Racing Academy

A Futurelab prototype research report

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EXECUTIVE SUMMARY

Racing Academy is a prototype for a massively multiplayer online (MMO) engineering and racing car simulation. Based on the most realistic vehicle physics and surface simulation yet developed, it gives players the capacity to manipulate the set-up of vehicles, and then to race them against an AI driver. In the prototype, Racing Academy was played as a standalone game, with a bespoke online messageboard providing players with opportunities to discuss their performance and to share advice about playing the game.

Racing Academy arrives to coincide with a recent curricular drive to re-establish the importance of engineering in school. The new GCSE engineering award and the award of specialist Engineering College status indicates the current initiative which seeks to combine D&T, maths and science to provide a multidisciplinary syllabus focused on providing vocational qualifications as well as the foundation for post-16 study. Further, a number of initiatives based around mechanical engineering have been established across the country, including those under the recently re-launched apprenticeship scheme, community-based initiatives, and a post-16 BTEC motor vehicle engineering programme.

Growing recognition of the educational potential of computer games also suggests that we need to pay attention to the kinds of learning that may be occurring when young people play. Particularly, research has identified how young people exchange knowledge about games and share with others the techniques to play them. Some research on MMO games also suggests that these are unique learning spaces in which young people are engaged in informal, peer-to-peer learning activities. Racing Academy aims to capture these understandings of computer games and put them to more explicitly educational use.

The prototype was trialled with two Year 10 groups at two secondary schools in Bristol. In total, 40 students played the game. One group was an engineering GCSE class, the other a GCSE science class. Each group completed a questionnaire about computer use, interest in video games and interest in cars/racing; they played the game twice; completed a questionnaire about their experience of the game; and four students were interviewed on DV tape about their experience of the game. While playing the game, two students from each group were recorded on DV tape, and transcripts from the messageboard were captured.

The learning research on Racing Academy has revealed that:

Many of the sample found the game engaging, challenging, and rewarding. Many of them clearly found the game tough at first, with comments on the messageboard reflecting this: "can any1 beat dis game", and "gears are rock to sort out" were typically vernacular responses. In the post-play questionnaire and interview responses, however, many of the students felt that the level of challenge was about right; that it was hard but fun, and that to make it easier would make it less interesting. The level of challenge in this prototype, it seems, then, is pitched at the right level.

Many players were observed repeatedly trying out alternative options and re-playing races until they could beat the AI driver. This trial-and-error approach often yielded success in the game, but it was clear that some students got 'stuck'. Particularly at the Monks Park site, this led to a lot of spoken chat and demonstration between players, indicating the value of having players co-located, as well as available online, to help each other.

Most students were able to use the messageboard, and understood the reasons for its inclusion. There were a number of problems associated with this aspect of the experience, however: notably, that players needed to tab between the game and the messageboard, often meaning that they would go long periods without seeing it; and LEA firewall security at the schools prevented player profiles from updating to the boards.

Most students exchanged knowledge about the game using the messageboards, including

informing others about best engine, tyre and gear ratio choices. Most of the communication on the boards took the form of direct query and response, with no more in-depth discussions about the reasons why some car set-up selections were better than others. Other forms of communication included bragging ("i won i am da best"), statements of intent ("boys its just we gunna win"), and direct instruction ("oi av the 2.6 rotary its fast n I win").

Very few students used the messageboard extensively. A common complaint from those who initially thought it a useful addition to the game was that very few others were posting any messages at all. Some students claimed that they did not use it much as they preferred just to play the game. Informal comments from some students, however, revealed that they might have preferred a facility such as Instant Messenger, which would have prevented them from having to open the messageboard browser separately to the game. Clearly any future iteration of Racing Academy intended for online use would need to integrate the chat functionality with the game as a single application.

By playing the game, many of the students were clearly beginning to grasp some of the engineering and mechanical principles upon which it is built. After playing, students talked together about aspects of the game such as wheelspin and friction, about what gear ratios are, and about how aspects of the game would translate on to the actual experience of driving a vehicle. In this respect, they were beginning to use and to consider understandings about engineering principles that had been revealed to them through the game itself.

The research identified some of the aspects present that would be expected in the early stages of the formation of a community of practice. The game appears sufficiently engaging and challenging as a game in itself, and for some of the students the messageboard functionality, and the capacity it provided to access the expertise of their peers, supported their play.

Summary of recommendations

You and two friends are taking the search and rescue course at the Astroversity – an orbiting academy where gifted students are trained to become space explorers. Your robotic tutors guide you on effective methods of data gathering, deductive reasoning on toxic gunk levels, and communication requirements as you patrol empty hangars looking for dummy victims. During this training session disaster strikes - the academy is hit by an alien vessel releasing poisonous toxins into the atmosphere. You and your friends must now put your new skills to the test as you really rescue your fellow students.
The above is not the packaging from a new playstation game but a project developed by Futurelab and the International Centre for Digital Content (ICDC) at John Moore's University, Liverpool, UK. Astroversity has the look and feel of commercial computer games but incorporates educational goals. It was designed to support students aged 13 to 15 to develop group skills (such as listening, turn taking, and providing justifications for suggestions), and scientific enquiry skills (such as data logging, hypothesis generation and testing, and analysis of data).

Astroversity is innovative due to:

- The use of multiple methods of representation: the students switch between a virtual online world and a paper-based representation they create as a consequence of exploring this world
- The requirement that team members do not simply work together by doing fulfilling different roles in the same task, but have to contribute information to a single activity with a collective outcome
- The explicit encouragement of meaningful self-assessment and reflection on the skills being developed within the task

If Racing Academy is to be developed further:

- consult with teachers and other staff involved in teaching and training young engineers, including GCSE engineering, BTEC motor vehicle, and voluntary group teachers
- continue to consult and trial game with young people in and out of schools in order to ensure sufficient level of challenge and engagement with material
- if online functionality is required, seek an alternative to independent messageboard, seeking to integrate communicative functions with the game environment.

For developers of other games in learning:

- base the game on particular aspects of education; but the curriculum changes regularly so some desk research on the subject and possible future developments is essential
- label the game explicitly as intended to promote learning. If the game is sufficiently engaging and challenging then young people are likely to enjoy it; if the material is sufficiently relevant then teachers are more likely to embrace it too
- ensure that the underlying simulation or model is realistic if the game is intended to help develop understandings of real things
- the process of achieving things (even if fantastical) should be logical and consistent, and have a firm rationale
- games in learning must provide feedback to players (such as meaningful scores, replays, measurements etc) in order to allow them to review and understand how they are performing.

For policymakers:

- it is possible for computer games that feature difficult real content to be engaging and challenging like mainstream titles
- the games development community should be supported or encouraged to develop new titles based on educational material, or to re-purpose existing assets
- games developers who wish to enter the education market bring with them extraordinary talent for engaging people in complex challenges: they should be supported to ensure that they are able to access clear, legible educational policy and curriculum documents, or they will be unable to engineer the 'stuff' of education into games titles sufficiently well.

1. CONCEPT AND AIMS

1.1 Vision

The overall goal of the Racing Academy project is to design and build a massively multi-user online automotive engineering academy, based on leading-edge computer games technology. The purpose of this academy would be to provide a progressive opportunity to learn real physics and mechanical engineering in a virtual community. It would be a persistent gaming environment for virtual automotive engineers and racers.

The game engine is based on vehicle dynamics simulation software developed by Lateral Visions. The software is extremely rich in its simulation, processing a massive number of different parameters in car and travel-surface design in order to model the car's mechanics. Success in the game depends on users' understanding of these mechanics and ability to alter them for performance gain. In a multi-user online environment, this understanding would be contingent on the knowledge gained through the community of gamers - a group of competitive and collaborative problem solvers working together, sharing knowledge and techniques in an information-rich environment - as well as that gained through their ability to access and negotiate other resources. This builds on two very salient ideas in the use of ICT

for learning: powerful games-derived simulation systems, and the internet and peer-to-peer engagement.

As well as this focus on informal learning in multi-user virtual spaces, the project is also intended to investigate how it might be possible to engage young people in learning tasks that are complex and challenging but exciting and rewarding. Particularly, there is an interest in how to keep teenage boys from becoming disaffected by the curriculum, by engaging them in tasks that are authentic, that involve real practices and through which they can see the effects of their choices, interventions and actions. Racing Academy, in the sense of the vision for the project, will require players to handle and analyse multiple (and multimodal) data sources, to make considered choices, to reflect on and review their interventions and actions, and to collaborate with others, as well as play the game itself.

There is an important gender question that should not be ignored. Racing Academy, like many mainstream computer games, is clearly open to the criticism that it is designed for boys, or that it will only be of interest to boys. We accept this. However, we believe that there is a valid rationale for designing mainly for boys where there is a need for resources aimed at them. We also believe that if we want to interest girls in engineering-related activities, then games like Racing Academy may well achieve that. This is one aspect for investigation through the project.

The Racing Academy project has built upon these arguments, then, to investigate how it might be possible to support young people's learning around motor vehicle engineering (and the associated D&T, maths and science) through a massively-multiplayer online game (MMOG).

