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An Investigation Into The Use Of E-Learning Resources Within An Environmental Context For Schools

Andrew Lewis Stephenson

Project Supervisors: Elizabeth Burd, Malcolm Munro

MSc by Research

Durham University, School of Engineering & Computer Science

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1. Introduction

Background & Context

The premise of this study was to take a game-based learning and investigate whether pupil engagement was enhanced through an environmental context and a competitive environment. Despite game-based learning being an active research area, there appears to be a relatively slow uptake by teachers (Axe & Routledge, 2011) which perhaps gives light to a certain pragmatism amongst teachers to adopt games in education. However, credibility is given to this body of research by a number of prominent authors (Becta, 2001; Kirriemuir & McFarlane, 2003; Shaffer, Squire, Halverson & Gee, 2004). Research has shown the most effective way of integrating game-based learning is to firstly identify the pedagogy for the learning tool and then wrap this with gamified elements (Gee 2003; Gee 2004). What this study aimed to do was provide a system where pupils could learn about environmental topics through a series of educational activities during a prescribed set of trials in school but also have the opportunity to use the system as much or as little as they liked outside of school hours. In addition, this study introduced a contextualised scenario which challenged participants to make decisions based on both moral and competitive judgement in order to determine whether there was an underlying pattern of competitive behaviour or whether users were motivated by more than just winning, a suggestion made by Deen & Schouten (2011).

As a concept, gaming strategies are ways that participants utilise an educational tool to win or succeed at the game-based element without explicitly fulfilling the pedagogical purpose. Literature suggests mixed results with previous studies as to the demographic profiles of participants who employ gaming strategies and also their motivations behind those strategies (Baker et al, 2004; Baker et al, 2005). This study aimed to identify basic demographic information for participants who used gaming strategies throughout the usage of this contextual e-learning system as well as the ways in which various strategies were used.

One of the fundamental parts of this study was a feature designed to test whether participants were more likely to exhibit selfish or morally responsible behaviour when posed with a number of environmental disaster scenarios. The questions took the form of Environmental Decision Points and provided users with an environmental disaster scenario and three options carrying different points values. The decision participants had to make was whether they chose the more selfish option (and progressed further up their class league table) or whether they took the socially responsible option (where they could perhaps feel better inside but had nothing tangible to show).

Overall, this study was designed to further learning in the areas of game-based learning, contextualised learning and gaming strategies within a cohort of Primary and Secondary school pupils.

Aims & Motivations

The main aim of this study was to present research findings in the field of game-based e-Learning within the context of an environmental learning tool for schools. Whilst this study uses existing research from game-based learning, gamification and gaming strategies amongst the cohort, it applies the research to an environmental learning tool that pupils engage with.

It is expected that environmental topics will become increasingly more widespread throughout curriculum in schools in the near future as education systems change to reflect trends in wider society. In addition to collecting data on how pupils responded to an environmental learning resource, questions were posed throughout the study which aimed to gauge pupils' wider understanding of the social issues and problems that environmental topics bring with them. Understanding whether pupils' thoughts and ideas match up with their actions is clearly a very important and pertinent point and one that is discussed throughout this study.

Adopting the environment and green topics as the context for this thesis enabled research into an area that is not strictly covered by the national curriculum but one that schools proactively encourage on an extra-curricular level, as can be shown by the high uptake of Eco-Schools Awards throughout England (Eco Schools, 2011).

Aside from the investigation of contextualised learning, this study aimed to investigate how different ages and genders of pupils respond to a competitive points-based learning zone, analysing the types of gaming strategies that they use and how this correlates with existing research. As such, a primary aim of this study was to create an environment that was scalable (in terms of user progression) and also extensive enough that users had the ability to engage with the system throughout the trial period and beyond if desired.

Research Questions

This study aimed to address the following research questions:

RQ1. Can e-learning resources on environmental awareness develop participant engagement?

1.1 Do participants derive enjoyment from time or effort invested into using e-learning resources on environmental awareness?

1.2 Do participants *perceive* that they are learning within an environmental-based e-learning resource?

1.3 Can e-learning resources on environmental awareness create retention in participants?

RQ2. Can e-learning resources on environmental awareness be used to develop ethical decision making?

2.1 To what extent do male and female participants focus on selfish and ethical decision making within e-learning resources on environmental awareness?

2.2 Do participants' ethical decision making choices vary over time in e-learning resources on environmental awareness?

RQ3. Do participants exhibit gaming strategies within e-learning resources on environmental awareness?

3.1 *To what extent* do participants exhibit gaming strategies within e-learning resources on environmental awareness?

3.2 *How* are gaming strategies used within e-learning resources on environmental awareness used by participants?

Throughout this thesis, research questions will be referred to in their shortened form (eg RQ1).

Assumptions

On engagement, this study was expected to create a contextualised learning zone that pupils would return to reasonably often throughout the study. More information on the gaming strategies implemented are detailed in Chapter 3.

Within the gaming strategies research, the inclusion of three points-accumulation mechanisms allowed for competition to flourish throughout the study with the aim of generating a constant level of interaction amongst the cohort which would prolong participants' interaction with the study.

It was envisaged that the majority of pupils would choose selfish options over socially responsible options as these would allow the participant to accumulate more points and progress through the system quicker. When provided with additional information, it was estimated that a proportion of users would change their mind to the more socially responsible goal.

Thesis Overview

The structure of this thesis will take the following format:

Chapter 2: This chapter begins with a review of the literature surrounding engagement with e-Learning resources with a particular emphasis on contextual and game-based learning systems generally and then more specifically for resources aimed at primary education level.

Chapter 3: This chapter details the full technical setup of the study, including architectural and technical diagrams as well as a full table of features included in the study and how they were monitored throughout the experiment.

Chapter 4: Following the software design, a full methodology of the study is detailed, including experimental details and information on participant selection as well as ethical considerations.

Chapter 5: The results chapter reports and provides visualisation of data collected during this study and relates this back to the research questions detailed at the start of this chapter.

Chapter 6: This chapter follows on from the results by providing a general discussion of the study's results as well as a systematic analysis of the data collected for each research question. In addition to an analysis and evaluation of results, this chapter details trends, limitations and extensions for each area of research conducted in this study. The chapter concludes with a summary of technical and experimental limitations and the threats to validity of the data presented.

Chapter 7: The final chapter presents the themes apparent in this study, areas of future work to be considered as well as a summary of conclusions.

2. Literature Survey

The aim of this chapter is to provide a detailed background to educational theory and pedagogy before investigating new and innovative approaches to improving education through technology. By starting with educational principles it is envisaged that these can be related to good examples of newer educational techniques further into this chapter. After detailing the theory, assessment methods and feedback are discussed as well as how these have changed with the introduction of greater technology and collaboration amongst pupils. The main part of this chapter follows and gives details on innovative approaches to e-learning, such as serious educational games and scenario-based learning. The final part of this chapter is to detail a brief history of environmental education and how this has become more prominent throughout the past few decades.

2.1 Traditional Learning Theory

This sub-section will introduce the key areas of traditional learning theory that will be referenced throughout this thesis. There are perhaps two popular areas of thought when considering teaching and learning: 'Instructionism' and 'Constructionism'. Broadly, instructionism is defined as the method for conveying instruction from the teacher to the learner and constructionism as the mechanism that learners use to develop models and understanding of the material being taught (Papert & Harel, 1991). Instructionism was based on the development of particular skills to fit in with an industrialised economy (Papert & Harel, 1991), whereas in the 21st century, industry has moved towards a highly electronic and technological, knowledge-led economy, meaning some traditional methods of educating are less effective at developing knowledge (Papert & Harel, 1991). Constructionism investigates the way that learners 'learn to learn', which illustrates how learners interact and engage with educational artefacts to boost self-directed learning (Papert S. , 1993). Constructionism appears to fit more relevantly with the culture of learning in the 21st century by being focussed more around the development and sharing of ideas, rather than simple knowledge acquisition. With a more globalised economy, the learning environment is becoming less homogenised and includes cultural factors that can affect learners' development. Constructivism, developed by Piaget (Ackermann, 2001), is a similar school of thought to constructionism but broadly focussed on what learners are interested in and able to achieve at different stages of their development. Constructionism and constructivism both suggest that knowledge is actively constructed and that with increased exposure to the real world, learners are provided with greater opportunities to develop knowledge structures (Ackermann, 2001).

Both Piaget and Papert were deemed developmentalists, sharing the idea that knowledge is constructed. Vygotsky (1978) contributed that knowledge is most effectively constructed within a particular situation and further to this that the highest level of intellectual development is with abstract thinking. Abstract thinking is the process of conceptualising ideas and understanding that each idea can have multiple meanings. Vygotsky (1978) suggested that this form of thinking was developed through the transition of knowledge from a context-bound scenario to one that is context free. The basis of all this theory has lead many academics to research the potential for more kinaesthetic forms of education, based on Vygotsky's socio-constructionist principles as well as

Papert's constructionism. Collins & Halverson (2008) suggest schools put too much emphasis on teaching by assimilation and recommend that this focus should be shifted to more a more kinaesthetic, tactile style where learning is developed through actions. Given this recommendation, technology should perhaps be used more as a catalyst to re-discovering learners' disengagement with education (Wood, 1998), a view that is supported by HEFCE (2009). There appear to be many educationalists mentioned in this chapter that are pointing towards integrating a more constructivist approach to education in order to provide pupils with more ways to understand the knowledge that they are tasked with learning.

2.2 Tacit Knowledge

This section introduces the notion of tacit knowledge: understood to be particular knowledge that individuals may possess but that cannot reasonably be taught or transferred. Tacit knowledge introduces an area of research that defines how some pupils can adapt to newer methods of teaching in different ways and the implications this has on innovative disruptive technological solutions. Whilst the majority of literature is based around very explicit forms of learning (such as that defined by the National Curriculum), there is also a more implicit form of learning that helps to develop tacit, heuristic and associative skills (Cox, 2010). Tacit knowledge, by definition, is what learners know but find difficult to articulate (Tee & Karney, 2010). Within a similar study of virtual worlds, Fields & Kafai (2009) found that - without instruction – a group of 9-12 year old participants successfully managed to discover an inside-gaming practice with each participant either heuristically generating a way of discovering the hidden technique or by finding out through peer tuition. Further, Tee & Karney (2010) put significant emphasis on tacit knowledge creation, defining it as "critical in an educational context", although admitting that few studies have put much interest into the topic. In their study, the authors make the point that in the digital age, if your teaching is simply 'explicit' then you may end up with some form of dystopian scenario where learners simply absorb knowledge but don't understand it or have any for of critical opinion of it. Tee & Karney (2010) further suggest that tacit knowledge is what differentiates us as human beings: explicit knowledge can be learned but when this becomes widespread, tacit knowledge becomes a form of competitive advantage. By its very nature, tacit knowledge is hard to develop and measure, although can be cultivated and manifested in a shared context (Tee & Karney, 2010). Nonaka & Takeuchi (1995) brought the two theories of explicit and tacit knowledge together by defining the SECI (Socialisation, Externalisation, Combination and Internalisation) model for knowledge creation. This model defines a spiral for how knowledge is outlined, interpreted and utilised by learners. Overall, due to its implicit nature, tacit knowledge is inherently difficult to study and develop; however the implications it can have within studies can vary quite largely and the effects are far-reaching.

2.3 Learning Assessment

This section will now detail research on learning assessment and how this has diversified with the introduction of more innovative teaching practices and the move towards greater collaboration between pupils. Assessment in learning is the process of collecting evidence that show's a learner's progression (Scottish Qualifications Authority, 2008). However, Raizen et al (1989) define the aims of assessment as:

1. A helpful tool for the teacher to guide instruction and make it more effective.
2. A way of impressing learners, staff and parents about the importance of learning
3. A policy tool to monitor the outcomes of instruction and help improve future programmes.

If these three aims are related back to the original definition by the Scottish Qualifications Authority (SQA), the author focusses on one particular strand of assessment (showing progression), although there are multiple types (and reasons) for assessment not simply as a mechanism of providing early indicators for final exam grades. In a traditional environment, test-based assessment usually takes the form of paper-based examination-style tests that are understood to show a learner's knowledge of a particular topic (SQA, 2008). Top-down assessment structures have hardly deviated from the form that they were devised in during the early 20th Century. The SQA (2008) argue that both teaching and assessment should be amended to reflect more accurately the requirements of the digital, knowledge-based economy at all levels (SQA, 2008).

Oshima et al (2006) suggest that education should be heading towards a knowledge-generation environment in their study that investigated implementing the 12 determinants of knowledge building, as defined by Scardomalia (2002). Oshima et al (2006) used principles such as realisation (relating knowledge to real life scenarios), democratisation (sharing knowledge within the cohort) and collaboration (managing the views of others and then synthesising the result) to change the way that science lessons were taught to Japanese Elementary School learners. The result of this experiment was that it led to a greater level of idea-centred activity within the cohort which helped to boost knowledge construction. Whilst this example shows one study that has received positive results as a response to adjusting assessment, perhaps greater weight is given to the subject with the recent announcement by the US Department of Education (2010) said a complete upgrade to all e-assessment across a large collection of states has been initiated and will be completed by 2012. This announcement provides a clear marker in the development of more relevant assessment in education, since the e-assessment platform will be building in functionality that will provide students with realistic and complex performance tasks, give immediate feedback to participants, provide adaptive testing as well as encorporate a number of features for a range of students (US Department of Education, 2010). This switch to a more digitally-inclusive variation on assessment will potentially alleviate some of the concerns that education had become a mechanism for passing exams and fostering memorisation (SQA, 2008).

Previous attempts to digitise the process of assessment resulted in criticism, since it took the form of too closely mimicking traditional assessment. Instead of completing tests on paper, learners were simply taking the same assessments online, which lead to the same pedagogic and educational problems as before (SQA, 2008). Perhaps an early-stage demonstration of new assessment was performed by the Open University (2010) that aimed to provide increasing levels of feedback to participants of an online maths course. This study provided immediate feedback to participants through an electronic-based assessment and then took a personalised tuition approach for participants that did not achieve the correct answer immediately. From an accountability perspective, learners

received the most points per question if they were able to immediately select the correct answer, but then received reduced numbers of points with the increased levels of tuition they received from the system.

2.4 Collaborative Assessment

One of the biggest problems with 'traditional' assessment mechanisms versus newer proposed forms of collaboration is the definition of collaboration. In the earlier form, collaboration was synonymous with cheating and was punished accordingly. However, with the rise and ubiquity of Web 2.0 tools in everyday life and also increasingly in education, collaboration forms a much more accepted role in society and so arguably, assessment should adapt to reflect this (SQA, 2008). In the 21st Century, it has become the norm to take a simple knowledge-based request that a student may receive in the workplace and to type it into a search engine and then synthesise the results in order to determine the meaning of a topic. Prensky (2001) argues that this exemplifies the fundamental difference between what is required from workers in the 21st Century and what our assessment systems are still examining. The skill required to fulfil this task was not knowledge, it was the understanding and synthesis of the knowledge that led the individual to the correct answer. Oshima et al (2006) agree with this principle and suggest building assessment around knowledge-based communities using computer-suppored collaborative learning. The aim of their study was to get learners to use reciprocal activities to reflect on their understanding of a particular topic with the aim of generating more concrete knowledge.

Even with newer forms of e-assessment proposed, the aim should still be on evidence generation (Scottish Qualifications Authority, 2008), with a particular focus on creating engaging, personalised and collaboratively-produced work. Vygotsky (1978) originally defined the term "Dynamic Assessment" that showed how learners should be tested more on mental models (as SQA later proposed), rather than rote knowledge. This concept would also help in alleviate the issue identified that learners are simply taught to pass exams. Crouch & Mazur (2001) took Vygotsky's theory of dynamic assessment and implemented it over ten years with classes of undergraduate physicists in the USA. The aim of their dynamic assessment was to aid engagement and increase performance by adding in iterative levels of peer-tuition and explanation throughout lectures. Students had to take a conceptual question proposed by the instructor, formulate their individual answer within a couple of minutes, report back to the instructor before the instructor took back control of the class, initiated a discussion before allowing students to break out into groups to discuss their own answers before concluding with their own answers. The result of this process over ten years has led to year-on-year increases in performance with some years achieving up to a 25% increase in performance.

Personal instruction - a term used to define learning by oneself - can provide a mechanism for discussing ideas and thoughts about a question with a partner before learners can input their answer into the system, along with a short justification for their reasoning. Vygotsky (1978) showed that by constantly increasing the level and complexity of problems, you can keep students within their "Zone of Proximal Development", whereby students adapt their own mental models of each problem and formulate their own questions. This process was integrated

in to the study by Crouch and Mazur (2001) as a way of detecting increases in development of knowledge amongst the cohort.

2.5 Learning Feedback

The topic of feedback links on from learning assessment and how this has also changed to reflect more modern teaching practices. Several studies have investigated the use of feedback in learning, such as the differences in feedback given to male and female subjects (Dweck, Davidson, Nelson, & Enna, 1978) as well as the lack of need for external reinforcement as a pre-requisite to learning (Hilgard, 1964; Mitra, 2008). Feedback from an educational perspective helps to reinforce topics that have been studied, which in turn assists in the learning process (Fields & Kafai, 2009).

