per group	20
Total		590

Different levels of challenge were identified, closely linked to keys skills that would benefit the students. Students could chose to do nothing beyond normal module activity and still earn some points, or select more demanding tasks, which might enhance their skills while gaining higher points for their group. For this experiment, feedback was presented weekly, showing the breakdown of group points, as indicted in Figures 2. This information was accessible through each student's virtual learning environment and was also displayed publicly.

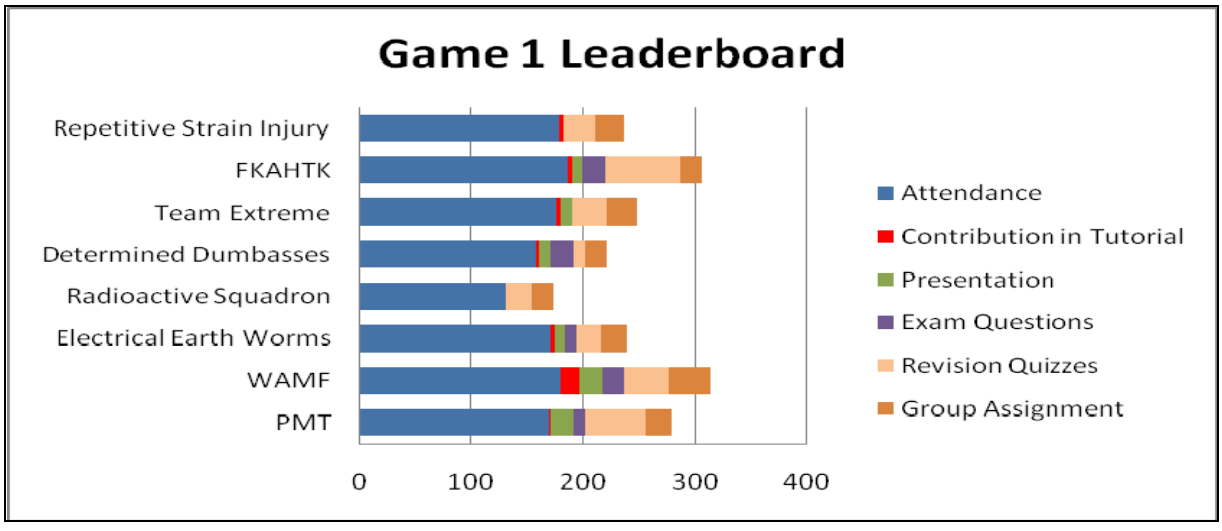

Figure 2: Graph of gamer points and the breakdown

The groups and their interaction with the game were observed in class. Some groups, like the *Radioactive Squadron*, were slow to engage but as the game neared the end of the semester put in

additional effort. In general, the groups would discuss their performance regularly and make strategic decisions about what tasks to tackle and who would tackle them. Attendance increased by 5% over the previous year, with completion of revision quizzes up by 70%. One unfortunate side effect was that the number of questions asked in lectures became unmanageable, showing that the rules needed to be fine tuned. Most significantly, the examination average for the module increased, and everyone passed at the first attempt (40%), as shown in the scatter graphs in Figure 3. This had never happened before and was both surprising and encouraging.

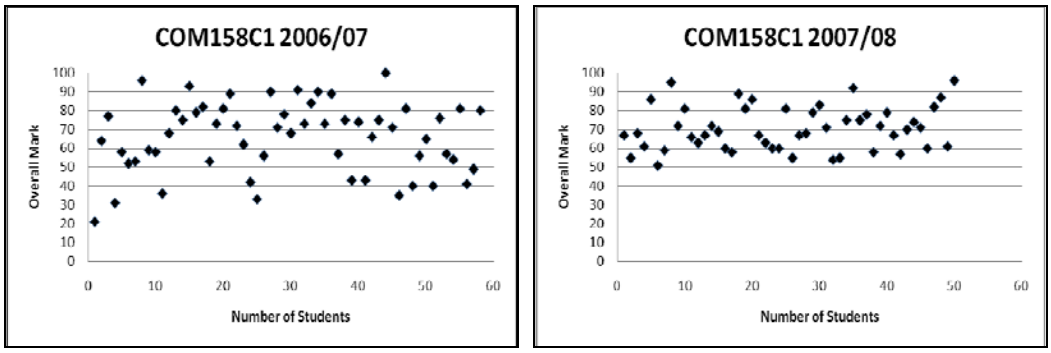

Figure 3: Comparative **m**odule results for COM158C1 for 2006/07 and 2007/08

Overall, student feedback was very positive and the game seemed to have been an enjoyable and worthwhile experience for them. With respect to the objectives of the experiment, the students clearly accepted the game and benefitted accordingly. The main criticism was in relation to feedback, with most students wanting points to be updated more frequently and many seeking information on their individual performance. These issues and the lessons learned in the first semester were used in designing the experiment on individual process game play implemented in Semester 2.