The creation of a true MMOG is a long process and not something that it would be appropriate to attempt without greater knowledge of the developmental issues and processes surrounding such an undertaking. It was proposed that the eventual goal should be sought through developing the concept in staged prototypical ways that would, through careful research and technical development, hold out the possibility of delivering useful educational tools at different stages of development. Futurelab's role in this process was to research the pedagogical and educational possibilities of such a game, and to support the development of a demonstration prototype that showcases the vehicle dynamics simulation technology.

1.2 Prototype

1.2.1 Simulation

There were two versions of the prototype game used in the trials, both based on the same underlying game concept. Players had to race a computer-controlled opponent (the 'AI driver') along a straight track representing a quarter-mile drag-racing strip: at the end of the race, which lasted typically between 12-15 seconds, the player's time would be displayed along with the car's current properties, and the player was given the option to return to the main menu, which presented control and car setup options. Players could choose whether to have the computer assist them with their steering (ie have the computer correct any oversteering to keep the player driving straight) and their gears (ie gear changes made automatically by the computer), or set these options to be controlled manually. The setup options differed between prototypes but both offered the chance to change components of the car prior to racing the AI driver again: the properties of each component were displayed as a graph and as numeric data.

Figure 1: Main menu, with only engine options available

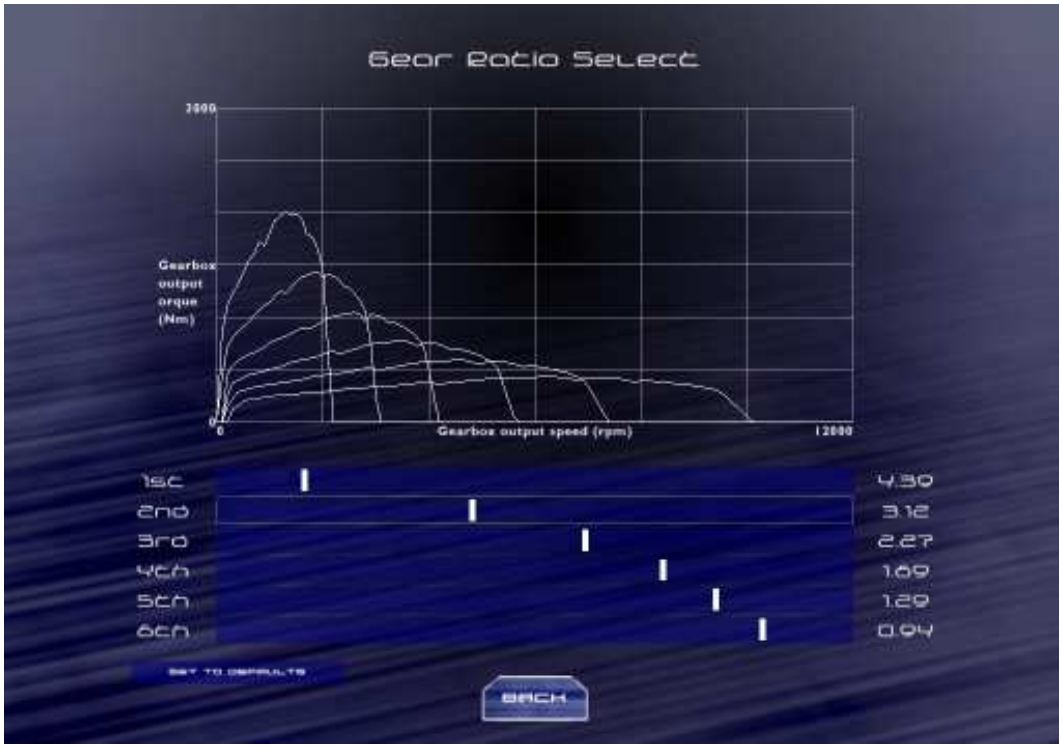

Figure 2: Changing gear ratios

In the initial prototype, players had the opportunity only to change the car's engine, from a selection of six: once the AI driver was beaten, the only remaining challenge was to beat their own best time. In the second iteration of the prototype, players had three levels of difficulty, each level providing more setup options. The first level offered a choice of six engines: once players had beaten the AI driver on this level, they could alter the car's engine and also choose from four types of tyre. Once they'd beaten the AI driver on this level, they were given the opportunity to alter the engine (with an additional engine added to the selection), tyres, and also to set the car's gear ratios. Once this level had been completed the remaining challenge was again to beat their own best time.

Figure 3: Racing (and losing to the computer)

While racing, the car's speed, engine speed (in revolutions per minute) and current gear were displayed onscreen: in the first version, these were numeric displays, while in the second they were more conventionally represented in the form of dials, in keeping with commercial racing games. The first version also displayed the amount of wheelspin the car was currently experiencing. Both versions displayed the player's time and their rival's time numerically.

	Version 1	Version 2
Straight track	✓	✓
AI opponent	✓	✓
Change engine	✓	✓
Change tyres		✓
Change gear ratios		✓
Numeric display of RPM and speed	✓	
Dial display of RPM and speed		✓
Wheelspin indicator	✓	
Manual transmission	✓	✓
Automatic transmission	✓	✓
Steering assist option	✓	✓
AI driver	✓	✓
Automatically record results on an external website		✓

Table 1: Features of the prototype

In order to succeed, that is, achieve a faster time than the AI driver, players had to alter the qualities of the car available to them at each level. It is possible to make productive alterations through trial and error: however, given the complexity of the game at even this reduced level, it was envisaged that making effective engineering decisions would require or stimulate some

discussion within the team, and so students would need to access and use the messageboard.

1.2.2 Messageboard

The messageboard used to facilitate student discussion was an adapted version of the free phpbb software (www.phpbb.com), a messageboard tool written in the PHP scripting language and using a MySQL database (www.mysql.com). This software was chosen partly because of the technical skills available, but also due to its release under the GNU General Public License (www.gnu.org/licenses/gpl.html), which allows users to freely modify code, provided any modified code is released under the same GPL conditions.

Some modifications were made to the software in order to limit users' ability to create new accounts, send e-mail, and edit posts: these changes were to enforce integrity of the data available for examination and to ensure that communication between students remained within the Racing Academy forum. Additionally, user profiles were altered to allow the display of data sent to the database from the prototype and to remove some options that were irrelevant to the trials.

The messageboard was also used as a repository for recording best individual times: although in the second iteration the game could record players' choices and best times on the external messageboard (Figure 7), the technical limitations of testing the prototype in the more restrictive firewall environment typical of schools prevented this being used.

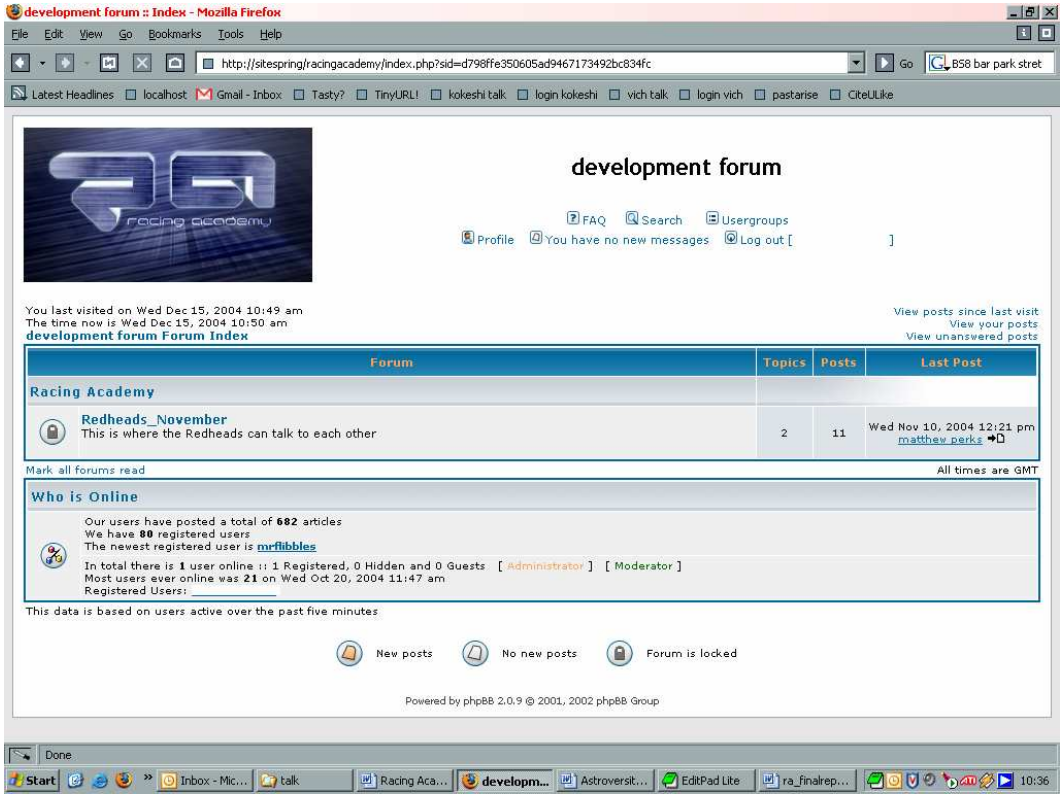

Figure 4: Forum view, with only player's team forum available

Figure 5: Team conversation

Figure 6: Posting a message to the team

Figure 7: Stats displayed on the messageboard

1.2.3 Competition and team set-up

All students involved in the trial were asked to organise themselves into teams of five players, giving us four teams per school. These teams were then informed that they would be competing against each other.