However, Hilgard (1964) argued that external reinforcement (for example, using a teacher to verify a child's learning) was not a pre-requisite for learning. This theory was also exhibited by Mitra (2008) who ran a study with rural communities in India where children taught themselves how to use the internet and learn English, simply by having a computer in a central area of their community. This example shows the power of self-learning and even within early-stage learners. Defining the boundaries of a learning experience and then allowing learners to develop their own strategies and make decisions throughout the system may lead to a liberalised learning environment but caution must exhibited: Wood (1998) commented that feedback and guidance given to learners directly shaped their behaviour and retention levels for knowledge gained through the a study.

Conversely, some cultures differentiate between effort and achievement on a task. For example, in Japan, who fare well in international educational comparisons of achievement, lower attainment is considered the result of a lack of ability, whereas in the western world it is defined as the learner having put in less effort to the task (Gardner, 1983). This point emphasises that western cultures view intelligence in terms of achievement but do not currently provide feedback to help this intelligence develop. By allowing learners to make conscious decisions within a particular context, Gardner (1983) argues that focus should be positioned more tightly on achievement and what is right and wrong within a task to emphasise success and show that it is not just effort that is required to achieve positive results.

Dweck, Davidson, Nelson, & Enna (1978) compared feedback given to boys and girls in a maths class showing the different approaches taken by the teacher for providing feedback to each gender. For boys, negative feedback focussed on the lack of effort input by the learner whereas when they succeeded in a task, emphasis was put on intellectual competence. There is little academic research on the effects of different approaches to feedback between genders, however, one study of perceptions to teacher feedback between genders within the context of a physical education class (Nicaise & Cogerino, 2006) suggested that it is very difficult to try and control the way that feedback is perceived and interpreted by different genders. The recommendation from this study was that feedback given to all participants should include positive and informational guidance and be given frequently.

Overall, this study did not provide any guidance on practice but in fact concurred with a much earlier book reviewing a number of American studies on gender feedback by Doyle & Good (1982, p. 173) where the authors concluded: "These results leave us in a muddle. Teachers do treat girls and boys differently, but the extensiveness of this differential treatment, whether it is perceived by students, and how it might affect their sex role behavior [sic] and attitudes is unknown." Doyle & Good (1982) advocated the use of frequent and positive feedback in helping to nurture more positive results. This idea corroborates with an Open University (2010) study into using technology to provide increasing levels of feedback in assistance with solving maths problems. In addition, simply providing positive feedback does not provide the learner with guidance on what they could improve on, so perhaps what the study meant was that feedback should always be presented in a way that so that the learner understands how they can improve.

The literature studied suggests a mix of responses to feedback in education with the main argument being that feedback provided to learners should be frequent (or perhaps gradual) and informational; allowing participants to judge their progress but also to provide them with advice on how to advance.

2.6 The Changing Needs & Expectations of Learners

As technology develops and new research is conducted, new methods of teaching arise but at the same time external factors can affect the educational expectations of learners. This section investigates the way that educational theory has developed and how learners' expectations and needs have changed accordingly. One of constructionist theories is that learning in the 21st century is much more about experience and the development and sharing of ideas, rather than the simple acquisition of knowledge (Ackermann, 2001). Papert (1993; 1994) developed a new approach to teaching mathematics by contextualising theory with a set of students by letting them program machines using the LOGO programming language. This study was met with mixed responses with one of the underlying problems being the concept behind the study - changing the way that teachers teach - is more of a cultural change than a practical one and this proved much more difficult than envisaged. Another criticism at the time was from those who argued that learners need much more support and guidance when using this form of learning than in the traditional form for it to be a success (Hoyles & Sutherland, 1989). Perhaps more abstractly, many neo-Piagetian theorists suggest a greater emphasis should be put on socio-cultural aspects of teaching (exemplified by Papert) as these are more likely to lead to more practical skill development. Vygotsky (1978) and Wenger (1998) both concur on the importance of social, cultural and historical components in education. In addition, Wood (1998) commented that the problem with learners' disillusionment in schools is due to its lack of relevance and value to the child's everyday life outside of the classroom. This point subsequently gives weight to the idea that education should be more closely tied to real-world contexts in order to provide students with a purpose behind their study. This argument is shared by educational technology practitioners (Siemens & Tittenberger, 2009) who advocate, "[to] use what they use [to teach]" and provides examples in the form of wikis, social networking sites and iPods. The problem here is that just simply using a new technology because learners are using it is not likely to be successful, since in most situations the learning goals will not have been completely thought through. In addition, there is conflicting evidence as to whether this

statement is shared across a variety of contexts as Higginson (2009) reported that a cohort of 16-19 year olds in further education were unable and unwilling to use technologies that they perceived as personal social spaces for their academic work. This perceived risk of adding new technology in education is shared by Manches et al (2010) who conclude that adopting radical new technology requires significant encouragement for school leaders. Similarly, Preskett (2010) presses the idea further by challenging that it is not simply a case of using the latest technology but using that technology to inform good learning design; therefore suggesting that starting out with a medium in mind is a dangerous option, as it can determine the way that you teach. These three studies provide conflicting reports in similar contexts so perhaps the conclusion for this study is to aim to generate some form of social, collaborative space without being tied to an existing one that learners may use in their private time and not to think immediately of an existing tool to base the study on but rather to investigate what the pedagogical aims are and then develop a tool around those.

Another theme amongst the two studies (Higginson, 2009; Siemens & Tittenberger, 2009) suggests that the best advice may be to realise that not every use of technology will result in gains to education but the concepts behind the individual uses of technology (such as a particular social networking site or the use of a wiki) are the most useful for studying to discover what it is that best aids learners' progression. Laurillard (2009) researched this concept in detail, commenting on the importance of online collaboration within education but criticising the method of delivery of e-learning by suggesting that online collaboration tools are seldom designed specifically for the educational sector. To make digital tools more effective, Laurillard said that tools should be designed for educational requirements rather than trying to tailor existing products to educational goals. For example, wikis combine Piaget's cognitive theory (Piaget, 1977) with Luhmann's theory of social systems (Luhmann, 1995) but whilst there is research to suggest that wikis are useful at enhancing individual knowledge – which can in turn assist in the development of greater collaboration - there is little known about the relative advantages of that specific technology.

Throughout the nineties and the start of the noughties, a large emphasis was put on providing greater and more ubiquitous technological solutions to schools throughout the UK (Arnott, 2004). This change, along with the rising popularity of the internet, has led to the development of a new style of learning and education within a more collaborative context (HEFCE, 2009). However, there is a certain degree of criticism that the use of superfluous technology is not helpful both from the educational perspective but also from the wider implications of learners' views and perceptions of technology (Rees & Metcalfe, 2009). The result of not using technology effectively can lead to longer-term perceptions of the use of technology and perhaps even lower motivations towards new initiatives (Rees & Metcalfe, 2009). Arguably, the use of VLEs (Virtual Learning Environments) to enhance education is an example of this issue with Siemens & Tittenberger (2009) commenting that the majority of technology in education is used for logistical processes, rather than pedagogical change. One further criticism comes from a technological infrastructure perspective with the integration of interactive whiteboards into schools throughout the UK: Smith et al (2005) suggest that the technology was integrated into classrooms before content could be developed, leading to a state where lessons were simply continuing as before but with the aid of

more technology. It appears that successful integration of technology for an educational gain is most likely to be realised when the pedagogical goals are used to define the technological requirements and these are tightly linked throughout the entirety of the project.

2.7 New Approaches to e-Learning

E-Learning is inherently a fast-moving area: technological advances in both software and hardware are allowing disruptive technologies to be developed that change the ways that educational content is delivered as well as the types of content that are taught. Section 2.7 aims to investigate ways that technology can improve e-learning based on the changing needs and expectations defined in Section 2.6. Higher Education Funding Council for England (HEFCE 2009) acknowledges that technology has a fundamental role in Higher Education and this view is shared by Siemens & Tittenberger (2009). One problem with much of technology in education in primary and secondary school level is that it is used to replace logistical processes (Siemens & Tittenberger, 2009), whereas the real value – as per the HEFCE (2009) report - is in enhancement and transformation of education. Enhancement encompasses how we can improve on current practices and transformation defines disruptive solutions that will result in a positive change to learners or in new processes being developed. It appears there may be a gap for educational practitioners to investigate enhancing and transformative solutions for education, based around sound pedagogic principles (Laurillard, 2009); examples of this kind of solution reside with approaches, such as serious educational games, scenario, and virtual world-based learning.

2.7.1 Serious Educational Games

Research based on this topic is quite extensive and spans a number of topics relevant to this study, such as the use of contextualised gaming and game-based learning. Despite quite an active research area, there appears to be a relatively slow uptake by teachers (Axe & Routledge, 2011) which perhaps gives light to a certain pragmatism amongst teachers to adopt games in education. Ofcom (2008) reported that the ubiquity of traditional video games in young people's lives was fundamentally extensive: 87% of 8-11's and 88% of 12-15's regularly playing console-based games at home, showing that it is certainly not an unfamiliar area for this age group. Credibility is given to this body of research by a number of prominent authors (Becta, 2001; Kirriemuir & McFarlane, 2003; Shaffer, Squire, Halverson & Gee, 2004) and research shows that serious games are useful in developing an array of different skills from increasing motivations to learn to developing engagement in topics to promoting competition amongst cohorts (Axe & Routledge, 2011). Interest in this research area is wider than simply academia as the BBC (British Broadcasting Corporation) was awarded £350m in 2005 to invest in the next generation of game-based learning resources (Prensky, 2005).

More generally, there is evidence to suggest that video games can provide added benefits outside of their traditional realm (Axe & Routledge, 2011); this comes in the form of qualitative and quantitative research. This research focusses on the wider, more tacit skills development that can be inferred through video game techniques, such as parallel processing, determination of relevance and non-linear exploration (Jenkins, Purushotma, Clinton et al, 2006). In addition, the integration of progressive feedback, integration of content for

different learning styles, and the ability to embed social features can lead to the development of an extensive learning platform. However, there are also a number of counter-claims that any benefits gained through use of educational games may not be long-term and actually motivations to learn through games are generally short-lived (Arnold, 1976; Lepper, Corpus & Iyengar, 2005). Other research suggests that when you introduce a points-based competitive game, some pupils may be motivated more towards points accumulation than the real learning goal (Deen & Schouten, 2011).

The success of any serious educational game, it seems, relies on how strong pedagogical principles are applied to the game-based medium as it is not as simple as creating a game and watching pupil engagement and learning levels increase (Gee 2003; Gee 2004). In terms of pedagogy, the traditional method of teaching will involve the introduction of a subject followed by a method of practice that allows pupils the ability to understand and apply the knowledge they have learnt. These mechanisms, such as quizzes, competitions or verbal examinations (Chen & Michael, 2005) use iterative development to allow pupils to develop new knowledge. Assessment is a difficult point for serious educational games; traditionally software used multiple-choice assessment mechanisms to judge achievement as this is straight forward and efficient from a computational perspective (Chen & Michael, 2005). However, this form of assessment has the possibility of leading to a scenario where pupils simply memorise answers in order to progress through the game, which has a limited educational effect. New forms of assessment are beginning to develop including constant assessment - where pupils are tested throughout a school year - through a variety of methods as proposed by Vygotsky (1978). This idea is extended by Chen & Michael (2005) in their overview of assessment in serious games: by using in-process assessment, pupils' decisions and interactions are monitored throughout the use of a serious game and accumulated with the results from activity scores within the game itself to build up a better overview of pupils' progress.

Pupils' expectations have changed quite dramatically in a generation due to the rapid increase in technology, from the introduction of digital media content to new and innovative ways of accessing information. Pupils now have the ability to be constantly engaged in their learning environments, but this engagement is spread across an array of different devices and areas (Prensky, 2005). Therefore, it is not necessarily the answer to say that games can engage pupils in learning but rather games that are based on pedagogical foundations and integrate good gaming principles that can help to progressively enhance and maintain pupil engagement in a topic. The expectations of pupils has also changed as a result of such a ubiquity of video games in many aspects of their lives, which has led to the development of a set of expectations that games should conform to, such as interaction, customisation and well-ordered problems (Gee, 2005b). Non-conformation to these expectations could easily result in an unsuccessful game-based learning tool. The ubiquity of games and video-game principles are becoming ever-apparent in schools but also in life more generally when the idea of studying a particular subject and then sitting an exam to achieve a grade is metaphorically compared to the idea of completing a number of problems to progress to the next area of the game (Gee, 2005b).

Gee (2003, 2004, 2005a, 2005b) delivered a set of 16 principles for creating games that can be used as the premise for serious educational games, including concepts such as the ability to identify, interact, customise and progress through a game to maintain user engagement. However, the motivation for using game-based learning principles in relation to serious educational games should not be that using games in schools will be a silver bullet to success but more that translating these engaging principles into educational systems will allow the ability to create greater enjoyment and stimulate greater learning (Gee, 2005b).

2.7.2 Gaming the System

Gaming the system is an area of research that has developed throughout the noughties based around participants exploiting aspects of educational systems rather than following the prescribed path of instructions to complete an activity (Ryan et al, 2006). Overall, the approach of 'gaming' a system is generally related to lower attainment levels and lower prior knowledge of a system (Baker et al, 2004; Baker et al, 2005), under the premise that 'if you can, do; if you can't, cheat'. However, Baker et al (2004) point out that some participants with lower pre-test scores in their study who didn't cheat, actually improved their scores throughout the study and so it is not clear what specific characteristics are required for a participant to 'game' a system. There are also other reasons proposed for the use of gaming in a study, such as the dislike of the study or a dislike of computers more generally (Baker et al, 2005).

Whilst a lot of research has been conducted on trying to prevent participants from using gaming strategies in experiments, little research has analysed participants' manipulation of a system and the decisions they make throughout the study to utilise certain aspects of a system to their own advantage, be that performance goals or otherwise. This ties into the idea of in-process assessment (Chen & Michael, 2005) where participants' decisions throughout the use of a serious educational game are assessed to build up a broader understanding of the mindset taken by the participant.

2.7.3 Scenario-based Learning

Scenario-based e-Learning is a relatively new concept and is based on creating an immersive and contextualised tool for learners to use to more fully understand a concept or subject area (Kindley, 2002). Situating knowledge or contextualising learning (as defined in Section 2.1) stems from two traditional schools of thought on learning: situated cognition (Lave, 1998; Lave & Wenger, 1991) and constructivism (Piaget, 1977). Compared to more traditional forms of learning, scenario-based learning immerses learners in a situation within which they are forced to react to their surroundings and adjust their behaviour to improve their performance (Kindley, 2002). Learning within this field appears to be much more of an iterative process for the learner where feedback is integrated into new actions and responses to the scenario. This view is shared by Wideman et al (2007) that concluded that learning through serious educational games is a largely iterative process where pupils use a 'trial-and-error' approach to understand the process of the game and then use it to their advantage.

During the late nineties and early noughties, there was a shift away from more static e-learning activities that simply present question and answer style actions to more fluid forms of ‘dynamic’ learning (Kindley, 2002). This idea is also shared by Gee (2005b) and Gardner (1991) who conclude that learning is a multi-faceted process: pupils have to learn the facts and then apply them in a particular context. A lack of pupil motivation in traditional e-learning resources may stem from a detachment from the material upon which pupils are learning - for example, if topics are not in context they become ultimately much harder to relate in to real world scenarios that learners can identify with (Lave, 1998).

Brown et al (1989) argue quite vociferously that by ignoring the situated nature of cognition, education fails to deliver on its key objective: providing usable and robust knowledge. On the other hand, scenario-based learning embeds knowledge into an activity whilst also integrating social and wider skills into the learning process. These social skills are much harder to integrate into traditional learning activities but are highly sought after in later life (Kindley, 2002). Developing learners’ needs with wider and social skills is an emphasis being implemented as part of a larger Personalised Learning agenda proposed by the Department of Children, Schools & Families (2008): here, the strategy is to develop learners to be knowledgeable about non-curriculum topics, such as being healthy and making a positive contribution to society. Akins & Crichton (2003) also agree that this type of learning is useful for developing wider skills: through peer collaboration and using tools in an authentic environment, learners are able to situate learning and develop personal meaning from the situation.

Compared to traditional learning, scenario-based learning fundamentally shifts the focus of the approach from an object or subject to the learner’s behaviour and similarly there are no static objectives of the task, instead these are dynamic and formed throughout the study, depending on decisions that participants take within the scenario (Kindley, 2002). Scenario-based learning adopts a much more kinaesthetic nature compared to other e-learning activities and this could potentially be the answer to the issues raised by a number of authors (SQA, 2008; Collins & Halverson, 2008) about the lack of relevance of traditional teaching methods in the digital economy. Scenario-based learning allows learners to engage in non-linear activities and become actively involved simultaneously in multiple activities, moving back and forth to complete tasks and generate a greater depth of meaning, which can lead to the development of multiple intelligences - a theory that suggests that there are different levels of intelligence - (Akins & Crichton, 2003). Scenario-based e-learning is still relatively low key in the research community with only a few papers written about it, such as one study by Katz and Lesgold (1993) that investigated the use of ‘authentic’ problem solving ability by simulating learning tasks and getting learners to run through the simulation to see what happens. This kind of ‘hands-on’ approach uses the power of computers to simulate a task and provide a better representation to learners whilst still preserving the educational process. The Open University (2010) proposed an increasing-support mechanism where learners received more support (and less credit) with increasing attempts of a particular question, thus bringing together an educationally-rich cognitive task with an innovative and automated support mechanism.