4.2 Semester 2: the process game with individuals

The second stage of the experiment involved the same group of students, with similar challenges but with some adjustment to the scoring scheme, as shown in Table 2.

Table 2: Rules for game 2

	Element	Score		Possible Total
1	CV	Create CV and Submit to study Supervisor	25	
		Polished finish	25	50
2	Group Dynamics	Weeks 1-5	25	
		Weeks 7-11	25	50
3	Outstanding Work	Assignment Week 2	30	
		Assignment Week 4	30	60
4	Answering Questions in Tutorial	10 points/week * 8 weeks		80
5	Coursework	Assignment Week 2	15	
6		Assignment Week 4	15	
7		Week 6 Test	30	
8		Group Assignment	35	
9		Personal Development System Use	5	100
10	Attendance	L1 = 2 points/week * 12 weeks	24	
		Lab = 4 points/week * 12 weeks	48	
		L2 = 2 points/week * 12 weeks	24	
		Tutorial = 2 points/week * 12 weeks	24	120
11	Asking Questions in Lectures	7points/Lecture*2 Lectures/week * 10 weeks		140
12	Quiz & Presentations	Quiz (additional reading) weeks 2-5 (25*4)	100	
		1 presentation within weeks (7-11)	100	200
13	Revision Quizzes	10 points per quiz		200
	Total			1000

The scoring scheme was based on the Xbox Live game system model, in which players compete for up to 1000 achievement points, which was a rounder target. Not all points were available immediately, so a weekly release plan of the gamer points was produced, as shown in Table 3.

Table 3: Weekly release plan of gamer points

	Elements											
Week	**Attendance**	**Ask questions in Lectures**	**Answering Questions in Tutorials**	**Assignment (1,2)**	**Outstanding Work**	**Group Dynamics**	**Class Test**	**PDP**	**Group Assignment**	**Quiz & Presentation**	**CV**	**Revision Quizzes**
1	10	14										
2	10	14	10	15	30					Quiz (100)		
3	10	14	10								From Wk 3	From Wk 3
4	10	14	10	15	30							
5	10	14	10			25						
6	10						30					
7	10	14	10							Presentations (100)		
8	10	14	10									
9	10	14	10									
10	10	14	10									
11	10	14				25		5				
12	10								35			
Total	120	140	80	30	60	50	30	5	35	200	50	200

Student feedback was given individually and updated daily. A tool was developed to display this feedback graphically. The user interface is shown in Figure 4. There are four main sections on the screen: basic student details are on the left hand side, information on gamer points is in the middle and attendance information is on the right. At the top, is a slider allowing students to give basic feedback on the perceived value of the performance display tool.

The gamer point section shows: the total points available at any stage, the score the student has obtained, their position in class and the highest and lowest scores within that class. The lower graph gives the mark breakdown, with further details displayed as the mouse pointer is moved over the bars.

Attendance was believed to be a key indicator of engagement so it was given a section to itself. This shows the percentage of overall attendance and a week by week breakdown. On reflection, this rather negative emphasis on attendance seems disproportionate to other aspects of the game and so is currently under review.

Comparing the 2007-08 class with the equivalent cohort in 2006-07, again showed significant improvements. Attendance was up by 4% and examination performance had also improved significantly as shown in Figure 5. In this traditionally demanding module, initial failure rates of the order of 25% had been common over many years but dropped to less than 10% in 2007-08. As in the first semester, there was a clear improvement in performance at the lower end of the class but there was also improvement across the class, suggesting that the game approach was bringing benefits to those with a range of abilities. Most significantly, Figure 5 shows a smooth distribution of marks for 2007-08, whereas the 2006-07 results suggested that a group at the bottom end had largely given up.