The scoring system for the competition was based on teams scoring the fastest overall time. Players were given approximately 30 minutes to play the game, at the end of which each should then post their best time for a single race against the AI driver to their team forum on the messageboard. These best times were then added together to give an overall team time. The winning team was the one that scored the fastest team time. This meant that while individual performance was a factor in the students' play, it was also important to ensure that every member of the team performed well. It was hoped that this structure would promote the peer-to-peer element of the game, as well as heightening the motivation to compete with other teams. (In the event of a team member being absent, it was agreed with the students that the absent team member would be awarded the average time of the rest of the team.)

2. RESEARCH CONTEXT

Racing Academy arrives to coincide with a recent curricular drive to re-establish the importance of engineering in school. In England, 35 secondary schools have been awarded specialist Engineering College status, delivering the new GCSE engineering syllabus which is supported by the Nuffield Curriculum Centre. The GCSE is a multidisciplinary course combining D&T, maths and science in order to develop students' understanding of engineering, and provides a vocational foundation for entry into employment as well as a foundation for post-16 study. Further, a number of initiatives based around mechanical engineering have been established across the country, including those under the recently re-launched apprenticeship scheme, community-based initiatives, and a pilot programme for BTec motor vehicle students at Buckmore Karting Park in Kent.

Additionally, since Racing Academy is based on real physics, it is intended for potential use in science. With the new 21st Century Science curriculum coming into practice in September 2006, the focus will be less on educating for the minority who go on to study science at post-

16, in higher education, or who end up employed in science; instead it will be on educating to cope with the diversity of students' interests and aspirations, and to inform them about science which matters to them directly. Alongside this broad 'scientific literacy', students will also be taught about the processes involved in exploring science, and about major scientific theories and their place in society. It is envisaged that Racing Academy might be used to meet some of the demands of this new curriculum, as well as the demands of post-16 physics.

The theoretical basis for an interest in the role of computer games in learning, and thus for Racing Academy, stems from the understanding that learning acts are situated in specific social contexts and in the interactions between learners; also that understandings are best developed when presented to learners progressively.

Therefore, the principles behind the game would be developed and learned in a progressive way, following the development of Jerome Bruner's 'spiral curriculum' and 'revelatory learning'. The entrants to the academy could develop vehicles with limited parameters and limited game play; a greater number of parameters and telemetry could be progressively provided to the learners (gearing, suspension etc) and the tracks could become more taxing (eg auto-cross and rallying). Learners, in their roles as engineers, mechanics and drivers, would be able to exchange knowledge about the system with each other, and gain from discussions with experts and from learning materials.

Lave and Wenger (1991) conceptualise learning and 'knowing' as occurring in relationships with particular communities, including formal professional communities as well as more informal 'hobbyist' or enthusiast communities such as wine-tasters. Lave (1991) conceptualises this as "situated learning in communities of practice". These communities evolve over time, and often overlap with each other. The scientific community, for instance, has developed particular vocabulary, methods, concepts and models, many of which have been adopted by other communities and have become part of popular thinking about a variety of subjects. It is therefore the relationships to these communities that allow one to 'know' about it. "In this sense," Wenger suggests, "knowing is an act of participation in complex 'social learning systems'" (2000: 226).

Further, however, communities have established knowledge bases and standards of competence with which individuals' own experiences of life and their own ways of knowing are not always congruent. Competence in a community is contingent upon one's access to the community's shared repertoire of communal resources, including language, routines, sensibilities, tools, artefacts, stories, and styles, and appropriate uses of that repertoire. Learning, therefore, occurs in the interplay between the social standard of knowledge and competency accepted by communities, and individual ways of knowing that reach beyond the horizons of the community to which one belongs. In this way, individuals can both come to align themselves with community competencies, and catalyse change in that community's competence. According to this view, communities are dynamic, changing systems.

Our interest from the perspective of Racing Academy is in how such 'communities of practice' might be fostered in computer games, and in the extent to which the sorts of learning that go on in computer games might be said to be situated in complex social interaction. James Paul Gee (2003) suggests that computer games are "little learning engines" that are carefully designed to be learned through practice and active play, and that "affinity groups" of players with common interests in specific titles or genres often coalesce informally around these. It is through the complex of social interactions and material artefacts available to the group that knowledge about such games, series of games, or genres, becomes part of a common currency or lexicon amongst the members. Computer games, then, can be said to be at the crux of dynamic social learning systems.

Massively multiplayer online games, or MMOGs, are distinguished from the more traditional types of game (such as the first-person shooter, the real-time strategy game, etc) by virtue of the very social nature of their gameplay. The scale of these games, coupled with their social affordances, provides a very different gaming experience to those games played in isolation,

perhaps the greatest being that "winning or losing is not the end of the game" (Sang-Min Whang, 2003), as these worlds' persistence ensures that life within them is as open-ended as life outside. We might expect, then, that many of the hallmarks of communities of practice may be observed within MMOG environments, and by extension expect to see evidence of the kind of informal learning described by Lave and Wenger (1991). In addition, these games still necessitate the kind of learning described by Gee (2003), strengthening his notion of affinity groups as groups present within the virtual game world: within an MMOG, the activity that marks a player as belonging to a particular affinity group is not limited to online activity outside the game but is an integral part of playing the game.

Further, MMOGs allow a player to adopt a rich set of identities that overlap. A player may identify as a member of a species, as a member of their guild, as a particular officer within that guild, as a fictitious character (role-playing), OOC (out of character) but still discussing game business, and so on. Steinkuehler (2004) gives an account of a learning event in the MMOG Lineage, describing it as an "apprenticeship into doing", and finds that both collaboration and "performing at the outer edge of one's current competency" are essential parts of learning within an MMOG. This recalls Papert's (1998) notion of "hard fun", and is linked also to Vygotsky's (1978) "zone of proximal development". The practice is engaging and demanding, an indication of effective learning in single-player games, and is supported by membership of a community.

With Racing Academy, the virtual gameworld in/through which we would hope to see a community of practice develop is based not on fictional qualities, but on real physics principles. By engaging with the game, players must engage with the underlying physics and, additionally, work as a member of a community of practice where the practice arises out of the real physics and involves the social negotiation of understandings.

3. RESEARCH PROCESS

The prototype was developed over three iterations by Lateral Visions, two of which were available for the trials in schools: each trial fed back into the development process and informed the following iteration. A small-scale pilot trial was carried out prior to taking the prototype into schools: each iteration of the prototype was tested once in each school, producing data from four trials. Research and design of the application are part of the same iterative process, informing each other stage by stage.

3.1 Research questions

- Is the simulation sufficiently engaging to maintain students' interest?
- Is there evidence of knowledge sufficient to progress within the game being exchanged?
- Is there evidence that this knowledge exchange is facilitated by the messageboard?
- Is Racing Academy appropriate for the formal classroom setting?

These questions are deliberately limited in scope. Communities take time to grow and develop. However, we had access to our group of students for just three hours in total: this is obviously nowhere near enough time for a community to form. Similarly, many modern games can take between 20 hours and 60 hours on average to complete, and with the additional gameplay possibilities inherent within MMOGs these games can demand as much time as a player feels they can invest. The learning described by Gee, for example, would not be apparent in games with only a short amount of time spent playing them. The lack of a dedicated game server or other internet capabilities within the prototype also made it impossible to examine the play generated by the game in any environment except a classroom.

Instead of looking directly for evidence of learning or established community, then, indicators of the elements described by Gee and Wenger as being crucial to games and community learning were sought. There are two primary areas of interest: engagement and knowledge exchange. The presence of these at such an early stage of development would suggest that the prototype would reward further work, while their absence would suggest that a re-evaluation of the project would be timely.

3.2 Research sites and sample

The trials took place with two groups, Hartcliffe Engineering College and Monks Park School. Knowle West Media Project, a local youth group focusing on providing access to photography, video and multimedia design experience for local people, was involved in the early data exchange activity, but unfortunately was unable to continue with the main trials due to a lack of available equipment; the results from this group are not presented due to the small sample size.

3.2.1 Hartcliffe Engineering College

In total, 20 students from Hartcliffe Engibneering College participated in the trials. 17 of these students are male; three female. All are students in Year 10, enrolled on the newly-formed GCSE engineering course.

Based in south Bristol, Hartcliffe Engineering College has completed its first year as a Specialist School. It serves a socially and economically deprived area: the most recent OFSTED report notes that 21% of its pupils are eligible for free school meals, above the national average, and describes pupils' "challenging behaviour". Students are drawn from a predominately white background, are mixed, and aged between 11-16.

Trials were carried out with the full support of the school's technical team and Phil Buckley, a teacher of design technology and engineering.

3.2.2 Monks Park School

20 students from Monks Park School were involved in the trial: 11 male and nine female. The students comprise a Year 10 GCSE science class.

Monks Park School is a mixed 11-16 community comprehensive school based in the north of Bristol, with a similar socioeconomic profile to Hartcliffe. The racial makeup of the school is more varied, however. Trials here were carried out in the adjacent City Learning Centre, a resource catering both to the school and to primary and adult groups from the community. Some of the pupils had been involved with previous Futurelab projects.