Other research suggests that bringing knowledge together within a particular context or scenario helps learners to understand that knowledge in a more practical setting (Wood, 1998). Based on the concept of this research, Siemens and Tittenberger (2009) advocate more emphasis should be put on teaching learners within the bounds of a particular scenario with the aim of boosting knowledge retention. Kindley (2002) suggests that scenario-based e-learning works best when integrated into a blended environment (a learning environment that delivers content through a variety of methods) with other learning solutions but stresses the importance of planning objectives of a study carefully for it to be a success. This last point is echoed by Akins & Crichton (2003) who caution that the creation of a successful scenario is not easy: in order for a scenario to be authentic, it needs to be as realistic as possible.

Further to working well in a blended environment, scenario-based e-learning can be particularly good at influencing behavioural change (Kindley, 2002). However, there is currently little research available on the successful implementation of behavioural change: one study (although based in a separate context), concluded that participants who were looking to reduce their smoking, drinking or poor food habits had to be in the position where they were 'ready for change' before effective behavioural change could happen (Rollnick, Kinnersley, & Stott, 1993).

Hartley et al (2010) investigated the use of scenario-based learning as part of a study into enhancing learner progression in a personalised learning environment and found that digital story telling – a concept where a class of learners create a short story based on the taught topic – could be used as a slightly more effective form of scenario-based learning.

2.7.4 Virtual World-Based Learning

Siemens & Tittenberger (2009) describe the distinction between game and virtual-world learning with the concept that virtual worlds are more immersive and can be used for a variety of situational tasks or activities, such as simulating real experiences and studying social behaviour. Games on the other hand generally involve the achievement of a particular goal. Virtual worlds, such as World of Warcraft and Second Life, are more diverse than games since the majority of the content is user-generated (Fields & Kafai, 2009), although despite this there is a whole wealth on research of virtual worlds across the academic spectrum from medical studies (Boulos, Hetherington, & Wheeler, 2007) to Newtonian mechanics (Dede, Salzman, & Loftin, 1996). However, despite such an eclectic mix of research areas, there is relatively little literature about the way that children form social relationships whilst in virtual worlds (Goodwin, 2006); Fields & Kafai (2009) investigated knowledge sharing within a 'tween' virtual world but came to an open conclusion about a variety of ways that their participants developed in-game knowledge including actual communication across the room where the study was being conducted. Fields & Kafai (2009) also suggested that online games do not provide the structured activities that are required within an educational context.

Many studies show how popular and engaging virtual worlds can be (Ke, 2008; Manches, Phillips, Crook, Chowcat, & Sharples, 2010), however, most do not investigate how these can be used effectively in an educational context. Bainbridge (2007) suggests that much more emphasis should be put on researching virtual worlds from a children's behavioural and situational experience perspective but there are, however, extensive ethical considerations for virtual worlds, as were highlighted at an ethics conference by the Technology Enhanced Learning Research Group (2010) in Second Life itself. Some of the main ethical challenges to virtual worlds were how participants (especially children) would be affected when access to the world would react it closed at the end of the experiment as well as whether ethical procedures implemented to safeguard vulnerable people actually fulfil their aim or whether they are simply in place to protect institutions. Overall, virtual worlds do not really provide a great deal of relevance to this study apart from some of the methods of data collection or the research methods used to elicit data.

Game-based learning, however, can provide a useful platform for computer-supported collaborative learning due to features such as cross-functional teams or peer-to-peer learning (Steinkuehler & Chmiel, 2006; Nardi & Harris, 2007). In addition, Ke (2008) found that game-based learning was the most effective way of producing positive attitudes towards maths; whilst not being quite as extensive as virtual worlds, the controlled nature of game-based learning adds in an advantage and could form a pillar of this study with the emphasis on driving motivation and engagement with the educational material, which is a concept mentioned by Vogel et al (2006). There is some evidence to suggest that teachers are requesting simpler versions of 'edutainment' games due to the lower computational requirements needed to run them, although this is contradicted by Gee & Hayes (2009) who stress the importance of games in learning due to the increasingly complex nature of them comparatively throughout their history, citing that some games these days require users to keep track of multiple goals and sub-goals, which the authors relate to developing more advanced cognitive structures. As may be expected with a slightly imbalanced gaming industry, there is some research to suggest gender-imbalances within game-based learning activities as well; one study by Ke (2008) concluded that this was due to weak female characters within the games themselves although other studies have shown that more neutral virtual mentors are successful at generating higher satisfaction and higher marks (Zhang, 2004).

From an academic research perspective, Ke (2008) reviewed differing strategies for game-based learning and concluded that goals structures could be co-operative, competitive or individualistic. Johnson & Johnson (1996) suggest that cooperation is considerably more effective in promoting achievement and retention within game-based studies with Ke (2008) adding that cooperative learning is useful since it puts cognitive structures within the bounds of a social context.

2.7.5 Personalised Learning

Personalised Learning, as defined by the Department for Education & Skills (2007) is:

> "Taking a highly structured and responsive approach to each child's and young person's learning, in order that all are able to progress, achieve and participate. It means strengthening the link between learning and teaching by engaging pupils – and their parents – as partners in learning."

This definition puts an emphasis on increasing the levels of engagement that learners have with education; a view shared by other authors and practitioners (Teachers Magazine, 2010) in addition to trying to tie in additional stakeholders into the educational experience. Other definitions of personalised learning include themes such as the promotion of inclusionism (Teachers Magazine, 2010) and the development of wider skills useful in later life (Higginson, 2009). Inclusionism aims to create more open tasks that can be used in education that do not differentiate learners on their ability, but rather tailor content to the level of the individual whilst providing support and feedback that again is personal to each learner (Teachers Magazine, 2010). Personalised instruction has been shown to increase performances in multiple studies (Kulik, Kulik, & Cohen, 1980) and also to extend the range and capacity of learners (Deartment of Children, Schools & Families, 2008). In terms of developing the potential of learners, guidance suggests that there should be challenging personal targets, rapid intervention and rigorous assessment to ensure continual development of individuals (Department of Children, Schools & Families, 2008). Collins & Halverson (2008) agree that personalised learning should be used to drive empowerment in learners so that they are enthused to find their own path of educational interest whilst being guided through the core curriculum material by a teacher or learning resource. The idea of empowerment is also shared by Higginson (2009) where the direction of learners was devolved from the teacher and technology was used as a facilitator to engagement in learning. Higginson's study discussed the use of this technology and recommended it could be useful as part of a distance learning course, although there is arguably no reason why it should solely be confined to this context and would be intriguing to investigate its use in a classroom situation. Higginson (2009) also uses the study to focus on the use of Web 2.0 tools such as wikis and blogs to develop a more personalised learning environment which may well be useful on a distance learning course but not in other contexts where the potential creative use of technology could potentially dramatically increase engagement and development of learners.

One of the key challenges with personalised learning is finding a way to cover every student's educational needs at the same time (Department of Children, Schools & Families, 2008) although technology could be used effectively to alleviate this issue. For example, the use of feedback in e-learning activities has significantly enhanced the traditional equivalent by being delivered to learners much faster (Gibbs & Simpson, 2004; Scottish Qualifications Authority, 2008) but feedback could also be developed to be much more personal, whereby learners benefited from bespoke tuition, thus allowing the teachers to spend more time with those individuals who are struggling.

Overall, there is a broad and strong support for the development of a more personalised curriculum for learners with the aim of tailoring content to a way that is individual to the learner. It appears that technology could potentially be a strong catalyst for this development but that current studies are focussing on rather simple, early-

stage research into this concept, As technology develops and becomes cheaper, there could be a shift towards the development of technology that greater exploits the personalised learning agenda.

Section 2.7 has summarised the literature on several new areas of educational technology and the ways in which these are transforming the content and delivery of educational material. One of the main points was the move towards more games and creative content being introduced into the educational arena as well as the acceptance and understanding of multiple learning styles and how these can be managed to ensure pupils receive a much more relevant educational experience.

2.8 Engagement in Technology

Many of the new methods generated in response from the changing needs and expectations of learnings put a large emphasis on engagement, facilitated through the technology upon which the method of learning was delivered. This section will investigate research based on how technology can build in engagement and how this can be used to an educational advantage. From HEFCE's perspective (2009), the focus of technology in education should be firmly on driving engagement in social learning and knowledge collaboration. This idea is broadly supported by the research: Siemens & Tittenberger (2009) concluded that higher engagement and motivation leads to higher attainment levels within students, as well as Collins & Halverson (2008) who argue that technology should focus students' learning around their goals and interests. By providing more personalised learning, students are able to find their own path through the educational and curriculum content that leads to a greater degree of engagement with the learning process and potentially higher attainment. However, there is some research that suggests that learners are not as homogenous as other studies suggest (Higginson, 2009). This provides a diversion from the majority of literature that shows methods of increasing whole class engagement and investigates reasons why certain learners may become more engaged than others. Higginson's study (2009) developed a topology of learners that classified different kinds of background that learners had, from the 'Digitally Reluctant' to the 'Digitally Experienced'. In addition to the topology of learners, Higginson (2009) identified a number of gatekeepers to successful integration of technology in an engaging way, the most significant of which was how the training of staff can play a central role in defining the success of a study for their learners. This point was raised by a number of other studies, such as Smith et al (2005) with their work on interactive whiteboards in education; concluding that, "teachers' inexperience in setting up equipment and in manipulating features on the [white]board lead to lesson disruption." Also, HEFCE (2009) reported that knowledge collaboration and engagement in social learning were real possibilities, but only if staff had adequate support to exploit these opportunities effectively. The report continues to add that technology is best placed in a supportive role and staff often require strong pedagogical skills to integrate general technology into useful services for learners.

2.9 Environmental Education

The final section within this chapter investigates how environmental education has evolved over the past decades as environmental topics have become more main stream. As an educational topic, the environment provides a

useful context for a number of educational activities despite not directly featuring in the National Curriculum. Environmental education was first established by Stapp et al (1969) but did not significantly take off during the 1970s as it wasn't considered to be a new concept but more a collection of topics, such as outdoor education and environmental studies, using 'the environment' as a centrepiece (Tilbury, 1995). During the 1970s and 1980s it was argued that environmental education failed to really identify its identity (Gayford, 1990/91) and subsequently was not adopted into mainstream education policy until the 1990s when it started generating significant traction (Tilbury, 1995). Stapp et al (1969) suggest that during the rise in prominence of environmental education was due (initially) to the rapid urbanisation and globalisation of the world, although throughout the same period much research has been conducted and reported in the media on the rising problem and associated debate around climate change in general. Tilbury (1995) argues that the focus has changed more towards sustainability from the roots of the topic that Stapp et al formalised in the 60s and that now there is widespread recognition that the topic of environmental education should focus more tightly around the longer-term aspects and implications of climate change on the planet (Tilbury, 1995). Several international organisations have highlighted the need for change towards greater sustainability and acknowledge the role that education has to feature in this process (UNESCO, 1986; IUCN/UNEP/WWF, 1991); Tilbury (1995) stresses the importance of schools in this process by advocating sustainability be integrated into more mainstream, formal education, rather than simply being a topic on the periphery of the curriculum. Tilbury (1995) continues that environmental education should take an holistic approach since it encompasses a much broader array of topics that simply physical and biodiversity issues, dealing directly with political, socio-economic and cultural issues across the world.

UNESCO (1986) suggested that research into links between environmental knowledge and values in broad demographics of the population show little correlation between knowledge and actions, meaning that there was *a "laissez faire"* attitude with people, where they know about the problems with the environment and even what they could do to help alleviate some of the dangers, but choose not to. This response was also shown by Hillcoat et al (1995) who showed that Australian teenagers had a good understanding of the local and global issues relating to the environment but seldom took any positive actions due to (what they saw as) a lack of significant changes they could make to their lives that would lead to a significant improvement of the global problem. This response was in stark contrast to the general views from the cohort that suggested the teenagers felt cynicism, frustration and powerless that their demographic were seldom chosen for studies into this area (Hillcoat, Forge, Fien, & Baker, 1995). To try and alleviate this problem, UNESCO (1986) published advice for teachers that suggested taking a more neutral role when educating about environmental and sustainability topics by trying to promote more socially desirable values relating to environmental topics, much like in gender and race equality. Gayford (1990/91) extended this idea by suggesting that teachers should completely avoid any form of indoctrination for when teaching about the environment. Instead of dictation, Tilbury (1995) suggests that teachers should seek to allow individuals to commit themselves to more social or collaborative learning style in the interests of equality, equity and sustainability.

Relating back to the Australian study by Hillcoat et al (1995) on teenage perceptions of the environment across a number of schools in Brisbane and Melbourne, some responses suggested there was a general recognition that environmental-related problems were likely to get worse in the future but also a general lack of motivation to turn thoughts into actions. In addition, students from inner-city schools broadly had a much more global view of environmental matters than those who attended suburban schools and who perhaps lived in more rural areas around Brisbane and Melbourne.

2.10 Literature Summary

This chapter has detailed a roadmap from early-stage educational learning theory through to the changing needs and expectations of learners in the twenty first century. Perhaps the main point is that e-learning tools are adapting to put greater emphasis on engagement with the learner in order to maintain their interest and also compete with the kinds of tools that learners are increasingly using outside of the classroom, such as social networks and content delivery networks. With the move towards greater technology in education and more e-learning resources being developed, the fundamental need to integrate solid pedagogical principles is paramount if learners are to benefit from newer disruptive technologies.

3. Software Design

This chapter details the technical details of how this study's software was architected, designed and delivered in order to meet the academic requirements of the study.

3.1 Outline of Solution

This study used an interactive online website called *Raise A Tree* (http://www.raiseatree.co.uk) as a facilitator to provide an online environment for monitoring pupil engagement, interaction and gaming strategies within a contextual virtual world. *Raise A Tree* provided a mix of social networking-style functionality and virtual world context to provide participants with the opportunity to discover and explore throughout the trial.

Participants were selected from a number of local schools to participate in the study during school hours as well as any additional time they had at home. School trials were always conducted in computer suites where each participant had their own computer. Within the study's four schools, three were primary schools and one was a secondary school. In total, 113 pupils participated in the study and these were split across three year groups (Years 5-7). More detail on the environmental and experimental conditions is given in Chapter 4.

Educational games are seldom played outside of the school time due to the fact that they lack the engagement of other games (Leddo, 1996) but this study was designed to embody as many good game principles (Gee, 2003, 2004, 2005) as possible to enhance engagement outside of trials as much as possible.

Participants were tasked with planting and raising virtual trees online over the study period. They could help their trees to grow by watering them online and successfully answering educational activities that were based around environmental topics.

One of this study's aims was to promote competition between the cohort in order to analyse competitive behaviour and gaming strategies that were developed by participants within a contextual learning resource. 'Gaming strategies' were defined as actions or traits that participants exhibited during the trials that formed some form of logical process towards winning in a points-based environment. In addition to gaming strategies, research into motivations and opinions of serious educational games and gamification will help to assess whether existing research is still relevant in an increasingly adaptable e-learning space. Gee (2003, 2004, 2005a) showed that by integrating aspects of risk-taking into serious educational games, players are encouraged to push the barriers of their comfort zones and discover new areas of the game as well as to manipulate aspects of their game for their own purposes.

Throughout the site, pupils received regular and informed feedback from which questions they answered correctly to how their tree had reacted to the level of water given to it by the user. Feedback is considered a

fundamental part of the learning process but also acts as a motivational and instructional factor that is well-ground in research (Blumenfeld et al, 1991; Pintrich & Schunk, 1996).

Environmental Decision Points - questions that disrupted the flow of the website's usage during trials - were integrated to challenge participants with environmental and social issues to understand motivations and reactions to global issues. These points aimed to break up point accumulation strategies to determine whether participants were simply motivated by winning or whether their conscience played a part in their overall gaming strategy. In addition, the motivations for this feature were as a result of the criticism of traditional assessment mechanisms in traditional game-based learning being simply multiple-choice. Instead, by integrating a mixed assessment approach - where a participant is assessed against a number of different types of learning activities - as defined by Chen & Michael (2005), the study aimed to build a more detailed overview of participants' motivations and decisions. Research on participants' conformation to social norms was conducted by challenging answers that were given and recording the extent to which participants changed their minds.

Finally, this study aimed to gauge an understanding of the environmental awareness and consciousness of the participants through a number of measures including questionnaires and behaviour exhibited on the website as well as decisions made throughout the trials.

3.2 System Architecture

Advances in web-based technologies and the ubiquitous nature of computer suites throughout schools defined that it would be sensible to develop *Raise A Tree* to be run over the internet. One of the comparisons for data as mentioned in the Experimental Setup was the ability to compare usage of *Raise A Tree* between trials and non-trial periods (for example, usage at home or during break times). To facilitate this usage, it was decided that the solution needed to be portable, universally accessible as well as be quick and easy to setup. In addition, lab-based experiments generally do not provide sufficient time for participants to build emotional bonds (Gee, 2005b), so by being able to access *Raise A Tree* outside of trial time, this problem was alleviated. Websites fulfil all of this criteria and whilst they may not have the full and advanced capability of desktop programs, the most important factor was the ease of which pupils could access the product, which is why *Raise A Tree* was developed to run via the internet.