Figure 4: Interactive personalised feedback tool

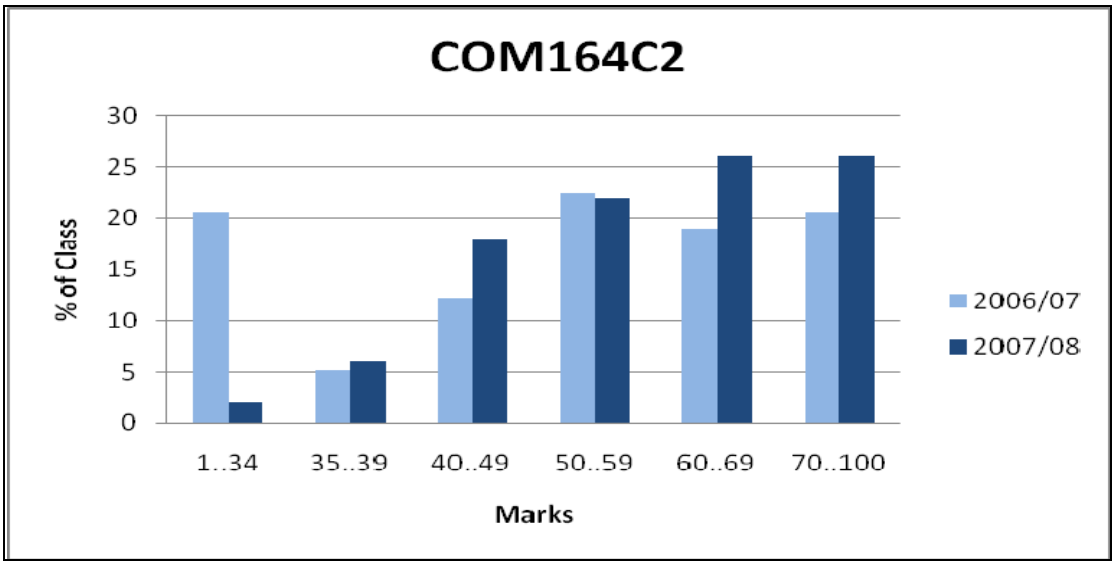

Figure 5: Results for semester 2 module over two years

As in the first semester, the students again rose to the challenges offered, engaged in the game and enjoyed the experience. The additional use of the graphical feedback tool also had a favourable response, with a satisfaction rating of over 80%. The experiment in the first semester made clear that students wanted to be aware of their own performance even if they work in groups. It was, however, unclear to what extent engagement and performance were dependent on peer pressure within the groups. More careful experimentation is needed here, but the results in the second semester suggested that the process game could run successfully without groups and so be relevant to individual e-learning.

5. Conclusions and future work

This paper has described some initial exploratory research into the use of games techniques to improve student engagement in e-learning. The overall objective is to help students reach their potential, which, as a side effect, includes reducing the student dropout rate. The work is being

approached as a series of investigative experiments moving from a labour intensive face-to-face form of teaching to full e-learning, involving minimum tutor contact. The paper describes the first two stages in this sequence. The first stage introduced a group game to a traditional first year programming module and the second extended that approach to individual students. The results have been well beyond expectations in several respects though there are also reservations in each case.

Fundamentally, the game approach to the teaching and learning process seems to be successful in that the students responded well, with all agreeing to participate and many rising to the challenges involved. One key question here, however, is the contribution to success from other factors, such as presenting the idea as an 'experiment' and the resulting increased personal contact from the lecturer and support staff. The approach needs to be repeated more routinely to remove the Hawthorne Effect (Cook 1967) and perhaps use greater automation to reduce the personal contact involved.

As well as embracing the game, the students also achieved significantly improved results. Again, the experimental factor is a concern but so also is the nature of the group of students involved. This group could have been particularly studious, through that is not reflected in their entry results, or they could have been particularly sociable and so well suited to playing this type of game. The experiments therefore need to be repeated again with another cohort.

A third, unexpected benefit was that the performance of the students improved in the other modules they studied, suggesting that there had been a beneficial change in their approach and study skills. It could be argued again, however, that this was in some sense an 'exceptional year' so more experimentation is needed before definite conclusions can be drawn.

At a detailed level, there are also many more issues to be explored, such as gaining a better understanding of the contribution of the individual challenges and determining the appropriate level of complexity in the game. The timeliness and appropriateness of the feedback is also crucial, as is the variations in level of challenge across the tasks to encourage full participation. Students will select these tasks strategically, based on preference and ability.

It was fortunate to have started with a group experiment as that seemed particularly successful. In particular, it was a gentle introduction to the game and gave the groups a clear social identity. Group cohesion and peer support were stronger as a result, ever if the main motivation was to achieve a good group mark. The transition to individualised feedback was sufficiently different to avoid the risk of the students becoming bored though that could be a factor if this were repeated for students in successive years.

Overall, this research has raised more questions than it has answered, suggesting the need for many more experiments. The results achieved so far, however, provide a very strong incentive to pursue that work.

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