3.3 Research process

The process for the trial took place over a number of sessions, and implemented a multi-methodological approach. The following table indicates what methods were used and what data was collected.

Activity	**Data collected**
A pilot session using an online messageboard and interface displays from existing racing games	Messageboard transcripts Annotated interface displays
Pre- and post-play questionnaires	Quantitative, tick-box answers Qualitative, written comments

Gaming sessions	Video data of case study students playing the game Messageboard transcripts Researchers' field notes
Interviews	Video data of 'guided tour' Interviews transcripts

Each of these research activities is described in more detail below.

3.3.1 Pilot

Prior to the prototype being trialled in schools, a preliminary session was held with pupils from Hartcliffe School. This session focused on the ability of participants to exchange knowledge and work collaboratively using a messageboard, allowing us to assess the level of competency within this environment and to adjust the trials proper accordingly.

During this session, students were also given print-outs of the interface from four different racing games. These interface displays were given blank labels, and students were asked to write on the print-outs what various parts of the interface were intended to communicate. These included cockpit telemetric displays.

They also provided their own descriptions of what they thought the term 'engineer' meant.

The pilot suggested the following themes for consideration prior to the later trials.

Students appeared:

- able to communicate and exchange knowledge to some degree
- able to identify the purpose of many game interface features and vehicle telemetry data
- to have an awareness of the general domain of 'engineering'.

Messageboard use indicated:

- broadcast style of communication
- tendency to communicate first rather than spend time considering
- messageboard idiom likely to be privileged over 'engineer' discourse.

Following the pilot session, a further session was held in which students divided themselves into teams of five members, decided on a team name, and individually chose a username and password for use with the messageboard. At this time permission requests were given to students.

3.3.2 Pre-play questionnaire

A short questionnaire was completed by the students at both sites prior to playing Racing Academy. This was intended to provide details of students' interest or lack of interest in cars and racing, and their computer gaming and online communication habits. A copy of the questionnaire is included in Appendix 1.

3.3.3 Playing the game

Students played the Racing Academy prototype over two full gameplay sessions in which they played as competing teams. In the first session, only Level 1 was available. In the second, students could play through three levels, choosing engine (Level 1), tyre (L2) and gear ratio (L3) set-up.

Both sessions followed the same format. Participating students were in the same room, each seated facing away from the centre facing the wall as dictated by the layout of the computers within the room. Students were asked to bear in mind that the prototype was for a game that would be played in an environment in which face-to-face communication with other players was not possible, and to imagine therefore that they could only talk to the other members of their team using the messageboard. The headphones were primarily necessary because sound is an integral feedback mechanism for the game. Nevertheless, it is possible that they had a secondary beneficial effect in reinforcing this willing suspension of disbelief. Very little person-to-person communication was observed during play. Students' focus on the task may additionally have been due to their prior participation in the earlier trial and familiarity with their general role of 'co-developers'.

Each team member had:

- access to a PC running the prototype application
- access to messageboard via the internet
- headphones
- reminder slip with messageboard details.

Process:

- background to activities and task outlined described by researchers
- two teams taken outside to other, teacher-led activities, unrelated to the trial (necessary as not enough computers to ensure one per student otherwise)
- team members asked to log on to messageboard and send other team members a message, under general supervision of researcher, to ensure all students are able to use the messageboard
- prototype started on all computers, students shown how to move between browser (displaying messageboard) and game using the Alt + Tab keys
- students given just over 30 minutes to play and use the messageboard (in the first session, time between first and last posts was 36 minutes): during this time, two students were randomly selected and videoed
- first two teams swap activities with second two teams
- second two teams taken through messageboard and game as before for just over 30 minutes (in the first session, time between first and last posts was 32 minutes): two more students videoed as before
- teams reconvened in classroom
- aggregate times for each team recorded by researcher, while discussion on students' experience of game and racing games in general led by other researcher
- teams' aggregate scores read out and team with lowest aggregate score (ie fastest overall time) announced as winner.

3.3.4 Post-play questionnaire

A second short questionnaire was completed by students after they had played the full Racing Academy prototype. This was intended to provide feedback on the game and the messageboard and to give students an opportunity to suggest features they would like to see included in subsequent versions of the game. This questionnaire is included in Appendix 2.

3.3.5 Interviews

Short interviews were conducted with four students from Hartcliffe school two weeks after they had last played Racing Academy. Intended to provide rich feedback about their perception of the game, these interviews were held with the students on their own. Each student was asked to provide the researchers with a 'guided tour' to the prototype, describing the software and how they used it while also demonstrating how to play. These interviews were recorded on DV tape.

3.4 Analysis

The units for analysis in this study include questionnaire responses, video data of students playing the game, messageboard transcripts, and interview data. The data collected from each research site is treated independently in this report.

3.4.1 Questionnaire responses

Questionnaire data from each site has been collated together and statistical summaries of the students' responses have been included. Due to the small samples, these are simple descriptive statistics, and no statistical analysis has been performed.

3.4.2 Video data

Video data was collected for four students from the Hartcliffe school research site, and for two students from Monks Park. (It had been intended that four students would be filmed at Monks Park but due to logistical difficulties this was not possible.) These case study students were selected randomly, although care was taken to ensure that a mix of female and male players were recorded. This breaks down as follows:

Hartcliffe:	1 white female	3 white males
Monks Park:	1 white female	1 black Afro-Caribbean male

The students were each filmed from over-the-shoulder while playing Racing Academy, with the video cameras set up to record the screen and all interactions with the keyboard and mouse. This allowed us to see how quickly the students grasped the gameplay, the extent of their engagement, the length of time it took them to complete tasks, which screens they tended to use, and how they controlled the game.

3.4.3 Messageboard transcripts

Transcripts taken from the messageboard have been analysed for their semantic content as individual utterances and as threads within longer dialogues between players. Principally, the transcripts are able to reveal the extent to which students exchanged or shared knowledge and understandings with one another during gameplay; how they represented those understandings; what existing understandings they brought into the game; what sense of team identity they developed; and whether these discussions helped to contribute to their success as players in the game.

Necessarily, given the sample, limited scope of the gameplay, and the short periods over which the trials occurred, these transcripts are able to reveal only indications, and not definitive statements, that any of the above were occurring. It has not been possible to claim that Racing Academy is sufficiently engaging, motivating and challenging that a community of practice has formed to support it. This should not be expected at this prototype stage.

A strict coding scheme or discourse analysis model were rejected due to the limited nature of the exercises that the students undertook. Also, while it would be possible to perform an interesting discourse analysis based on the students' posts to the boards, much of this would fall outside the bounds of the project objectives and research questions.

4. FINDINGS

Due to some logistical differences in how the trials took place at the two main research sites, and due to differences between the two samples, the results from the trial are discussed separately.

4.1 Hartcliffe Engineering College trials

4.1.1 Pre-play questionnaire

Students completed a brief questionnaire at the time of the pilot task intended to reflect their interest in cars and racing, their computer gaming activity and their familiarity with using a messageboard. The results indicate the extent to which the students were familiar with, or interested in, a variety of media concerned with cars and racing. The results from the Hartcliffe study are discussed here, although it was completed at the time of the initial pilot study, and so only 13 students' responses are available out of the 20 participating in the trials.

Note: All tables are intended as summaries of the data collected only. Only those options receiving a response from more than 50% of students are included. For the range of tick-box options for each question reported on here, refer to Appendix 1.

	Response	**No of responses (N=13)**
If there was a programme on TV about cars and racing you would -	want to watch it	8
At school, if you were in a lesson about cars and racing you would -	enjoy it	12
How often do you talk to your family or friends about cars or motor racing?	a few times a week	9
Which of the following do you ever look at to find out more about cars?	TV	10

Table 2: Interest in cars and racing (Hartcliffe)

	Majority response	**No of responses (N=13)**
How often do you play computer games (PC)?	a few times a week	10
How often do you play computer games (console)?	every day	7
Where do you play computer games?	at home	13
How often do you play racing games?	a few times a week	9
How often do you use messageboards or chatrooms on the internet?	every day	5

Table 3: Computer use (Hartcliffe)

There is a general level of enthusiasm for the broad domain of cars and racing, with more than half wanting to watch television programmes on the subject (predominantly *Top Gear*), around two-thirds talking to friends and family about cars and racing more than once a week, and a

clear majority claiming they would enjoy a lesson based in the area. Only one would actively watch something else and would not care about a lesson on the subject (the same student). This may be a reflection of the nature of the class - all students had chosen to study an engineering GCSE and so to some degree were self-selecting.

Practical engineering, as reflected by the question, "How often do you build or fix cars?", is less of a feature of the students' experience, with most respondents claiming to build or fix cars a few times a month or hardly ever: only one, however, never built or fixed cars.

All students played computer games a few times a week, whether on PC or console platforms. All played at home, with four playing at school and two of these also playing at friends' houses: the comparatively low number of people playing at friends' houses suggests that gaming may not be a directly social experience in a physical sense for these students. Only one student mentioned another platform, specifying that they could play "anywere on my gameboy".