Raise A Tree took the form of a client/server architectural model with all data being stored in a central database server. Centralising the data store provided easy access to create the social networking-style functionality of the site for the participants as well as creating an easy access model from which data analysis could be conducted after the study had concluded.

3.2.1 Database Design

Raise A Tree was designed using a relational MySQL database hosted on the same server as the main website for fast access. Figure 3.1 details an entity-relationship diagram for the site.

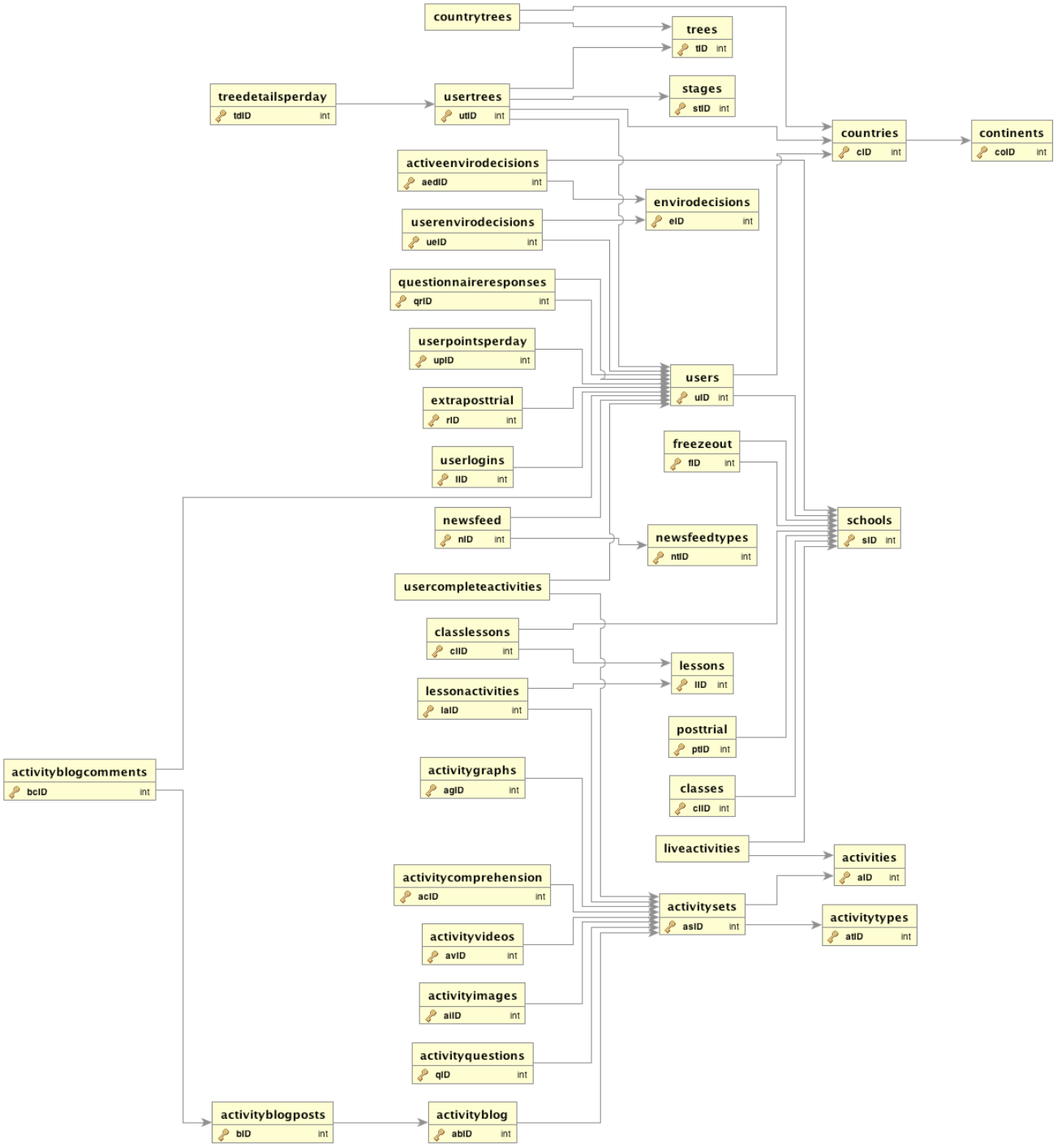


Figure 3.1 - Raise A Tree's entity relationship diagram showing the site's database design

The main entities in the database were 'users', 'usertrees' and 'treedetailsperday' which defined each of the participants, their virtual trees and the key statistics recorded each day for each of their virtual trees. The relationship between users, virtual trees and statistics is represented in Figure 3.2:

Figure 3.2 - The relationship between users, their virtual trees and the statistics recorded each day.

Educational activities (topics) contained a number of activity sets which in turn contained a number of questions. Participants could complete each activity set up to five times everyday and every time they started the activity, a random set of 10 questions would be generated from the database. In addition, the entity 'usercompleteactivities' documented all participant activity attempts, including the score for the activity and the date and time of completion.

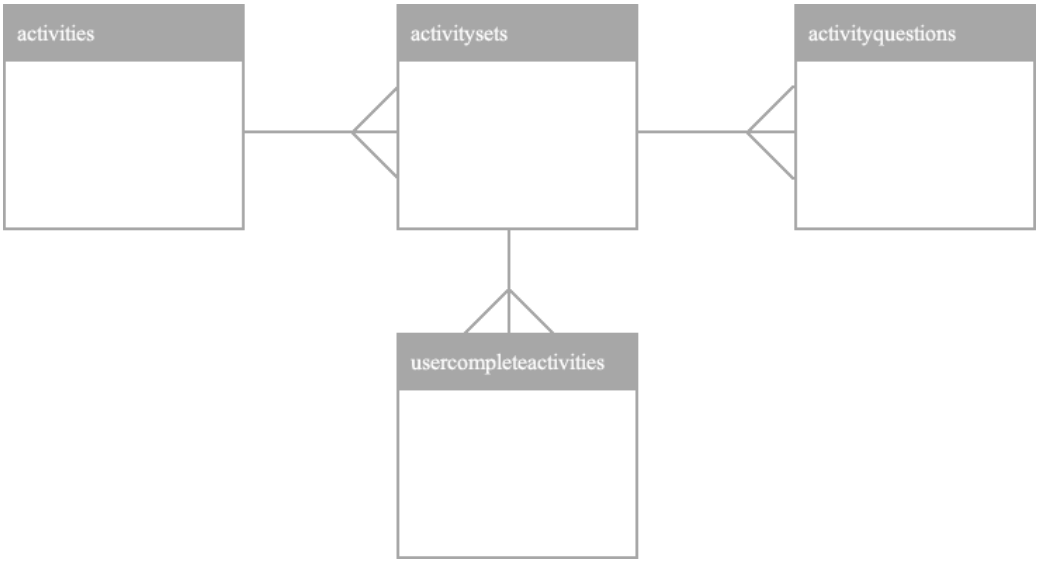


Figure 3.3 - The relationship between activity topics, activities and questions randomly selected.

In addition to all activity attempts being recorded in the 'usercompleteactivities' table, every action and link that a participant conducted throughout the trial was recorded and logged in a separate database for analysis of trends and evaluation of routes participants took outside of the trials. Information logged in the database included the participant's unique id, the action they took as well as the date and time stamp.

For example, a selection of log records are displayed in Table 3.1 to show the types of data collected through the logging mechanism:

Table 3.1 - A set of example logs collected throughout the study

User ID	Action	Date/Time
123	User logged into the website	2012-01-01 10:15:32
123	User viewed the My Tree Dashboard	2012-01-01 10:15:32
123	User viewed the Virtual Watering Can	2012-01-01 10:15:33
123	User selected to water their tree (usertreeID: 123) with 0.5 litres of water (health of tree reduced by 5%)	2012-01-01 10:15:34
123	User viewed the My Activities	2012-01-01 10:15:35
123	User viewed all activities in the 'Habitats' section	2012-01-01 10:15:36
123	User started the 'Why Birds Live In Trees' quiz	2012-01-01 10:15:37
123	User completed the 'Why Birds Live In Trees' quiz and scored 50%	2012-01-01 10:15:38
123	User planted a new Oak tree (id: 789) in South Africa	2012-01-01 10:15:39
123	User was shown Environmental Decision Point (id: 4)	2012-01-01 10:15:40
123	User chose option 2 for Environmental Decision Point 4	2012-01-01 10:15:41
123	User decided to change their mind to option 1 for Environmental Decision Point 4	2012-01-01 10:15:42

The purpose of adding an in-depth monitoring and logging system with contextual information was so that the routes and decisions that each participant made throughout their usage of Raise A Tree in and outside of the formal trials could be mapped back during the analysis stages.

3.3 Development Processes

Raise A Tree was developed using a combination of agile development methods in order to provide incremental development and testing of the system alongside frequent integration of new feature ideas from participants. On the outset, functionality was defined for the two-stage development of this study (as is detailed in the Trial Plan below). This functionality included the core set of features that were required to facilitate *Raise A Tree* as a vehicle for testing the research questions defined in this study. These features were designed and implemented using an iterative development process and test-first development. Features were defined using user stories and development iterations were complemented by frequent feedback from teachers and other educationalists to ensure that the product being developed was accurate, appropriate and relevant.

During trials, participants had the ability to provide feedback and suggest new features whilst they were using the website: this feature fed into the iterative development cycle by providing a useful testing ground for new functionality. To ensure that all trials were as fair as possible, new features were only added if it could be verified that their addition would not affect the core research purpose of this study. A list of all new feature requests are detailed in Appendix 5.9.

3.4 HCI (Human Computer Interaction) Considerations

From an HCI perspective, research into other children's websites aimed at the 9-12 year old market was conducted to analyse and identify the features and colour schemes that should be reflected in *Raise A Tree*. The result was that visual artefacts such as bright bold colours, avatar characters and big-block buttons were integrated into the design to ensure that the site was unequivocally designed for children, as can be seen in Figure 3.4:

Figure 3.4 - HCI Considerations in the design of Raise A Tree

Providing participants with individual usernames and passwords for *Raise A Tree* was imperative to ensure that all data could analysed and compared amongst the cohort. However, consideration had to be given for the age group of the demographic and so a simplified user login system was developed that featured incremental

usernames (eg SchoolUser1, SchoolUser 2) and simple, tree-themed passwords (eg oak, birch) to try and allay as much as possible the threat of participants forgetting their login details. Participants were also each given individual membership cards at the beginning of the trial with their usernames and passwords written on - a consideration that helped to reduce the amount of usernames and passwords that were lost or forgotten throughout the trial period.

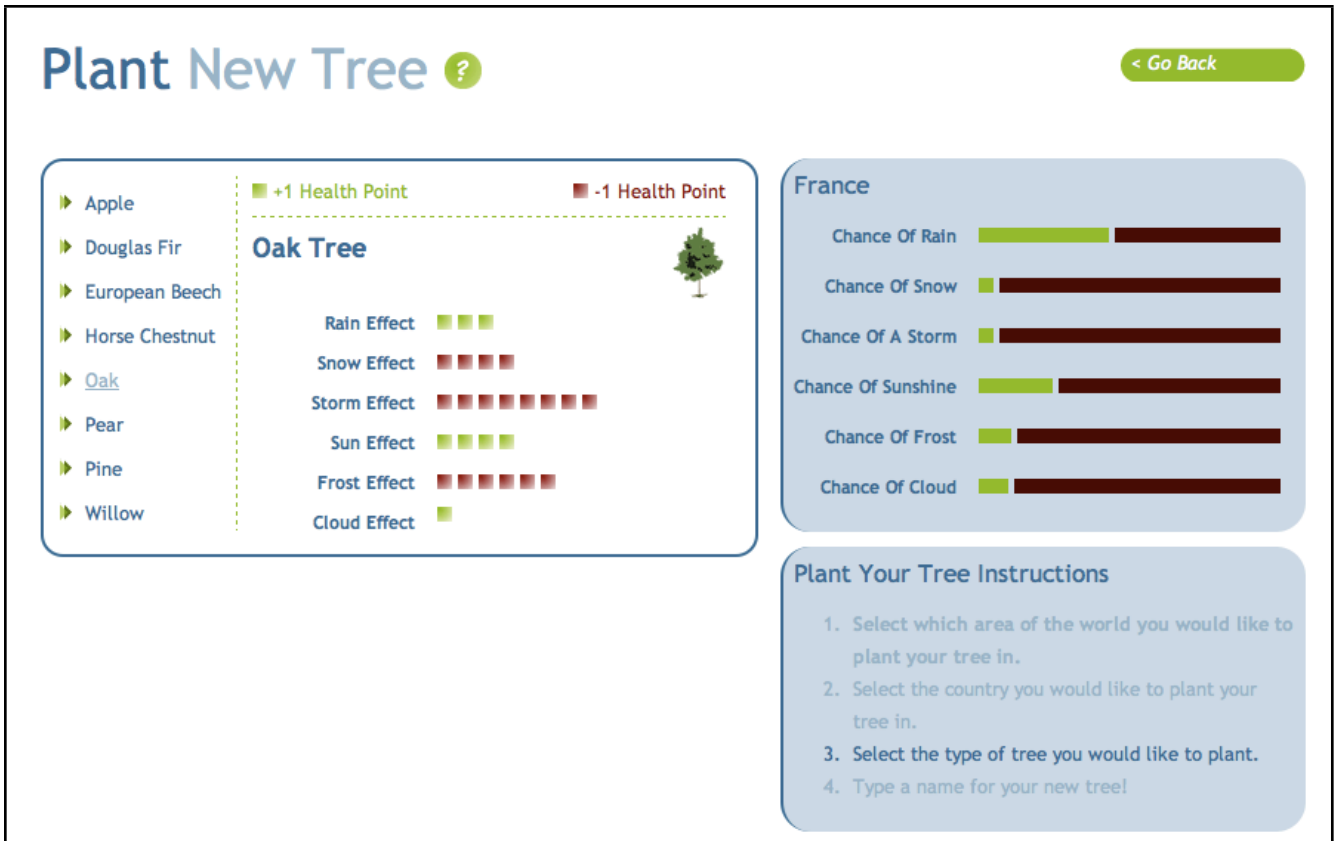
3.4 Website Setup

This section gives a brief overview of the different features of *Raise A Tree*, their aim and purpose as well as how their usage data was collected and tested. Table 3.2 defines each of the key features of the study that were designed or developed to add value to the study. Each feature is defined with its aim, the purpose and reasoning behind its integration as well as information on how its usage was tested or monitored throughout the study.

Table 3.2 - Features of the Raise A Tree website, why they were included in this study and how they were tested.

Feature 1 - User Account Management & Login	
Aim:	To provide each participant with a unique username and password that would be easy to remember across the trial period and that could provide access to *Raise A Tree* during and outside of trial periods.
Purpose:	To separate each participant from each other for the purposes of data collection, analysis and evaluation. HCI Considerations for this study's participant demographic were made and a simplified system was used to reduce the number of forgotten details.
How Tested:	N/A
Research Question(s):	N/A
	

Feature 2 - Virtual Trees	
Aim:	To provide a facilitator and context for the serious game element of the study.
Purpose:	Participants each had the ability to plant and raise three virtual trees. Each tree could be personalised by which country it was planted in, what type of tree it was and also what it was called.
How Tested:	When planting a virtual tree, participants were provided with data on how their chosen tree performed in each different type of weather as well as the probability of each weather form occurring in the country they had chosen. They were then asked whether they would like to proceed with their chosen combination, which provided a voluntary logical reasoning exercise. An analysis of the number of users who considered this logical reasoning when planting a virtual tree is covered in Chapter 4. Trees also provided a feature to monitor and compare emotional engagement with virtual objects by assessing how frequently participants returned to nurture their trees and monitor their progress. Understandably, it was envisaged that participants would relate to their virtual trees in different ways and this is later discussed in Chapter 4.
Research Question(s):	RQ1



Feature 3 - Personal, Class & Environmental Points	
Aim:	To provide a catalyst for competition and to nurture competitive behaviour over the trial period.

Purpose:	To create three distinct levels of achievement during the trials: **Personal Points** were collected by nurturing virtual trees, answering activities successfully and also any points dedicated from Environmental Decision Points. A user's personal points defined their position in the class league table. **Class Points** were an accumulation of the whole class' points, as well as any points dedicated from Environmental Decision Points. The level of class points defined that class' position in the class league table, where each class competed against each other **Environmental Points** were an accumulation of every participant's points as well as any dedicated from Environmental Decision Points. Points also defined a level-based achievement model for participants whereby as they achieved more points, they increased level.

How Tested:	At the start of the first trial, each classification of points were explained to the participant users and questions on the purpose of each type of points were answered to reduce any ambiguity that may have existed. Since points formed a core part of this study, the analysis of their usage spans two research questions: whether contextual game-based learning can increase engagement and also whether points accumulation strategies are used in a competitive e-learning game. Primarily, points were tested in partnership with the educational activities as this symbiotic relationship represented a 'cause and effect' scenario for participants to understand their progress on *Raise A Tree*. From a competitive perspective, points defined a participant's position in the league table and it was envisaged that competition between peers would drive participants to want to earn more points so that they could overtake other users. As can be seen in Appendix 3.1, the points graphics featured on the right-hand side of the screen showing participants the current personal, class and environmental points levels. Under each graphic was a button entitled 'Earn More Points', which led the participant to the activities section. Data was recorded on which option the participant chose in each scenario in order to record if there was any correlation between particular strategies and motivations to earn points.
Research Question(s):	RQ1, RQ2, RQ3
	
Feature 4 - My Tree Dashboard	
Aim:	The My Tree Dashboard provided easy access to both the facilitator (virtual trees) and catalyst (points & league tables) for this study.

Purpose:	The purpose of this section was to provide a simple snapshot overview of a participant's account including quick links to each other aspect of *Raise A Tree*. The dashboard provided small visualisations of a participant's points and league table position, as can be seen in Appendix 3.1.
How Tested:	Since the dashboard was a central repository for accessing a user's account, data collection focussed mainly around its use as a tool for measuring a participant's emotional engagement with the site and their virtual trees by quantifying return visits and time spent on viewing their trees' development. Data on return visits and time spent on the site was added to other areas of *Raise A Tree*, such as the virtual watering can to accumulate the total amount of time spent nurturing and viewing the progress of a participant's virtual trees.
Research Question(s):	RQ1

Feature 5 - Educational Activities

Aim:	To provide a context and mechanism for facilitating the competitive points structure of the study.
Purpose:	The purpose of this study's activities was to provide a repeatable mechanism for participants to use in order to gain points and compete with other users. Based on Gee's (2003, 2004, 2005b) principles of good games, repeatable activities provided aspects of challenge and consolidation to promote challenging problems for pupils that they could repeat in order to learn through an iterative process (Wideman et al, 2007). The types of activities included in the study were split between requiring active or passive engagement. The only active engagement activity was a blog post where participants were asked to write a short piece of prose, based on a scenario or topic. Passive engagement activities were presented as multiple-choice activities where pupils had either a one-in-three or a one-in-four chance of selecting the correct answer. These activities were configured to randomly select 10 questions from a pool of around 20-30 stored in a database, meaning that two participants sat next to each other would have different questions displayed in a different order to discourage cheating. Multiple-choice activities were deemed to be passive due to the chance that participants would randomly select answers without considering the question.

How Tested:	Activities were split between curriculum and extra-curriculum activities. Since educational content and learning was not the focus of this study, a participant's activity scores were largely irrelevant. However, since participants earned personal points for every correct answer they chose, there was an incentive to complete activities conscientiously. A detailed analysis of participants' approaches to answering activities is shown in Chapter 4, including particular strategies adopted and distinctions based on this study's variables. Active and passive engagement activities formed a core part of the data collection and analysis sections of this study as well as providing a repeatable mechanism for encouraging usage of the website outside of the trial periods and points accumulation strategies. Data detailed in Chapter 4 reports on usage during and outside of trials, popularity of activity types (including participants' opinions on these) as well as strategies for how specific activities were used to develop gaming strategies throughout the study.
Research Question(s):	RQ1, RQ3

Feature 6 - Environmental Decision Points	
Aim:	To assess participants' environmental and social consciousness as well as their conformation to social norms.
Purpose:	Environmental Decision Points provided a mechanism for disrupting the flow of a trial by posing a structured question to all participants that had to be answered before the trial could continue. For an example Environmental Decision Point, please refer to Appendix 2.

How Tested:	Every participant was shown the same decision point and individually were able to choose from three answers. The structure of each decision point was the same: a problem has occurred in the world, which has had an environmental impact. Each user gains access to some resources that would help to alleviate the problem but have the choice of whether to keep the resources for themselves (Selfish Goal), donate them to their class (Local Goal) or donate them to the people mentioned in the question (Ethical Goal). Each response carried a points value that was varied across the trials to analyse participant behaviour and opinions of social and environmental topics. After selecting their desired response, pupils were confronted with an additional piece of information and given the chance to change their answer or keep their original choice. This decision was designed to challenge participants' conformation to social norms. Primarily, participants' first and second choice answers were the main focus for data collection, although since decision points carried a varying points value that participants were able to assign, they played a role in the wider area of points accumulation and gaming strategies.
Research Question(s):	RQ2, RQ3

Environmental Decision Point

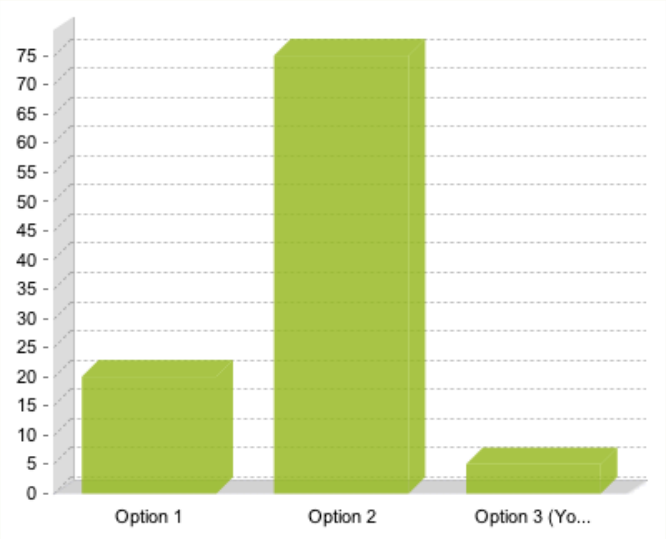
Question

There are severe floods in Pakistan and millions of people have had their homes swept away, resulting in a reduction of 200 Environmental Points. You come across 100Kg of seeds - what would you like to do with them?

- ○ **Plant them yourself**
  Collect 200 Personal Points
- ○ **Donate them to your Class**
  Collect 200 Class Points
- ○ **Send them to Pakistan to help people grow more crops**
  Collect 200 Environment Points

Submit Vote >

A friend tells you that he thinks 95% of other users who answered this question chose a different answer. Would you like to change your answer?



Change Answer

Keep Answer

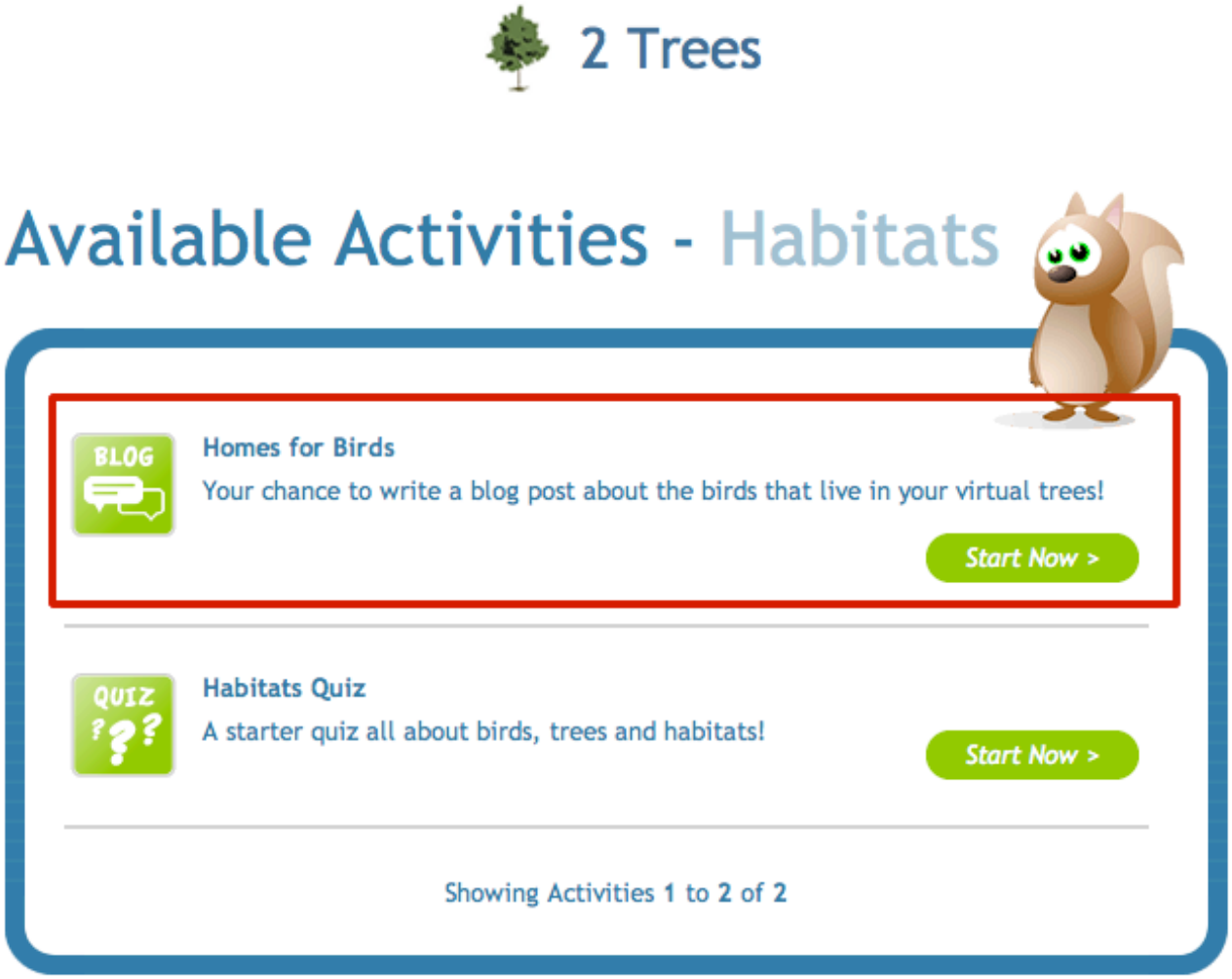
Feature 7 - Virtual Watering Can	
Aim:	As a facilitator for engagement with the website.
Purpose:	The purpose of the virtual watering can was to provide participants with a mechanism of nurturing their virtual trees. Participants could water their virtual trees once every 10 minutes, up to a maximum of five waterings per tree per day.
How Tested:	Data on the frequency of return visits was collected and compared alongside individual points accumulation strategies to try to understand participants' motivations for engaging with the website.
Research Question(s):	RQ1, RQ3

Feature 8 - Lesson Zones	
Aim:	To introduce a structured approach to completing educational activities during the trial time.

Purpose:	Lesson Zones removed the ability to access *Raise A Tree*'s gaming features (such as the virtual watering can) and provided a structured path through a series of activities that formed a lesson in order to focus participants' attentions.
How Tested:	N/A
Research Question(s):	N/A

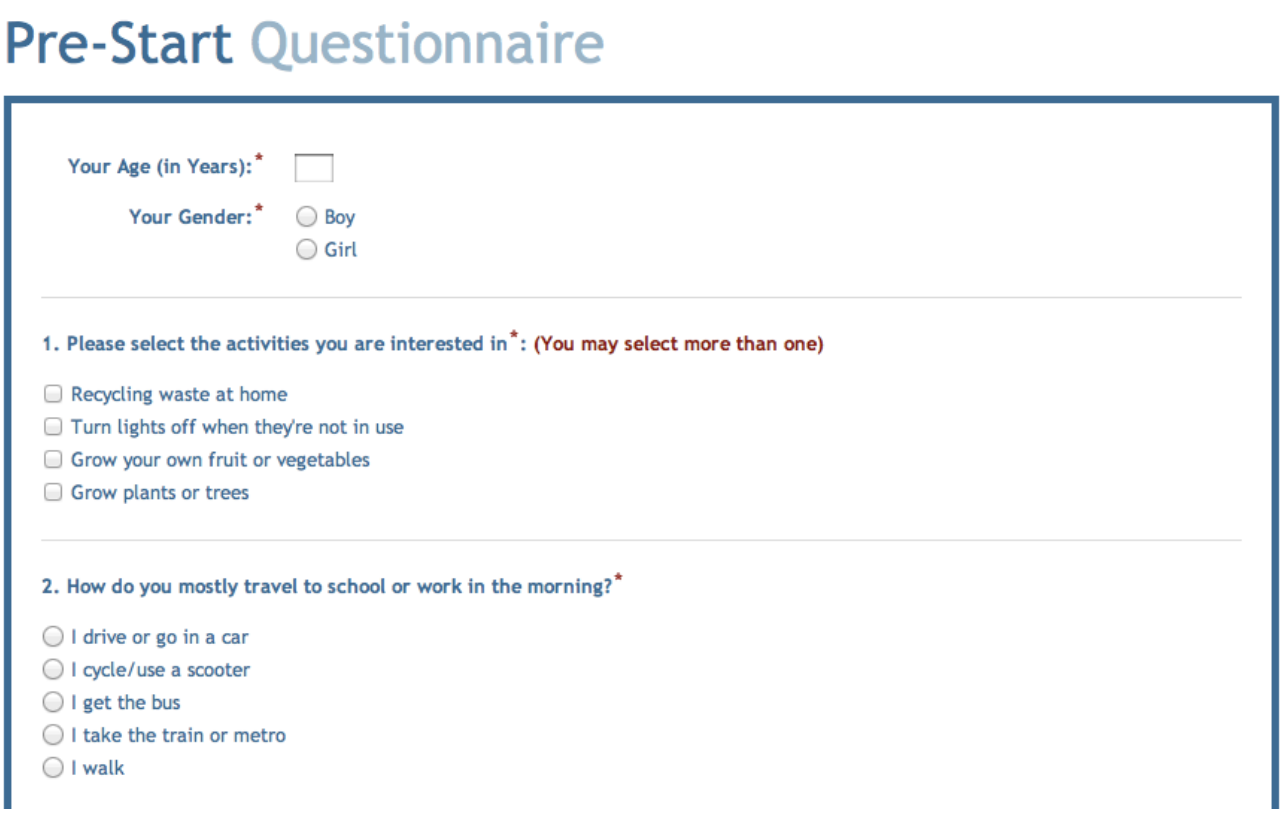
Feature 9 - Hidden Features	
Aim:	To provide hidden content and functionality that participants could find and manipulate to their advantage.
Purpose:	The purpose of this feature was to detect how quickly participants found and utilised the hidden areas of the study website and whether they then went on to use these features in relation to a point accumulation or gaming strategy. There were two hidden features within this study: **1. How to plant multiple virtual trees.** One of the first tasks given to each cohort was to plant their own virtual tree although there was no immediately visible way of identifying how to plant more trees after this. To gain access to planting more virtual trees, users needed to click on a non-descriptive link presented throughout the site, as can be seen in Appendix 3.2. **2. How to earn 5x as many points on a particular activity.** The second hidden feature featured in the form of a particular activity that participants could choose to complete. This blogging activity awarded participants with 5x the normal amount of points (50 personal points) for an activity upon completion.

How Tested:	The initial data on this feature reports how quickly each feature was discovered and by how many users. In addition, results on how long it took for the feature to become widespread throughout the cohort are reported. Secondary data is reported about how participants utilised knowledge of these features after the initial discovery and whether they used them to their advantage or as part of a wider gaming strategy.
Research Question(s):	RQ1, RQ3



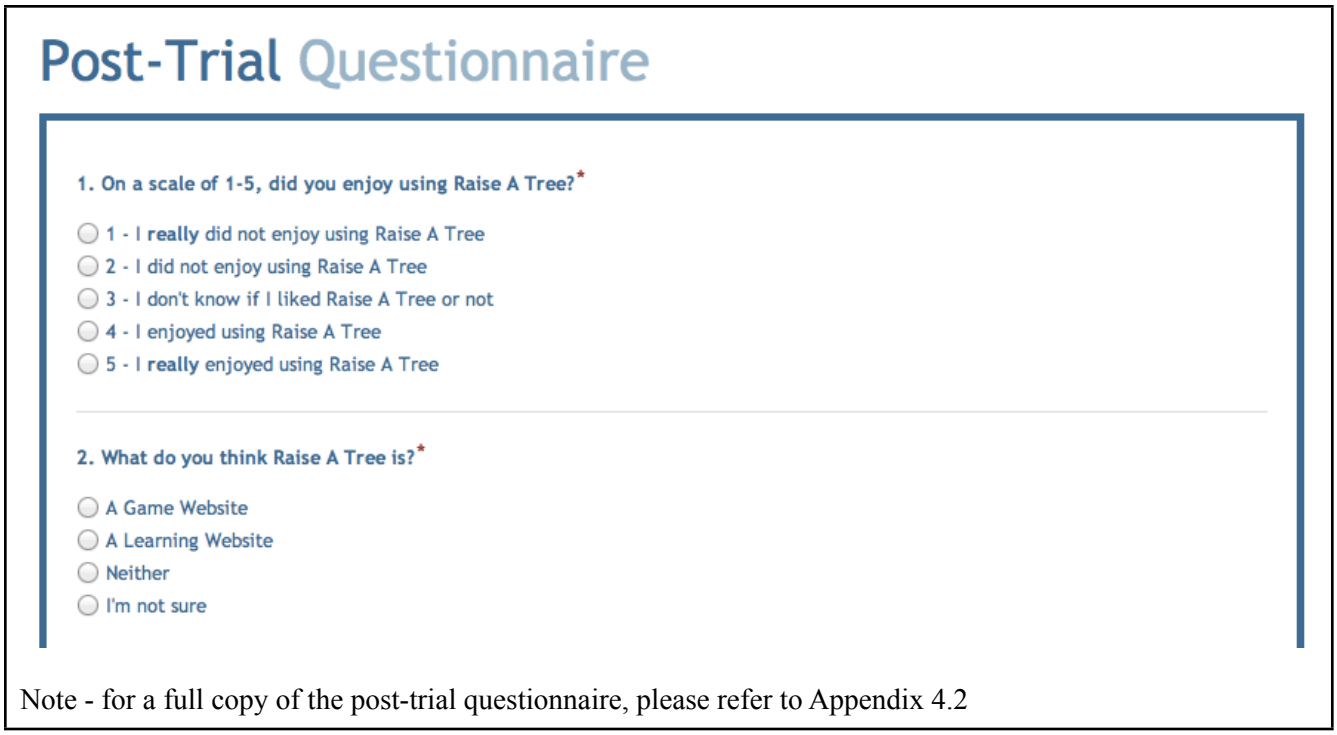
Feature 10 - Pre-Trial Questionnaire	
Aim:	To gauge an understanding of participants' backgrounds with respect to environmental topics.