Nine of the 13 chose *Need for Speed: Underground* as their favourite game, commonly citing the customisation options and graphics as reasons: "because you can tune up your car and put pictures on the side like street cars" was a typical response. Other games mentioned included *Gran Turismo* ("because you have to work from scratch" and "because it is challenging") and *Burnout 2* ("you get to race around streets and bonet people"). Two tentative themes raised here that would be worth further exploration are the sense of ownership engendered by having agency over the car used in the game, and the appeal of games that subvert social norms.

Messageboard and chatroom use was evenly spread between daily and regular monthly use: there were no students that claimed "never" to use either.

The students' responses provided this broad picture of the group:

- high interest in cars and racing
- little practical experience of car/kart/remote control car engineering, with a couple of exceptions
- high engagement with computer games and racing games
- familiarity with computer-mediated communication.

4.1.2 Engagement

Students' engagement with the activity was primarily represented by their concentrating on playing the game to the exclusion of chatting with peers, and, as the activity progressed, posting on the messageboard. They found the activity as a whole - being asked to do a new task, having something written specifically for their class to use, playing a game in lesson time - a positive experience ("alrite dis init"). Enthusiasm for belonging to a team was also seen, with many posts covering the same ground as bazzer's "ite boys its just we gunna win": team members were aware of and excited by the competitive element of the activity, and their intra-team talk reflected the kind of morale-affirming talk associated with team activity in other areas (for example sport). The comparatively greater difficulty of Racing Academy elicited comment from the beginning, with eatmydust's exclamation of "he's invicable!" occurring around the same time as more audible expressions of astonishment were heard around the classroom. None of the comments observing this increased level of difficulty were negative (for example, Clarky04's prefacing of his comment with "lol", or "laugh out loud"), and the greater level of skill and attention required by the game may have made a positive contribution to the pride in achievement expressed by many participants on completing a level or the game, for example, frazer04's "ha ha i dun it i won da game". A number of examples indicating engagement with the task include:

JordSBOB: *dis is good init*

eatmydust: *nnnnnnnnooooooooooooooooooooooooooooo hes invicable*

bazzer: *te boys its just we gunna win*
moore4me: *alrite dis init*
Clarky04: *lol its hard im still on lvl 2*
frazer04: *haha i dun it i won da game best time 12.196*
bazzer: *i won i am da best im on level 3 lol*

4.1.3 Knowledge exchange

There were many requests for information or items of knowledge volunteered on the messageboard, but it was noticeable that during this short session no deeper exploration of the underlying principles was observed, despite this being a feature of some discussions held after the activity. Knowledge given to the rest of their team by students seemed to be predominantly instructions to use a certain combination of components, presumably arrived at after personal experimentation. This assumption is given support by Lathz04's comment of "oi av the v6 3 litre engine its fast n i win", an utterance which, despite its being expressed in the vernacular of the messageboard, can be seen to be an example of supporting a hypothesis ("use the V6 3 litre engine") with empirical evidence ("it's fast enough for me to win using it"). There are different levels of sophistication within these knowledge-sharing posts, ranging from simple observation (cozy_90's "gears are rock [hard] to sort out" - this can also be seen as a bonding utterance, sharing a difficulty with the team) through simple hypothesising (JordSBOB's "da tyres effect ur speed and control") to more subtle instruction, as seen by eatmydust's suggestion to Jordan to "use the rotary 2.6 litre engine i use manual but its up to u". A range of examples of the students' attempts to share knowledge are included here:

JordSBOB: *can any1 beat dis game*
SPEEDCREWSACOUNT: *my cars frozen [newline] it wont move*
SPEEDCREWSACOUNT: *I just got 16.254*
hope04: *what is the best engine?*
eatmydust: *speed team we should use the rotary 2.6 litre*
hope04: *14.268 i won!!!!!!!!!!!!!!!*
eatmydust: *jordan use the rotary 2.6 litre engine i use manual but its up to u*
Lathz04: *oi av the v6 3 litre engine its fast n i win*
bazzer: *every1 use a v6 3 litre it helps*
cozy_90: *can any 1 stop wheel spinning*
JordSBOB: *da tyres effect ur speed and control*
cazwellgreen04: *OI FRAZER GO ON 4 LITRE DIESEL WIT GEARS ND JUS PRESS X THROUGH IT LOL*
moore4me: *wen i use it i loose*
[changed]: *wat engine r u using moore*
eatmydust: *my best score is 10.67 secs so far on 2.6ltr enginr slicks and i changed the gear ratio*
cozy_90: *gears are rock 2 sort out*
[changed]: *use slick tyres*
moore4me: *rotatory 2.6 litre slick tyres all da wa*

4.1.4 Additional areas of interest

Some indication that participants were in a classroom environment and aware of the presence of researchers can be seen in several posts, for example:

blueteam2:	*no its 7 i heard the man just now*
blueteam7:	*dat bloke got 1 eyebrow*
Lathz04:	*yo everyone I got a camera on me back lol*

While these don't devalue the posts that refer solely to the game, they reinforce the notion that isolating team members from their actual social context is unfeasible and even undesirable. Attempting to limit communication to the activity would have stunted the flow of conversation that was crucial to student collaboration.

While it was possible for participants to misrepresent their achievements within the game by posting deliberately inaccurate scores and so on, the following two comments were the only instances seen during the trial of students doing so:

cazwellgreen04:	*6.5 lol jk [newline] 12.6 !!! smoke nd fly on tour 04*
Lathz04:	*i got 1.01*
Lathz04:	*joke lol*

After the second trial (described below), one student who had reported the fastest time was concerned enough about having accidentally misreported his time to find the researchers and explain the mistake, anxious not to be thought of as having cheated.

This level of trust is of course primarily a measure of the integrity of the students, but it might also again reflect a level of engagement and commitment to the activity through the desire to complete it 'properly'.

4.1.5 Post-play questionnaire

After playing both iterations of the prototype, students were asked to complete a questionnaire describing their experience of the activities: they were also asked to make any suggestions for improvements they felt would benefit the game. For logistical reasons it wasn't possible to complete this until two weeks after the experience of playing the game, so some responses may be due to the game not being fresh in students' minds.

Note: All tables are intended as summaries of the data collected only. Only those options receiving a response from more than 50% of students are included. For the range of tick-box options for each question reported on here, refer to Appendix 2.

	Majority response	**No of responses (N=19)**
How much did you enjoy, or not enjoy, playing Racing Academy?	really enjoyed it	9*
How hard or how easy did you find Racing Academy?	quite hard/about right	7/7*

If you got stuck playing Racing Academy, did you want to...?	keep trying until I won	11
Did you use the messageboard?	sometimes	10
If you did use the messageboard, what kind of things did you use it for?	posting my best times	13
Did you think the messageboard...?	didn't really change the game	11
How did you find out what the best engine was?	worked it out by trying them out	16
How did you find out what the best tyres were?	worked it out by trying them out	13
How did you find out what the best gear ratio was?	worked it out by trying them out	14

Table 4: Post-play questionnaire (Hartcliffe)

*Although these figures individually represent less than 50% of the sample they represent the highest proportion of the responses for these questions.

The general impression among the students was largely positive. All students felt positive to neutral about playing the game, with no-one saying they did not enjoy or that they "hated it". Students' impression of the level of difficulty was similarly consistent, with no-one feeling that it was "very hard" or "very easy". For four of the five students who found the game "quite easy", their response is not borne out by observation in the classroom. This may reflect a lack of imagination, in that they didn't realise they lacked competence but merely thought the game was exceptionally limited, or it may be due to a desire to report competence they are aware they lack. All four were boys. The fifth student to report finding the game easy was female and one of the most competent players.

Those students who, when stuck, didn't keep trying until they won largely claimed to "try again a few times" rather than ask for help. Although it is certainly encouraging to see that no students would "give up" and a majority would keep trying until achieving success, there may be an element that is reporting what they feel would be the "right answer". In the trials many more were observed asking for help than the five who reported doing so.
There is also the possibility that they didn't view asking another team member about their experience as "asking for help". Certainly, although a clear majority reported working out the best setup for themselves, at the same time 10 students reported asking their team for help, 12 read it on the messageboard and 11 said that they knew a lot about cars already: plainly many students are giving more than one response to the question, and this opens up an interesting avenue of speculation.

Possibly, there was no conflict in some students' minds between claiming to have arrived independently at a result and having arrived at that result through their interactions with other team members. Prior knowledge, too, appears to count as "working it out on my own". It may be that the claim to independent progress is purely a matter of pride. It might be that they claimed all methods of deduction that they tried, not just the one that was successful. It might also be that students view collaborative work as something that produces results every team member is entitled to 'own': even if it is only one person that actually worked out a good choice of engine and posted their conclusion on the messageboard, the rest of their team might feel that every member of the team 'worked it out'. This raises the question, how many people were working things out? And in a broader sense, what ratio of 'doers' to 'followers' can you tolerate in a productive learning community?

Across the educational realm more generally, it is fairly typical of young people's self-reports about their learning to claim they have reached their own conclusions without help. Culturally,

the emphasis in the UK (and more widely) is on the achievements of the individual, as realised through the examination system. If we wish to stimulate collaboration, and young people's recognition of the value of collaboration, then, we need to recognise first that young people are driven primarily by the imperatives of individual attainment, and not by the motivation to reference the assistance of peers or other sources.