Purpose:	The purpose of this feature was to understand whether a participants' background affected any of the choices or decisions that they made throughout the trial as well as provide a benchmark for comparing data on environmental consciousness across the cohort.
How Tested:	Data was collected in the form of an eight-question survey at the beginning of the study. A copy of this questionnaire is displayed in Appendix 4.1
Research Question(s):	RQ4



Note - for a full copy of the pre-start questionnaire, please refer to Appendix 4.1

Feature 11 - Post-Trial Questionnaire	
Aim:	To gauge participants' opinions of the study.
Purpose:	This section was used to better understand whether this study was successful in answering the research questions defined.
How Tested:	Data was collected in the form of a 12-question survey at the end of the study. A copy of this questionnaire is displayed in Appendix 4.2
Research Question(s):	RQ1, RQ3, RQ4



Note - for a full copy of the post-trial questionnaire, please refer to Appendix 4.2

3.5 Educational Activities

The educational activities used in *Raise A Tree* were devised in collaboration with teachers at the selected schools to fit in with the relevant national curriculums and to ensure that the level of difficulty matched that of what the participants were capable of.

3.5.1 Activity Types

The educational content used in *Raise A Tree* was split down across six different types of activity: basic quizzes, picture quizzes, video quizzes, maths quizzes, comprehension quizzes and blog posts.

Table 3.3 identifies the different activity types available as well as their purpose and where they fit into the national curriculum:

Table 3.3 - Activity types used within Raise A Tree along with their purpose and connection to the national curriculum.

Activity Type	Purpose
Basic Quiz	To act as an introduction to the educational content delivery. Basic quizzes included 10 randomly selected questions on a topic and were delivered with three or four multiple choice answers for participants to select.
Picture Quiz	These two activity types were added in to enable a greater degree of interaction with the chosen topic. The picture quiz presented information visually for participants to analyse and interpret and the video quiz enabled participants to watch a short video clip with audio. Both activity types were followed by 10 randomly selected questions on the chosen topic.
Video Quiz	
Maths Quiz	The maths quiz was designed specifically to provide content that covered different maths topics of the national curriculum. The quiz would start with an interactive chart that participants could interact with before posing 10 randomly selected questions.
Comprehension Quiz	The comprehension quiz provided participants with an activity where they had to read a passage of text on a particular topic and then answer questions based on that text in the same multiple-choice format of the other activity types. This activity was designed to assess participants' reading and comprehension skills.
Blog Post	The blog post activity was the only type where participants were given the creativity to write a short piece of prose and then comment on their peers' work. Designed to fit into the English section of the national curriculum, this activity type included a focus on not only reading and writing skills but also critical thinking.

3.5.2 Activity Topics

Raise A Tree as a game is focussed around the environment and environmental topics, such as forests, ecosystems and renewable energy so this context was used to devise further educational material for use within this study. Table 3.4 gives an overview of the educational resources created for this study including the type of activity they were:

Table 3.4 - Activities created for the Raise A Tree study

Topic	Activity Title	Activity Type	Description
Habitats	Homes for Birds	Blog Post	Your chance to write a blog post about the birds that live in your virtual trees!
	Habitats Quiz	Basic Quiz	A starter quiz all about birds, trees and habitats!
Green Plants	Parts of a Plant Quiz	Image Quiz	See if you can identify all the parts of a quiz in this image quiz
	Plant Nutrition Quiz	Comprehension Quiz	Come and read about how plants make their food!
	Growth Quiz	Basic Quiz	Come and answer some simple questions about how plants and trees grow
The Environment	Protecting the Environment	Comprehension Quiz	This one's a biggie and is also the million dollar question - come and see how much you know!
	Rainforest Quiz	Picture Quiz	A little quiz all about rainforests from around the world
	Animals, Birds & Trees of the Rainforest	Blog Post	A blog all about the different types of animals, birds and trees that you might find in the a forest

Topic	Activity Title	Activity Type	Description
	Layers of the Rainforest	Basic Quiz	A quiz about the structure of a rainforest and what the different layers do.
Energy	Buzzing About Electricity	Video Quiz	Come and watch this music video to find out what the buzz is about Electricity!
	Different Sources of Energy	Blog Post	What do you know about the different ways we can generate energy? Lots hopefully!
	Energy Chart Quiz	Maths Quiz	How well do you know your bar charts? Come and have a test!
Water	Water Cycle Quiz	Image Quiz	A quiz all about the Water Cycle
	Temperature & Water	Basic Quiz	Come and answer questions about temperatures!
Transport	Getting to School	Blog Post	Come and write a blog post about how you travel to school in the mornings
	How Many People Walk To School	Maths Quiz	Come and have a look at our wonderful graph and see if you can answer the questions about how many people are walking to school!

4. Experimental Design

This chapter provides a detailed breakdown of the technical and experimental design, including reasoning on decisions made and the implications that these had on the study.

4.1 System Design

Raise A Tree was developed to try and provoke emotional engagement between pupils and their virtual trees in order to see whether this enhanced engagement levels. Principles from a number of studies on boosting engagement were considered in the design phase of this study, such as high-resolution multimedia and competition (Mitchell & Savill-Smith, 2004), virtual characters and a sense of achievement and progression of tasks throughout the game (Gee, 2003) as well as a series of pay offs and bonuses that motivated pupils towards further achievement (Wideman et al, 2007).

A number of Gee's 16 principles for good educational games (Gee, 2005b) were built into the development of *Raise A Tree* to create a pedagogically-sound system that was focussed around sustaining user engagement and interaction. These principles included:

- **Identity** - Creating a hook through the concept of growing and nurturing virtual trees. Users were only able to water their virtual trees five times per day, which gave them a reason to keep coming back to the site.
- **Interaction** - Constant mentoring through the My Tree Bark section allowed pupils to see what their peers were doing and encouraged them to complete more activities in order to progress through the website.
- **Customisation** - *Raise A Tree* was developed with a certain number of hidden features to allow pupils to find and manipulate these features of their site to their own personal gaming strategies and styles. This also aids in researching the level of emotional engagement that pupils exhibited.

4.1.1 Design & Development Considerations

The decision to develop *Raise A Tree* as a website led to a setup that was designed to encourage usage outside of the set trials (which were always during school hours). The purpose of such a decision was to develop a better understanding of participants' usage of the website and its features as well as to detail the proportions of users who were interested in visiting the site of their own accord. From an ethical perspective, it was important to ensure that suitable access to *Raise A Tree* was provided by each participant school outside of curriculum time for those pupils who did not have access to the internet at home. This point is detailed further in the Ethical Considerations section below.

4.2 Variables

The two main variables for comparison within this study were the year group and gender of participants. Year groups varied across the different participant schools and ranged from Year 5 to Year 7 (ages 9-12 years old). Gender classification was split down within each cohort.

The reasoning for the use of these variables in the study was to analyse and evaluate how different participants reacted to the study's aims and research questions and whether there were any trends that could established as a result of the data collected.

More information on the demographic data of the study's cohort can be seen in the School Selection section.

4.3 Data Collection

At the beginning of the first trial for each participant school, pupils were issued with *Raise A Tree* Membership Cards which gave details of their assigned username and password for the study. The first task for participants was to fill in the pre-trial questionnaire in addition to their age, gender and (at the discretion of the school) their real name. Determination on whether to request real names from participants was made on a school-basis and was only used to help out any participants who had forgotten their login details in subsequent trials. More information is available on this point in the ethical considerations section below (section 4.8). Pre and post-test questionnaires were used as per the recommendation of Wideman et al (2007) to gain a complete understanding of the backgrounds of participants at the outset of the study and how their opinions and views changed through the course of the experiment.

Throughout the study, every action a participant took was logged in the website's relational database so that any trends or strategies that emerged during the study's analysis could be traced back and investigated retrospectively, as per the recommendations by Wideman et al (2007). Data stored included a user's unique id, the action taken (eg 'The user watered one of their virtual trees') and the date/time stamp of the action. Data was collected and stored throughout the study period (even after the formal trials had concluded) to capture data usage from participants outside of the trials. Whilst it may have been advantageous to also capture audio and video feeds from each of the trials (Wideman et al, 2007), logistically this was outside the scope of this study.

In addition to the data log, the only other identifiable data collected was in the form of participant inputs to the website, such as a name given to their virtual tree or any activity answers (including blog posts) that were completed during the study.

The final data set collection for each cohort was the post-trial questionnaire, which is presented in Appendix 4.2.

4.4 Statistical Analysis

Data collected throughout this study was split down into qualitative and quantitative data with the aim of qualitative data being the ability to collect opinions and ideas about the usage of *Raise A Tree* and the quantitative data to show the extent to which these opinions were exhibited.

The most important decision taken when designing this study and planning the data collection was to try and simplify questionnaires and data collection methods as much as possible since the study's participants were of a young age.

Qualitatively, this thesis will analyse results using the following techniques:

1. **Five-point Likert scale**
   Designed to gauge participants' opinions on a particular area of the study by constraining the number of choices available in order to derive a succinct classification of opinions.
2. **Boolean/multiple-choice comparison metrics**
   These metrics were used when it was required to gauge whether participants preferred one option or another in order to determine a ranking.

Quantitatively, the statistical analysis methods used include:

1. **Pearson Correlations**
   Pearson correlations are used in this thesis to determine whether there is any kind of statistical correlation between two data sets, predominantly between male and female participant data sets to help identify results that may indicate answers to RQ2.
2. **Box Plots**
   These are used to determine the spread of a particular feature in this thesis. Plots are used to identify whether a particular practice was exhibited by the entire cohort or just throughout a number of participants and aids in easier visualisation of data where traditional numerical analysis cannot.

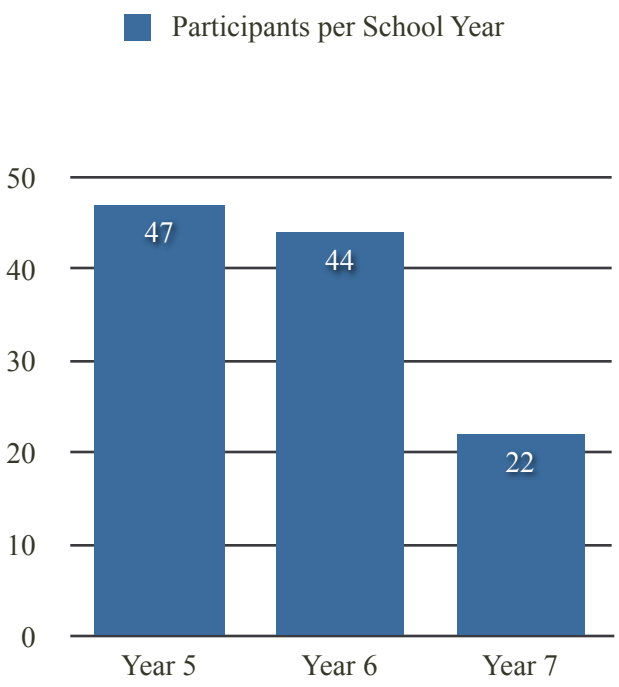
4.5 School Selection

A selection of thirty five schools were invited to participate in this study after hearing an overview of the project at an Advanced Skills Teacher meet-up. In total, six teachers across three schools (two primary, one secondary) responded and were accepted in participating in the study. The participant schools were: Walkergate Primary, Cragside Primary and Benfield Secondary. All schools were located within a 1.7 mile radius of each other and the two primary schools acted as feeder schools for the secondary school.

Unfortunately, one teacher at Benfield Secondary school was unable to continue after the first trial so all data collected from this cohort was discarded.

From the schools selected for this study, Walkergate School performs on a par with the Local Authority and National Average for Primary School Performance (Appendix 1.1), Cragside consistently achieves above average (Appendix 1.2) and Benfield school performs below average for Secondary Schools (Appendix 1.3). Detailed information on each school's performance data can be found in Appendices 1.1-1.3.

Overall, there were a total of 116 participants in this study (excluding the pupils at Benfield school who were discarded). Three participants did not manage to complete all of the tasks required of the study owing to their absence in one or more of the trials and so the their data was also discarded from the results of this study. The demographic information of the 113 participants is displayed in Figures 3.2-3.3.



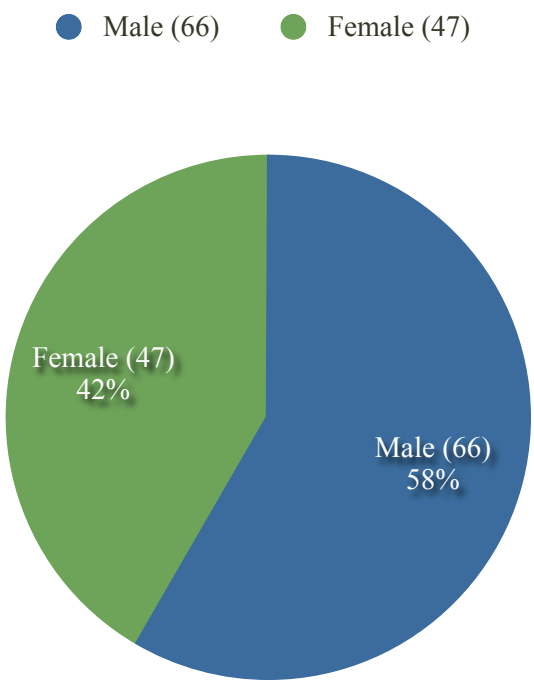


Figure 3.2 - Study participant data split by Year Group

Figure 3.3 - Study participant data split by Gender

It was envisaged that each class cohort would use *Raise A Tree* across three trial sessions set out at timed intervals with additional time to explore and use the website in the interim if desired. Unfortunately, owing to individual school commitments and industrial action, many of the planned trials had to be re-arranged leading to a variety of time intervals between the three trials of each of the schools.

4.6 Trial Plan

Each cohort of users participated in a set of three planned trials throughout the study, the contents of each trial are detailed below:

4.6.1 Trial One - Introduction

The aim of this trial was to provide a familiarisation with *Raise A Tree* itself. Participants were guided through a serious of tasks aimed to highlight each of the functions of the site separately in order to give a complete overview and understanding of the system.

Tasks included planting and watering a virtual tree, completing one of each different type of activity (eg Blog, Basic Quiz, Comprehension, Image Quiz, Maths Quiz, or Video Quiz) as well as answering two Environmental Decision Points throughout the session.

Once participants had completed the structured activities, they were free to explore the site on their own.

4.6.2 Trials Two & Three - Solar Power Lesson & Wind Power Lesson

The second and third trials began with a simple task to re-introduction *Raise A Tree* to each participant: participants were tasked with logging into the website, looking at the progress of their trees and then watering them with the virtual watering can.

Following this, the study's structured activities began through the website's Lesson Zone (Feature 8 - Table 3.2). These activities focussed on a series of quizzes and blog posts based around the topic of Solar Energy (Trial two) and Wind Power (Trial three). Activities were structured to become increasingly more difficult in order to engage and challenge participants. The Lesson Zone guided participants through each of the different activity types through each lesson.

Interspersed within each lesson's activities, pupils were confronted with three more environmental decision points to answer in each trial.

To conclude each trial, pupils were given another chance to water and look after their virtual trees once all the lesson activities had been completed.

All educational content was formed in association with a number of teachers and other educationalists to ensure they met educational standards and were appropriate for the audience.

4.7 Trial Setup

The setup for each trial and each cohort was the same to ensure fairness and continuity throughout the trial. Each trial began with a pre-trial briefing where the tasks for the trial were explained clearly and concisely using a pre-written script to ensure continuity across trials before any questions were taken from the participants.

Across the cohort and trials, a number of questions were asked after the initial briefing but the majority of these were just a clarification of the task.

The most important pre-trial briefing was given at the very start of the study and included information for participants to ensure that the aims of the study were met as closely as possible. It was explained that with their login cards, participants could access the *Raise A Tree* site outside of the trial periods if they had internet access at home or during break times at school. In addition, any actions that were conducted on the website would be

logged (anonymously) for the period of the study. Finally, participants were informed that they would be still be able to access the website after the trial finished until the end of the study.