Only one student failed to write anything on the messageboard at all, and only two thought they posted messages "very often". All students had to post their times to the messageboard at some point during the activity in order for their team to have a final score, so the main reason for using the messageboard given in the table above is slightly misleading. There were some students who frequently shared their times with the rest of the team, and others who only posted theirs at the end of the session. Among those who did more than just post their time, the board was used for asking questions (11 students, again casting into doubt the widespread claim that they had not used other people's help to succeed), giving advice and reading what others had posted. Encouragingly, no students used the board for chatting about issues unrelated to the game. Only one person thought that having the messageboard available made the game worse; those who thought it made a difference thought it improved the game. Those that didn't use the messageboard gave reasons that fell into two categories: "because it was hard to work" and "I'd rather just play the game" are representative responses.

There was an encouraging level of support for a commercial version of the prototype. In conversations with some students it was frequently referred to as a "demo", rather than (for example) a prototype or alpha version; this reflects their vocabulary to some extent, but it may also be an indicator that the prototype, in their eyes, belongs in the gaming domain, rather than being 'edutainment'.

Recommendations for future development centred on providing more of what was there, rather than changing or removing any elements. Broadly, students wanted to see a choice of circuits and increased customisation options: "being able to customise looks more, earn money and buy upgrades", "add more engine and tyres and other parts for example body kit", "make it a track to drive round more cars and more track and an place where you can charge the look of your car" were all typical responses.

One student suggested that any future version should "have our name in the credits" and made a further suggestion that "when its in the shops [we should] put it out on xbox because my PC is rubbish".

4.1.6 Interviews

Interviews were completed with four students who had met with varied levels of achievement during the trials. To date, the responses from two of these have been transcribed.

Initially students were asked to demonstrate how to play the game as if it was new to the interviewers. This demonstration led into a wider discussion of the games' merits and shortcomings.

eatmydust (male, 14)
This student appeared comfortable with the game, displaying personal preferences (many statements prefaced with "I usually…") and making recommendations ("[it's] better to use manual [rather than automatic gear transmission]", "try not to over-rev it at the beginning otherwise you'll wheelspin"). He demonstrated having some kind of conception of the 'right' way to do things ("don't know if I'm doing it the right way"), but no apparent feeling of being bound to this or letting it prevent him experiment in his own way.

He seemed to learn about playing the game through systematic experiment ("changing gears slows you down", "every time I try and change something", "it's good how you can look back at your past results... because you can see what you've done and improve yourself"): he didn't

display any inclination to back up his findings with causal explanations, although he seemed curious about what the reasons for some effects might be. The vehicle parts associated with his best times were regarded as 'best' and were adopted. Overall, he showed commitment to playing the game as well as he was able, demonstrating frustration at not being able to match his performance of two weeks earlier.

When asked for more general comments on the game he focused on the ability to customise the car, drawing a distinction between alterations made to enhance performance and those that would be purely cosmetic, saying, for example, that it would "be good to put different body kits on it" and when asked if this was to improve performance replying, "just for looks", because the car "looks better and feels more... [trails off]". His comments indicate something of the relationship between players and their car, and the way commercial games have shaped the expectations of students: typically, commercial games allow the player to choose their car from a selection, rather than progressively altering a single model. Despite acknowledging the purely cosmetic nature of adding spoilers, decals and so on to a car, the feeling of ownership engendered through these accessories would add significantly to his enjoyment of the game.

Other comments dealt with the more educational aspects of Racing Academy, pointing out for example that the screen displaying the option to change the car's gear ratios "would be good if it had an explanation". Ultimately, a developed community would be able to provide this input through shared accumulated expertise, but in the absence of such a group, the lack of information made it harder to understand the effects that changes to parameters had on performance.

One positive general comment about the game was that, "it's different to other games because you just press the accelerator and it does it for you, but in this one you got to think more". This supports the idea that asking players to operate at the limits of their competency can increase engagement with the game. The "graphics are good", and it would be "interesting to see it on a circuit".

Overall, this student found the game challenging, engaging and enjoyable. His explorations of the engineering principles underlying the game seemed motivated by a desire to perform well within the game above any other motivation, and these appeared limited by the lack of supporting information within the community and the game.

smoke+die (female, 14)
This student also reported generally enjoying Racing Academy. Although on her questionnaire responses she claimed not to be interested in cars or racing on television or computer games, she had been engaged by the game, stating that she both enjoyed it and found it quite hard. It was this element of 'hard fun' that she particularly appreciated, as she would have found it boring if it had been too easy. She said that she almost never plays any computer games.

In her guided tour to the prototype, she demonstrated clear awareness of how the game worked, how to operate the interface, and what most of the information on the screen was intended to communicate. She had also clearly grasped a number of the key 'play' techniques for operating the game, particularly not holding down the throttle key but tapping it gently to get a good start. This, she said, she had been shown by "some of the boys".

She had also, however, developed a few strategies of her own for achieving good racing times. During the guided tour of the engine set-up level, she demonstrated how she would first try out each engine by racing it on automatic transmission, listening and watching out for the gear changes; she would then race on manual transmission, aiming to change gears at around the same points in the race. She had identified that the sound of the engine and "when the revometer gets to red" indicated when gears should be changed.

From this it is possible to see that this student was working out the game both by exploring it on her own, and by getting help from others. This supports the idea that learning in games often does occur through individual exploration, and when players support each other with

advice.

Interestingly, this student was also able to explain how some of the data on the statistics pages should be interpreted. While browsing the different available engines she explained that she was looking for the engine that had the lowest possible mass to the highest possible RPM ratio. This had not been explained to the students, and had not featured on any of the messageboard discussions. It is possible, given the tentative manner in which she explained this aspect of the game that she only explicitly gave this attention and worked out the ratio in the interview. This should not be seen as a negative thing, but as a potential opportunity for educators, who would be able to guide these understandings during gameplay in a classroom, or for other players who might be able to lend their expertise to other, novice or apprentice players.

4.2 Monks Park School trials

As with Hartcliffe school, the trials at Monks Park followed the same set of activities. However, in this case the activities were spread over two sessions, with the questionnaires being completed immediately prior to and following the students experience of playing the game. Additionally, technical difficulties in the first trial prevented the session being as well-structured as its equivalent at Hartcliffe, with the result that the students' experience was less structured overall.

4.2.1 Pre-play questionnaire

A summary of the students' responses to the questionnaire about interest in cars, games, and computers is given in the tables below.

Note: All tables are intended as summaries of the data collected only. For the range of tick-box options for each question reported on here, refer to Appendix 1.

	Response	**No of responses (N=16)**
If there was a programme on TV about cars and racing you would -	try to find something else to watch	10
At school, if you were in a lesson about cars and racing you would -	enjoy it	10
Which of the following do you ever look at to find out more about cars?	TV	8
How often do you build or fix cars (including remote-controlled or go-karts)?	never	12

Table 5: Interest in cars and racing (Monks Park)

	Response	**No of responses (N=16)**
How often do you play computer games (PC)?	every day	6*
How often do you play computer games (console)?	every day	6*
Where do you play computer games?	at home	15
How often do you play racing games?	hardly ever	6*

How often do you use messageboards or chatrooms on the internet?	a few times a week	8

Table 6: Computer use (Monks Park)

*Although these figures individually represent less than 50% of the sample they represent the highest proportion of the responses for these questions.

The students who participated in the Monks Park trials varied in their enthusiasm for cars, racing and computer use. Nearly two-thirds would turn over if there was a TV programme about cars and racing on television, while the same proportion would enjoy a lesson on the same subject. Though it cannot be said conclusively, it is possible to conjecture, then, that some of these students would find the subject of cars and racing interesting during school time, though not particularly interesting in their own time.

Three-quarters of the class never built or fixed cars: the majority played computer games, when they did, at home, although all of these also played at school, and only two who didn't play at home played with friends or at school. Half would watch television to learn more about cars, which in this sample meant *Top Gear* or *5th Gear*; other common sources of knowledge were the library and google.com or yahoo.com search engines. Only one student read books, used the web, read magazines and watched television to find out about cars.

Four students named the Audi TT as their favourite car; all but two students were able to name a favourite. Reasons given for choices of favourite car were similarly superficial, with no mention being made of any specific properties of the chosen car: "because it is very fast and look great" and "because it looks lush and is fast" were two typical responses.

All but one of the six who played computer games every day played on both PC and console. Of those students playing on a console, only one "hardly ever" played, compared to four students who "hardly ever" played games on a PC. There were no students who "never" played computer games. The number of students playing specifically racing games varied evenly between those who played every day and those who never played. The favourite racing game, preferred by half the students, was *Need for Speed: Underground*, a street racing game in which money can be earned to invest in the appearance of the car being raced: "because you can kit up your car" and "because you can customise your car from the vinals to the colour" were typical justifications for this choice. *Gran Turismo 3* and the *Italian Job* were equal second place, with much more general justifications: "it's addictive", "because I love cars and racing games" and "don't know" were representative responses.

There was more of a trend with students' messageboard and chatroom use. Half used one of the two "a few times a week", with three using one every day, two using them rarely and two more "never" using them.

The students' responses provided this broad picture of the group:

- varied interest in cars and racing
- little practical experience of engineering, with a couple of exceptions
- high engagement with computer games and racing games
- some familiarity with computer-mediated communication.

4.2.2 Playing the game

Both sessions followed the same format as at Hartcliffe. Participating students were in the same room, grouped around tables with members of different teams sitting together in an effort to encourage teams to use the messageboard to communicate. Tables were circular or oblong with four students facing each other.

Each team member had:

- access to a PC running the prototype application
- access to messageboard via the internet
- headphones (in the second session)
- reminder slip with messageboard details.

Process:

- background to activities and task outlined described by researchers
- team members asked to log on to messageboard and send other team members a message, under general supervision of researcher, to ensure all students are able to use the messageboard
- prototype started on all computers, students shown how to move between browser (displaying messageboard) and game using the Alt + Tab keys
- students given approximately 20 minutes to play and use the messageboard (in the first session, time between first and last posts was 15 minutes): during this time, two students were randomly selected and videoed
- aggregate times for each team recorded by researcher, while discussion on students' experience of game and racing games in general led by other researcher
- teams' aggregate scores read out and team with lowest aggregate score announced as winner.

In the first session there were technical issues with setting up the computers and connecting them to the network beyond researchers' control, which led to the undesirable situation of some students having access to the game while other were waiting to be logged onto the network. Students were asked to bear in mind that the prototype was for a game that would be played in an environment in which face-to-face communication with other players was not possible and to imagine therefore that they could only talk to the other members of their team using the messageboard, although this made less impression on this group than it did with the Hartcliffe students due to the ongoing resolution of the technical difficulties. Additionally, the environment in which students were playing the game encouraged face-to-face communication to a far greater degree than the classroom at Hartcliffe.

The classroom culture allowed students to feel more comfortable in moving around the classroom and playing the game on computers used by other students; consequently, running an activity in which team times were a meaningful measure of competition was not possible. The sessions here were more valuable insofar as they allowed researchers to measure the level of enthusiasm for the game in a group not explicitly interested in engineering.

4.2.3 Engagement

Perhaps reflecting the more varied levels of interest in engineering and racing within the group, fewer positive messages were seen in this group, although as noted above this may be disproportionate and not an accurate reflection of the general levels of engagement across the group as a whole.

[changed]:	*as any1 won a game yet im doin soooooo crap, i dont fink its a game 4 girls!!*
Rainbow:	*i havent won either im sooo crap!*
Princess-Sally:	*help im confussled*
Casie:	*ha ha i won one*
Princess-Sally:	*no i havn't won yet hav u dere lafin coz i keep doin wheel spins nd dnt no how 2 stop*
CI+1:	*[what the hell i cant do it im rubbish*
Loudy:	*well done star good goind me and sally are goin 2 miles per hour sorry were rubbish*

Princess-Sally: *yay i dun da first level go me*
Flower: *this game is poo. iv only 1 once!*
Sophie: *i won!!!!!!!!*

There is a willingness to admit perceived personal incompetence, rather than attributing a lack of immediate success to the difficulty of the game, as seen in Hartcliffe.

4.2.4 Knowledge exchange

In contrast to Hartcliffe students' use of the messageboard, there was a clear differentiation between those who were engaged in the game and motivated to discuss their performance, and those who preferred to talk about their lack of interest in the activity. Although the former were observed to be in the majority, the situation in which the activities took place encouraged their communication to be face-to-face and so not recorded on the messageboard, while those who preferred to take less interest in the game found the messageboard better suited to their talk.

As in the Hartcliffe trials, these students tended to oscillate between asking for advice and providing straight answers. There were no lengthier discussions around why particular options were better than others.

Panda: *ave u found any way 2 make ur car better*
Casie: *chose a v6 3litre*
star: *hey girls if u want to win u have to put x and up in the same time*
Rainbow: *i picked the engine 4 litre diesel turbo on the1st gear and won ok soph luv laura xxx*
Woody: *completed level 2 with rotary 2.6 litre engine and 225/40 ZR17 X slick tyres and manual transmission*
Woody: *completed level 3 with rotary 2.6 litre engine 225/40 ZR17 X Slick tyres gear ratios: 3.03 1.87 1.45 1.19 1.00 0.94 and transmission manual*
Panda: *use the slick tyres the 1 at the bottom*

It is again clear that the students rarely established collaborative behaviours with one another, instead tending to cooperate to find out the perceived 'right' answer, or combination of set-up options. Likewise, there is little discussion around the game, but simply a series of queries and responses, along with blunt unsolicited advice from players who have 'solved' the game, as can be seen in the contributions of star and Woody in the excerpts above.

4.2.5 Gender

One major criticism of computer games in general is that they are primarily designed for boys. The following thread indicates how a number of the girls at Monks Park strongly perceived Racing Academy to be "for boys" and "not for girls":

Flower: *i thnk htye shuld hv made a virtual shoppin game 4 us. cuz this is BORINGGG!!!!!*
Sophie: *yup i agree shoppin wud b soooo much more fun!! and wed b v v gud at it!!*
Rainbow: *i cnt believe boys and how they say that girls are dum cuz they cant play racing games but then i bet that if there was a shopping game they wudnt be able to do it!!!!*
Rainbow: *they shud make sumut for girls not jus boys it seems like they only*

design stuff for boys now! solhie who do u fancy huh huh huh

Arguably, these girls' identities were being formed in opposition to perceived traditional male roles, with cars identified as particularly masculine concerns and shopping as a feminine activity. While interesting a balance of the genders is, of course, an issue for any game being aimed at an educational setting, we should acknowledge that one of the initial aims for Racing Academy was to help to engage boys with difficult scientific concepts through a dynamic game; it was not specifically designed to promote girls' involvement in engineering related activities. It should also be noted that the three girls in the study from Hartcliffe were all enthusiastic about the game, though these students had, of course, all opted in to the engineering GCSE while the girls at Monks Park had not.

4.2.6 Post-play questionnaire

The responses to Racing Academy from Monks Park were less enthusiastic overall than those from Hartcliffe. The students "quite enjoyed" it, and found it "quite hard". They generally used the messageboard less, and mainly did so only to post their best race times, and reportedly played the game principally by trial and error.

Note: All tables are intended as summaries of the data collected only. Only those options receiving a response from more than 50% of students are included. For the range of tick-box options for each question reported on here, refer to Appendix 2.

	Response	**No of responses (N=16)**
How much did you enjoy, or not enjoy, playing Racing Academy?	quite enjoyed it	7*
How hard or how easy did you find Racing Academy?	quite hard	11
If you got stuck playing Racing Academy, did you want to...?	keep trying until you won	8
Did you use the messageboard?	sometimes	8
If you did use the messageboard, what kind of things did you use it for?	posting my times	8
How did you find out what the best engine was?	worked it out by trying it out	11
How did you find out what the best tyres were?	worked it out by trying it out	8
If Racing Academy was finished and in the shops, would you...?	think about buying it	8

Table 7: Post-play questionnaire (Monks Park)

*Although this figure individually represents less than 50% of the sample it represents the highest proportion of the responses for this question.

4.2.7 Teachers' comments

During the trials at both sites the groups' teachers were present, and offered some informal comments on the prototype and what sorts of activities and curricular areas they might use it to support.

Comments included:

- illustrating kinetic energy
- graph-reading
- illustrating friction
- thinking about forces, such as down-forces.

The teachers also all commented that the students were highly engaged by Racing Academy, even in its limited prototype state, and that they would like to be able to have a copy of it available for them to use in the future with their students. This is an encouraging response.

5. CONCLUSIONS

5.1 Specific Racing Academy conclusions

It is clear from the trials that the game used in conjunction with the messageboard was engaging enough to stimulate students' interest and motivation, and that this enthusiasm led to a desire to share experiences among fellow participants. The presence of such a level of engagement would be a prerequisite for any educational game, and so this is a positive indication that Racing Academy could sustain further development.

There is also evidence, from the messageboard, field observation and the post-play questionnaires, that knowledge required to succeed in the game was exchanged amongst participants: this would support the notion that a community of practice could form around Racing Academy. The group showed the beginning of developing a common language to discuss common in-game issues, a core group of players whose prior knowledge and social skills facilitated the development of other group members, and a gradual accumulation of artefacts representing the group's short history (best times, questions since answered, comments that were no longer relevant, all stored on the messageboard).

It is not possible within the scope of this study, however, to conclusively claim that Racing Academy is able to support, or is supported by, a community of practice of engineers and motor racers. This research has indicated that the prototype is sufficiently engaging and challenging for students to need and want to communicate with each other in order to be more successful as individuals and as teams playing the game. This would seem to suggest that a fully developed Racing Academy has potential as a persistent online environment though, as yet, the game would require further development to conclusively prove this potential.

An interesting question is raised by the fact that for these students being able to change one car's components (in effect, making it a different car) was nothing like being able to choose cars from a selection. Requests for being able to change your car or for more cars might indicate a general conception of cars as fixed things, not seeing that changing an attribute of a car might make it a different car. In this sense there is an issue surrounding the extent to which playing Racing Academy should support the development of understanding how cars work as systems and sub-systems of parts, not just as more or less powerful vehicles per se.