4.8 Ethical Considerations

There were a number of ethical considerations that were detailed during the planning of this study. To begin, the participants were all under the age of 18 and therefore considered 'minors' for the purposes of ethical classification, meaning that consent had to be sought for each of the participants. After discussions with the teachers and head-teachers of each of the participant schools about the study, it was discovered that a number of the teachers felt that the actions and research of the study could be classified as a 'classroom activity' and as such, consent could be given by the teacher on behalf of all the participants. The overall consent was possible due to the schools having collected consent from individual parents at the beginning of the academic year to hold overall control of participation for each pupil on the usage of academic resources. Across the study, the decision to give consent to participate in trials was given to individual teachers: if they had collected consent forms for individual pupils at the start of the academic year then it was deemed unnecessary to collect additional consent forms. However, in the case where there were no prior consent forms, participants were each given consent forms to take home to their parents or guardians to sign before they could participate in the study. Overall, only Walkergate School were issued with consent forms for each of their participants.

As part of the data collection part of this study, logs were captured in the database that detailed particular tasks that participants had completed or actions they had taken on the website. These logs formed part of the infrastructure of the website and therefore were mandatory in providing statistics that could quickly be linked or related as part of the study's data analysis. Detailed discussions were held with each participating school about this issue before the study began and all schools felt that this was a reasonable and necessary requirement.

Other ethical considerations noted at the outset of this study include the emotional issues that could develop as a result of a sudden removal of any objects upon which participants had become emotionally attached. As one of the aims of this study was to see how effective contextual learning systems were at generating emotional engagement between users and virtual objects, it was imperative that this issue was analysed and a plan developed to mitigate any potential effect to participants as a result of partaking in the study. To allay the possibility of this issue occurring, access to the *Raise A Tree* website was enabled for all users after the trials concluded but no new content was posted.

All data and personal information that were required for the purposes of data analysis in the study were stored in a central database on the internet. Access to the database was restricted and all passwords were encrypted to add two levels of protection for participants' data. Since usernames for *Raise A Tree* were incremental and passwords were simplified to increase the study's usability, there was a risk that participants might be able to gain access to one of their peer's accounts. It was judged that the creation of easier login credentials for participants was a valid trade-off for the potential problem of a participant accessing someone else's account. The reasoning for this

decision was based on the the type of functionality that could be sabotaged on a participant's account. Since there was only one access point for losing points (through the virtual watering can) it was deemed that the process of logging into someone else's account was actually counter-intuitive, since every other feature of the site would have increased the amount of points on the account that had been accessed illegitimately.

5. Results

This chapter provides a breakdown of the data results collected, organised by the research questions defined in the introduction of this thesis. A log analysis and overview of issues faced throughout the study prepends the main results section and gives detail on how these issues may have affected the results collected.

5.1 Log Analysis

Over the course of this study, there were five classes trialled across three schools (two primary and one secondary school) that each ran through three structured trials of the *Raise A Tree* website. In total, the 113 users of these schools logged in to the website 1,271 times cumulatively, which worked out at an average of 11 logins per user across the study's period. There were 223 virtual trees planted using *Raise A Tree* and these were watered using the virtual watering can a total of 3,135 times. Each participant owned - on average - 2 virtual trees each and watered each tree around 14 times throughout the study. From the 16 non-Lesson Zone activities that users were free to complete as many times as they liked, 43,336 attempts were recorded working out at an average of 383 activity attempts per user.

5.2 Trial Reports & Questions

Throughout each trial of the study, a report was written that noted any observations from the trial as well as any problems and questions that were asked by participants. Overwhelmingly the questions related to points covered in the pre-trial briefing that the participant wanted to clarify or hadn't heard correctly and so will not be detailed any further. There were five questions noted down that related to the wording used in activities that the participant had not understood. In these scenarios a teacher would attend and explain in simpler words what the question was asking the user to do.

5.3 Issues Faced

Across the study there were a small number of issues faced which are detailed in the next section alongside the impact that this was estimated to have had on the trial data.

5.3.1 Blog Post Gaming Strategies

It transpired within the first week of running trials of this study that there was a vulnerability with the *Raise A Tree* website that allowed participants to re-submit the same blog post an unlimited amount of times, leading to a scenario where several users in the first two trial classes accumulated a disproportionately high number of points compared with their peers. Primarily, this issue affected the study's planned data collection but it also provided data for an additional research area based on the different ways that gaming strategies were used by participants. Results on this additional research area are covered under RQ3 in this chapter.

To ensure that the rest of the trials were delivered without issue, it was decided that a number of technical enhancements should be implemented to remove the ability to post a duplicate blog post and also limit the number of attempts for each activity to five, per user per day. In addition, validation measures were added to the

website to remove the ability for users to submit a form more than once. Data on the practice and usage of gaming strategies during the first week of the study is detailed later in this chapter. Owing to the changes made to the site after the first week of trials, data for RQ3 is restricted to just two cohorts from the same school (Walkergate Primary) and whilst these are compared, references to the rest of the study's participants are not made.

5.3.2 Website Load Issues

As a direct result of the blog post gaming strategies issue detailed in Section 5.3.1, there was an unexpectedly high amount of website traffic generated in the first week of the study that led to cases of the *Raise A Tree* website experiencing sporadic downtime. All these cases were experienced during the first two trials of the study, which were conducted with the two classes from Walkergate Primary School.

5.4.3 Minor Issues

In addition to the major issues detailed above, there were two HCI (Human-Computer Interaction) problems observed throughout the study relating to the design and implementation of the simplified login system and membership cards. Firstly, some users were observed to have difficulty logging into *Raise A Tree* because they had spelt their usernames incorrectly. The most commonly reported mis-spelling throughout the trials was the word 'school'. The second HCI-related issue was with the passwords assigned to participants and written on their individual membership cards. Here, the problem was that the passwords had been written by hand on the cards and some of the participants could not interpret the handwriting.

5.5 Research Question Results

The remainder of this chapter details the data collected for each research question defined.

5.5.1 - RQ1 Can e-learning resources on environmental awareness develop participant engagement?

The aim of this research question was to use a series of game-based e-learning utilities - such as points accumulation and league tables - within a particular context - environmental awareness - to determine whether this would increase engagement levels in school pupils.

RQ1 was broken down into the following lower-level questions:

1.1 Do participants derive enjoyment from time or effort invested into using e-learning resources on environmental awareness?
1.2 Do participants *perceive* that they are learning within an environmental-based e-learning resource?
1.3 Can e-learning resources on environmental awareness create retention in participants?

Engagement in this study was measured through a range of quantitative and qualitative measures in order to gauge a full overview of participant data. The remainder of this section details the results from the methods used to evaluate participant engagement, starting with some general overview data on engagement from the post-trial

questionnaire and quantitative data logged throughout the study before moving on to detail participant perceptions of what *Raise A Tree* was to them. Finally, this section will present a selection of quantitative data on how participants used and returned to the website.

5.5.1.1 Post-Trial Questionnaire Data

Data collected from the post-trial questionnaire is displayed in Figure 5.1 which details participants' enjoyment rating of *Raise A Tree* based on a five-point Likert scale (where 5 was good and 1 was bad), split down by gender and school type:

5 - Really Good	4 - Good	3 - OK	2 - Bad	1 - Really Bad

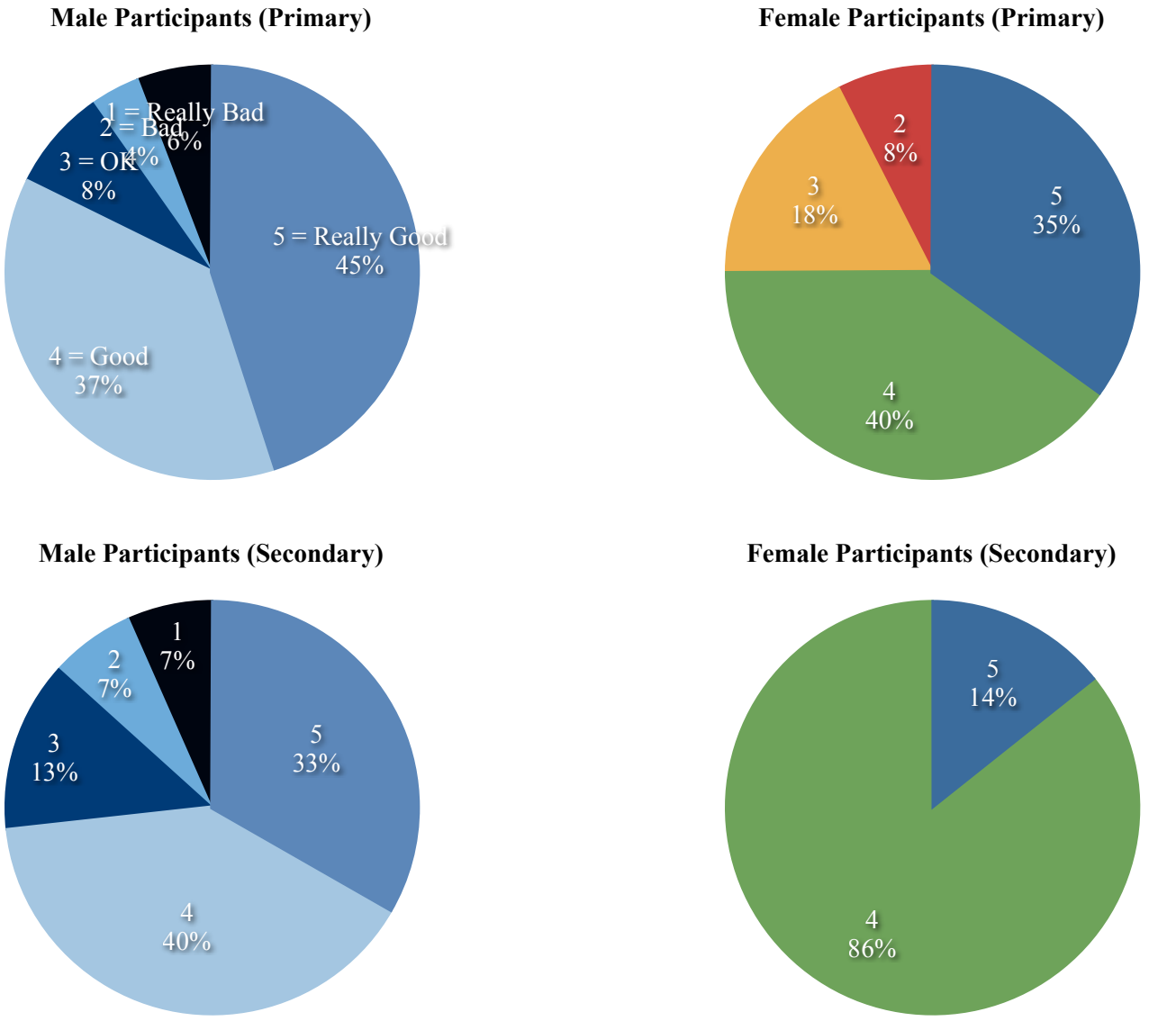


Figure 5.1 - Male and Female enjoyment of Raise A Tree measured on a five-point Likert scale spread across Primary & Secondary Schools.

The purpose of the data visualised in Figure 5.1 was to determine a high-level overview of participant reactions to Raise A Tree immediately after completing the final trial.

To benchmark the enjoyment of *Raise A Tree*, participants were then asked whether they preferred using *Raise A Tree* against a series of other activities (referenced as 'Competitive Measure'). The purpose of this question was to try and develop a better understanding of where (on average) participants saw Raise A Tree fit into a number of other activities that they may do on a daily basis. The results are defined by percentages of respondents and split by gender and displayed in Figure 5.2. For example, in the first bar of Figure 5.2, 88% of male participants preferred using *Raise A Tree* to Classroom Learning.

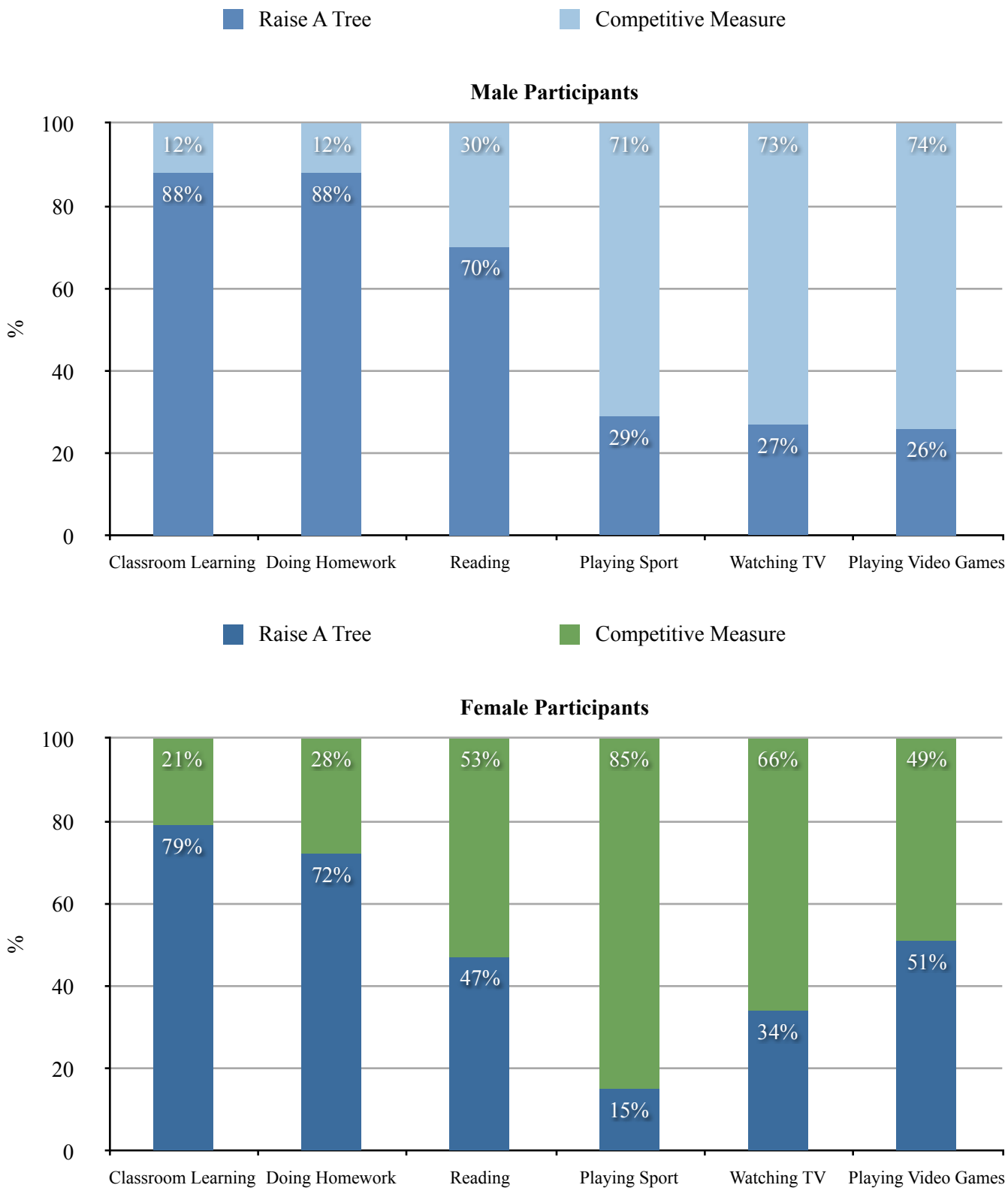


Figure 5.2 - Male and Female enjoyment of Raise A Tree vs different competitive measures.

To gauge participant opinions of *Raise A Tree* as a serious educational game, participants were asked to classify their understanding of the study as either a game, learning tool, neither or whether they weren't sure. The results are displayed by gender in Figure 5.3:

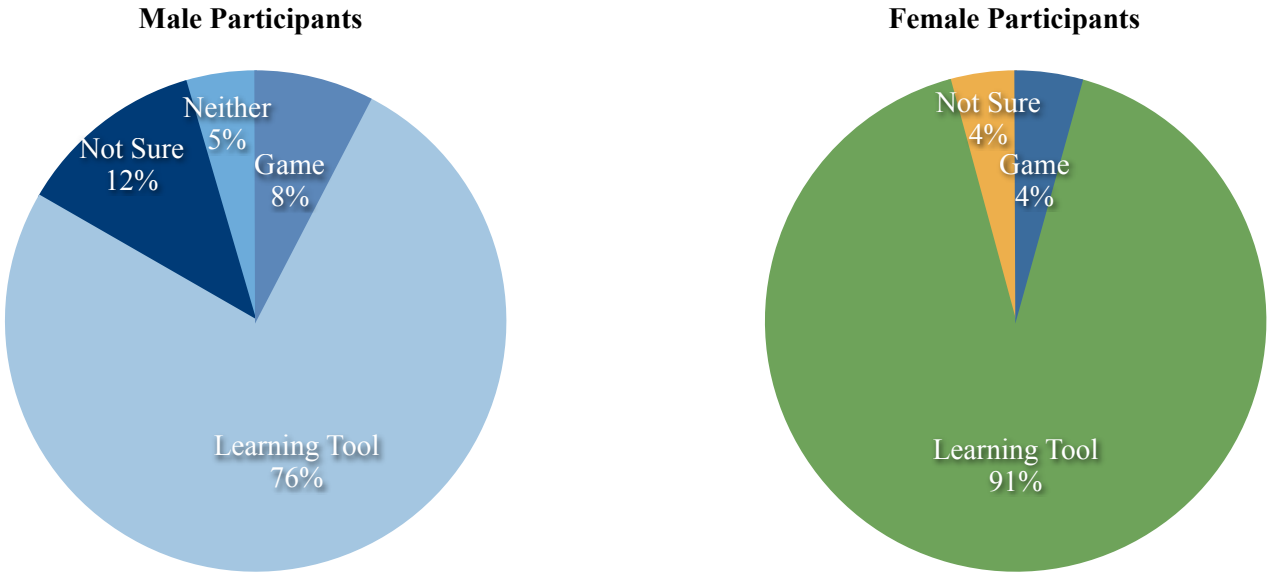


Figure 5.3 - Male and Female classification of Raise A Tree

Participants were also asked to describe *Raise A Tree* in one word, in order to generate a 'wordle' - a graphic that puts commonly mentioned words in larger text - that highlighted opinions of the site. The results displayed in Figure 5.4 show an overwhelmingly positive response to *Raise A Tree*:

Male Participants

Female Participants

Figure 5.4 - Wordles showing how male and female participants described Raise A Tree in one word.