It is clear from the messageboards that the students are familiar and comfortable with the particular vernacular lexicon of 'Netspeak' (for instance, exclusive use of lower case), which they mixed with instances of 'street' argot and youth jargon (for example, "dis" and "da" for "this" and "the") in many of their posts to the boards. While this may at first appear detrimental to more the formal or curricular lexis of engineering or science, what we might suggest is that teachers would be able to work with students from these instances of web idiom towards less colloquial and more educational discourses. There is an interesting tension here: can engineering concepts be said to be understood even when articulated in a non-

engineering idiom, and would demanding that students use an 'approved' vocabulary be a barrier to their understanding?

6. RECOMMENDATIONS

6.1 General recommendations

It is clear that Racing Academy has potential application either as a standalone classroom tool to be supported by teachers working within the curriculum, and/or as an out-of-school application for use by independent players operating in an informal community of practice.

In either case, there two clear imperatives for further development if Racing Academy is to have educational potential:

- consultancy from experts in the teaching of mechanical engineering with young people, such as those working on modern apprenticeship initiatives, such as at the ITE training centre in Bournemouth, or those at initiatives such as Buckmore Karting Park in Kent
- ongoing consultancy with a network of young people, and practising teachers, in order to balance engaging, challenging gameplay with complex science and engineering.

In more general terms, the project helps us to understand several things about the design of computer games for learning:

Young people like to be able to personalise aspects of games, such as cars or characters. This is important in terms of lending them some form of 'ownership' or sense of 'belonging'. Much of this is superficial, but essential to engagement.

It is possible to design engaging and challenging tasks that feature real data and real physics, and in which successful play depends on developing some understanding of those features. A more fully designed game, however, would need much more explicit attention to content and to the ways in which the simulation is revealed than in this necessarily constrained prototype.

Games for learning should not be developed in such a way that their educational content is delivered 'by stealth'. These games are for learning; they should be labelled as such. The reason to develop games in learning is to help engage students with complex material and processes, not to pretend that they are 'having a break' from the hard business of their education.

In developing games and simulations such as Racing Academy, it is essential to ensure that the underlying simulation or model is realistic if the game is intended to help develop understandings of real things; alternatively, if the game is fantastical but aimed at promoting process skills, it is essential that these skills are mapped closely on to the skills needed outside of that fantastical world.

It is likely that it will be important for much of the engineering content of Racing Academy and other games like it to be more clearly visualised, for instance, being able to 'play' with a dynamic 3D diagram of a gear box.

It should be possible for players working with such simulation games to be able to replay and review the actions they have taken in the game environment.

In a classroom environment, it will be important for students to be able to generate meaningful data from the models with which they are experimenting; for example, generating representations of down-forces, or of power and torque. Some of this is in evidence in prototypical ways in the existing Racing Academy demo, but would need to be made more

explicitly available.

The design of online communities for education is always going to be difficult. At the very minimum, it is clear that it will be necessary to enforce a code of conduct that ensures young people do not simply turn any messageboards, chatrooms, etc., into verbal boxing rings.

Young people should be able to choose their own usernames and passwords, both to protect their anonymity and to give them a sense of their own online identity.

It is clear from the experience of Racing Academy that most young people will only use an online messageboard if they absolutely see the point of doing so. If the activity/game privileges individual performance and offers a messageboard just as a trendy addition then that forum will fail. The activities must to some extent be predicated on the idea of collaboration, sharing, and exchange. It needs to be more than just a forum for letting others know how you have done.

6.2 Possible applications in a formal classroom setting

There are already applications which might be found for the prototype as it stands - the teachers present during our short sessions all individually requested a copy of the prototype for use within their science and engineering lessons. The experiences within the prototype have already provided the jumping-off points for thinking about kinetic energy, friction and graph-reading - it seems plain that the standalone game could be a valuable classroom tool when supported by input from a teacher

The prototype as it currently stands was designed for use within the trial settings described above, with all their limitations: for a classroom tool based on Racing Academy to be valuable would require giving focussed attention to the content, working closely with educators and students to ensure that the motivation and engagement already demonstrated could translate into some kind of rich understanding of general engineering and physical principles.

With new sites of engineering for young people appearing across the UK, too, it is possible that the game could have application at these locations, or even to provide a forum for young people at multiple engineering sites to collaborate or compete.

However, if Racing Academy is envisaged as an online game for use in schools, it will be necessary to liaise with LEA staff to prevent technical issues such as firewall security measures and so on from disrupting the game.

6.3 Possible applications outside the classroom

Racing Academy was envisaged as something that could grow into an MMOG, with an expanding set of groups coming together to race and tweak cars in the ways they found most appropriate, and supporting a developer community by making the parameters of the games engine transparent to advanced users so that it can be modified and extended. This would be a revolutionary and ground-breaking achievement: for this to happen, there are a number of areas which would need significant attention:

Networking capacity would need to be an integral part of the game, in order to allow player-versus-player racing, messaging at a speed more in keeping with the kind of conversations people want to have, true integrated persistence and other tools to support the formation of groups on a formal and ad hoc basis.

The online safety of the target user base would need careful consideration in order to make their time online safe and rewarding. This would take effort from technical, promotional and design perspectives: making an online game safe without limiting the players' experiences

unduly is a non-trivial task.

A relationship with the game community would need to be carefully managed, and issues such as balancing commercial IP requirements with the benefit of having a modding community, for example, or allowing game item trading on sites such as eBay, would need to be dealt with: while strong community support can save on investment in some areas, maintenance of this community is a crucial and resource-hungry part of running a sustainable MMOG.

There would need to be a clear vision of how the game would progress and expand in order to continue to be relevant to the community supporting it: most commercial MMOGs release updates and new playing areas on a regular basis in order to maintain community interest.

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APPENDIX 1: PRE-PLAY QUESTIONNAIRE

A bit about you.

Could you please tell us a little bit about yourselves. We will not tell anyone else what you have written - it is just to help us with our research.

Using computers

How often do you play computer games?

	On a PC	**On a console**
Every day		

A few times a week		
A few times a month		
Hardly ever		
Never		

Where do you play computer games?

At home	
At friends' houses	
At school	
Somewhere else (please tell us where)	

How often do you play motor racing games?

Every day	
A few times a week	
A few times a month	
Hardly ever	
Never	

What is your favourite racing game?

Why is it your favourite?

How often do you use chat rooms or messageboards on the internet?

Every day	
A few times a week	
A few times a month	
Hardly ever	
Never	

Cars and racing

If there was a programme on TV about cars or about motor racing would you:

Want to watch it	
Not care whether you watched it or not	
Try to find something else to watch	

At school if you were in a lesson about cars or motor racing would you:

Enjoy it	
Not care about it	

Wish you were in another lesson	

How often do you talk to friends or family about cars or motor racing?

Every day	
A few times a week	
A few times a month	
Hardly ever	
Never	

Which of the following do you ever look at to find out more about cars?

Books		Which books?
TV		Which programmes?
Websites		Which sites?
Magazines		Which magazines?

How often do you build or fix cars, including real cars, go-karts and radio-controlled cars?

Every day	
A few times a week	
A few times a month	
Hardly ever	
Never	

Do you build or fix real cars, go-karts or radio-controlled cars, or other cars?

What is your favourite car?

Why is it your favourite?

APPENDIX 2: POST-PLAY QUESTIONNAIRE

These questions will help us to make Racing Academy a better game. Please be honest about it. Thank you.

Your name

How much did you enjoy, or did you not enjoy playing Racing Academy? (Tick one box)

Really enjoyed it	
Quite enjoyed it	
It was OK	
Did not enjoy it	
Hated it	

How hard or how easy did you find Racing Academy? (Tick one box)

Very hard	
Quite hard	
About right	
Quite easy	
Very easy	

If you got stuck playing Racing Academy did you want to...? (Tick one box)

Give up	
Try again a few times	
Ask for help	
Keep trying until you won	

Did you use the messageboard...? (Tick one box)

Very often	
Sometimes	
Hardly at all	
Never	

If you did use the messageboard very often or sometimes what sorts of things did you use it for? (Tick any that apply)

To post my best times	
To ask questions	
To give my team advice	
To brag to the other teams	
To chat with my friends	
To chat about the game	
To chat about cars	
To chat about other things	
To read what others had posted	

If you did not use the messageboard at all, or hardly used it at all, why? (Please write your reason here)

Did you think the messageboard...? (Tick one box)

Made the game better	
Didn't really change the game	
Made the game worse	

How did you find out what the best engine, tyres and gear ratios were? (Tick all the boxes that apply for each)

	Engine	Tyres	Gears
Worked it out by trying them out			
I asked my team for help			
Somebody posted it on the messageboard			
I know a lot about cars already			
I looked at somebody else's screen			
I didn't find out!			

Can you remember what you thought were the best engine, tyres and gear ratios? (Please write)

Engine
Tyres
Gear ratios

If Racing Academy was finished and available in the shops, would you...? (Tick one box)

Definitely want to buy it	
Think about buying it	
Might borrow it from a friend	
Definitely not buy it	

Tell us one thing that you think would make Racing Academy a better game (Please write your comments here)

Is there anything else you would like to tell us about Racing Academy? (Please write your comments here)

Thank you! Your comments will help us to make it a better game.