5.5.1.5 Participant Opinions on Topics Learned

As part of the post-test questionnaire, participants were asked if they felt they had learned anything about a set of topics during the study. The results are displayed in Figure 5.8 and taking the three bars for Renewable Energy; the blue bar shows that 85% of male participants felt they learned something about Renewable Energy whereas the green bar shows 78% of female participants agreed.

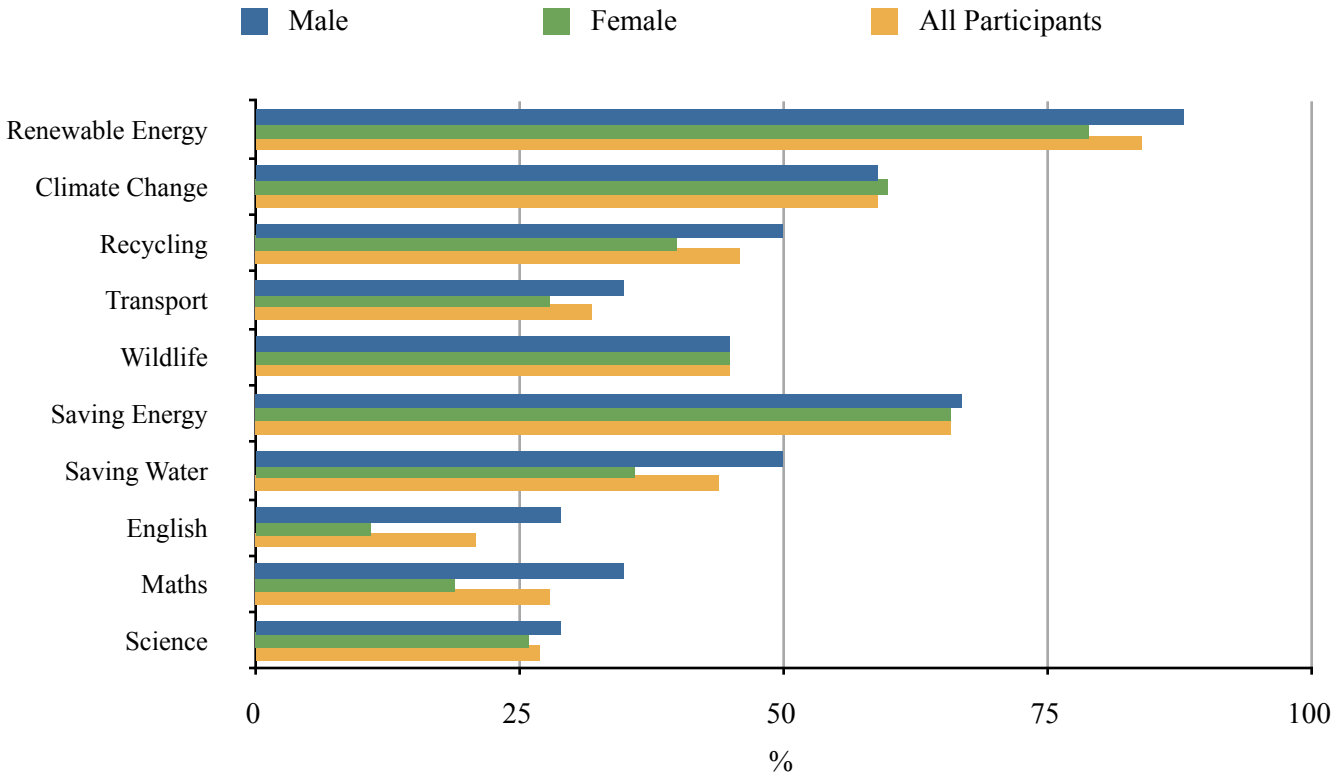


Figure 5.8 - The spread of activities completed by male and female participants outside of trials without outliers

The Pearson correlation was taken on the male and female responses in Figure 5.8 to determine whether there was a correlation between the choices made by male and female participants. The result identified a positive correlation of 0.953, showing male and female participants appeared to respond in the same way almost every time.

5.5.1.2 Website Return Visits

The amount of return visits participants made to *Raise A Tree* outside of the study's formal trials were recorded in order to assess the individual level of interaction that each user had and whether this was shared across the cohort. Data in Figure 5.5 shows a box plot of the number of return visits by each participant in the study: female participants appeared to return more frequently that male participants on average but there were potentially outliers for both male and female participants at the top end of the spectrum. Data is split into gender groups and displayed in Figure 5.5:

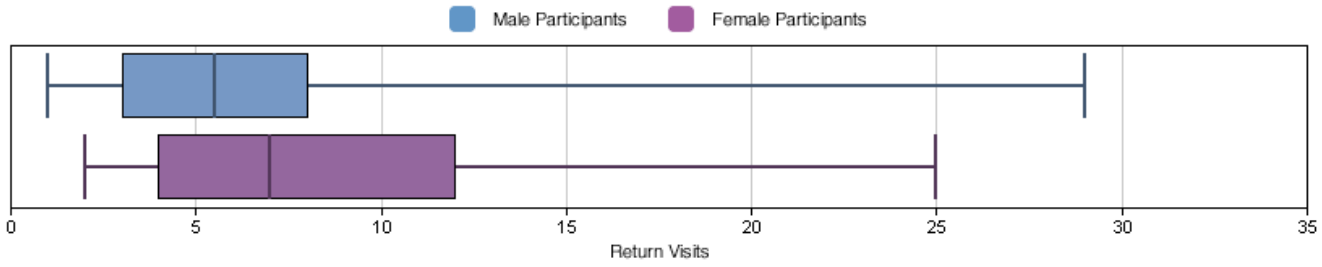


Figure 5.5 - Numbers of return visits across male and female participants throughout the study.

The data from the box plot in Figure 5.5 is also detailed in Table 5.1, highlighting the extent of return visits across the cohort. Table 5.1 shows that every participant returned to Raise A Tree outside of trials at least once and the average number of return visits was eight.

Table 5.1 - Return participant data across the cohort.

Maximum Visits	29 Visits
Minimum Visits	1 Visit
Average Visits	8 Visits
Total Return Visitors	113 Participants (Out of 113)

5.5.1.3 Website Usage Time

In addition to the number of return visits that each participant made to *Raise A Tree* outside of trials, the amount of time they spent on the site (in minutes) was also recorded to gauge an understanding of whether participants were quickly returning to water their tree every day or coming back for longer periods, perhaps to complete the educational activities. The amount of time each participant spent was calculated by the date and time of the links on which they clicked. Times were only accumulated if the user remained on the website page for less than 10 minutes before clicking on a new link or submitting an activity. Data is grouped by gender and displayed in Figure 5.6:

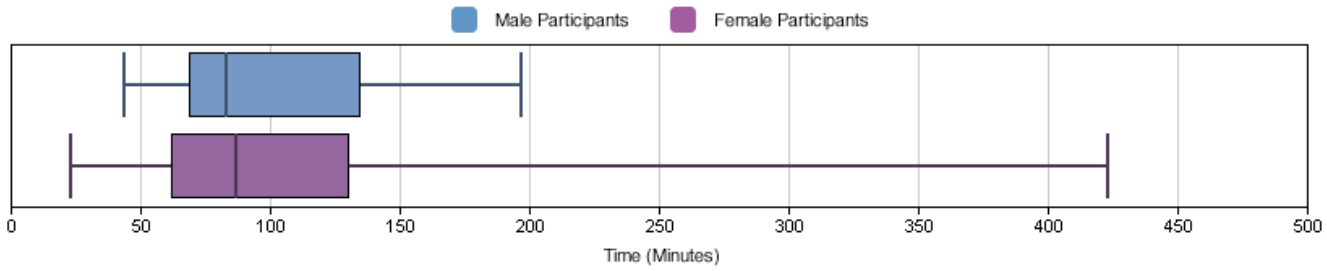


Figure 5.6 - Amount of time (in minutes) spent outside of trials on Raise A Tree across male and female participants throughout the study.

The sample size, maximum, minimum & average time spent during return visits from Figure 5.6 is also detailed in Table 5.2. The average number of minutes spent during return visits across all the users was 101 minutes with one participant returning for 423 minutes in total.

Table 5.2 - Time spent during return visits across the cohort.

Maximum Time	423 Minutes
Minimum Time	23 Minutes
Average Time	101 Minutes
Total Return Visitors	113 Participants (Out of 113)

5.5.1.4 Activity Completion (Outside of Trials)

One key measure of engagement with the study was the extent to which participants completed activities outside of the formal trial periods in order to give further insight into whether participants were using *Raise A Tree* mainly for fun, as an educational tool or as part of a wider gaming strategy. Data on the number of activities completed by both genders is displayed in Figure 5.7. It appeared that there was an outlier in the original data so this was removed and the updated data set it displayed in Figure 5.7:

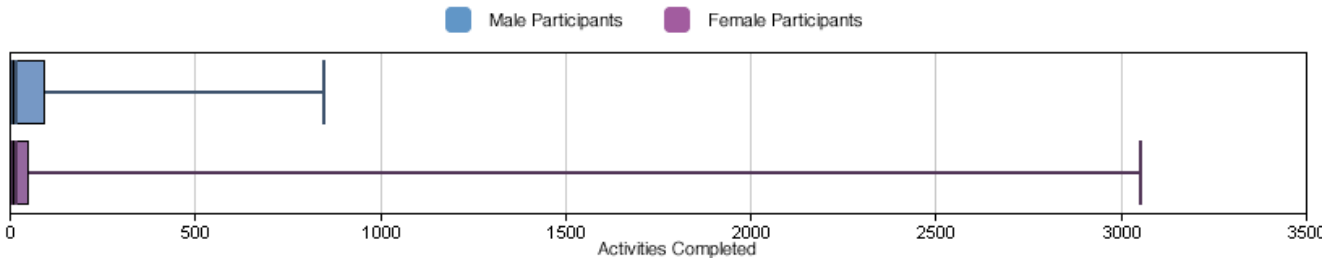


Figure 5.7 - The spread of activities completed by male and female participants outside of trials without outliers

Even after removing the outliers in Figure 5.7, the data is still fairly difficult to accurately interpret owing to the fact that a small number of participants were deemed to 'have employed gaming strategies during the first week of trials where large quantities of duplicate blog posts were submitted to the system. More data on the gaming strategies used are detailed later in Section 5.5.3.

5.5.2 - RQ2 Can e-learning resources on environmental awareness be used to develop ethical decision making?

The aim of the second research question was to pose structured questions to participants and then challenge them to make a decision through a feature called Environmental Decision Points (detailed in Table 3.2 and Appendix 2). Each decision point set the scene that some form of environmental disaster had occurred in the world but that each pupil had come across a bonus that would help alleviate the impact of that problem. Each pupil was given a choice of three options for what they wanted to do with the bonus: keep it for themselves (selfish goal), share it with their class (local goal) or share it with the people who had been affected by the environmental disaster (ethical goal).

After selecting their initial answer, participants were then given an extra piece of information about the environmental disaster and asked if they would like to change their mind. The purpose of this additional information was to judge participants' conformation to social norms when posed with a scenario where they were under the impression that a majority of other people who had answered that decision point, had answered it differently to them.

As the trials progressed, the points value attributed to each choice a user could select varied in order to see whether participants' opinions could be influenced by certain gaming strategies (ie whether participants were simply motivated by points accumulation or whether they had more of an ethical outlook).

RQ2 was broken down into the following lower-level questions:

2.1 To what extent do male and female participants focus on selfish and ethical decision making within e-learning resources on environmental awareness?

2.2 Do participants' ethical decision making choices vary over time in e-learning resources on environmental awareness?

A list of the environmental decision points posed to participants is detailed in Appendix 2.

The results for this research question are split into first and second response data: the answers that participants made initially and then whether they changed their minds.

5.5.2.1 Environmental Decision Point Data Trends - First Responses

An accumulation of all the data from the environmental decision points is collated in Figure 5.10, split down by each decision. Taking the first bar as an example, Figure 5.10 shows that 32% of participants chose the Selfish Choice, 3% the Local Choice and 65% the Ethical Choice.

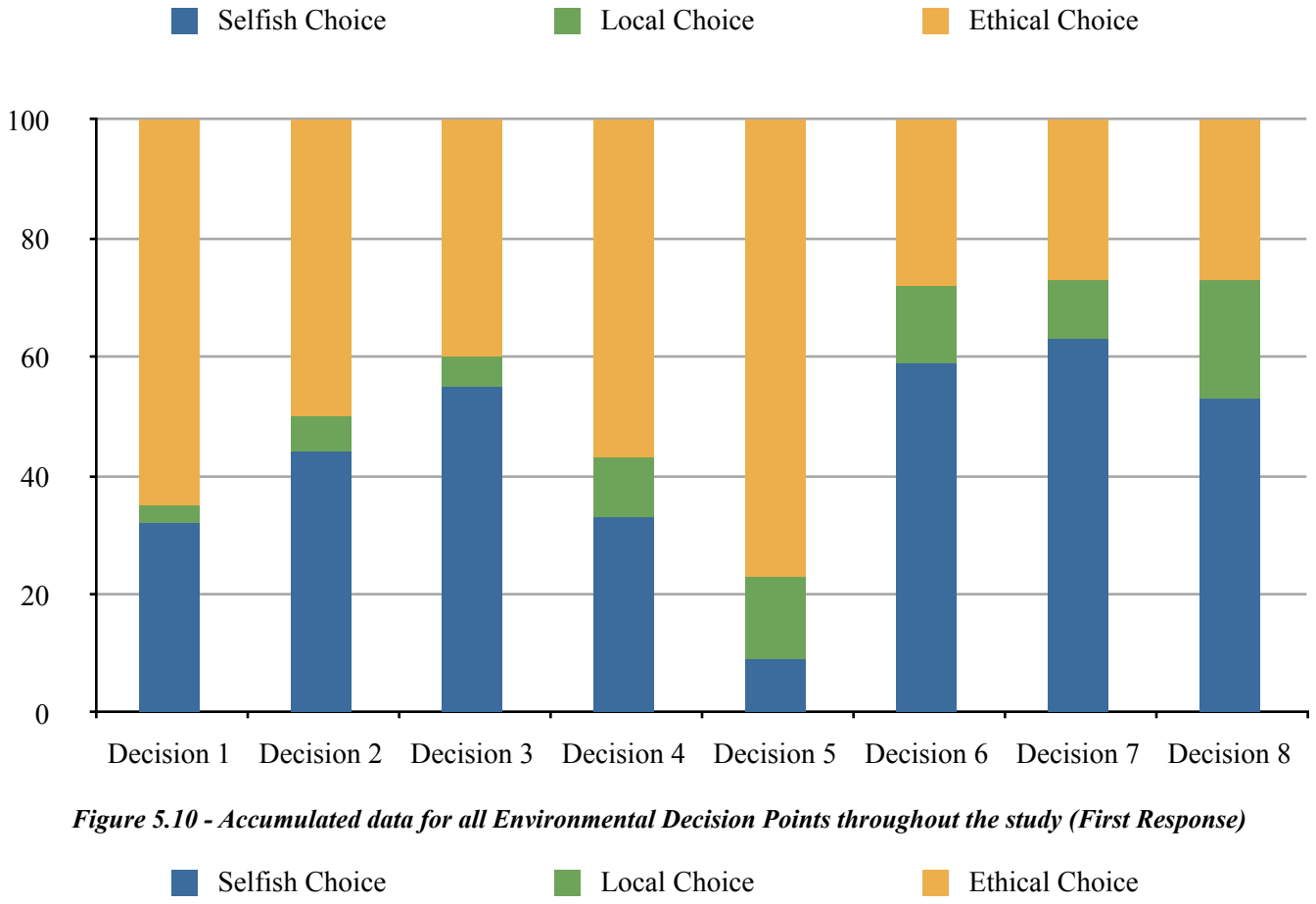


Figure 5.10 - Accumulated data for all Environmental Decision Points throughout the study (First Response)

Figure 5.11 breaks down the data from Figure 5.10 above into genders for each decision point in the study.

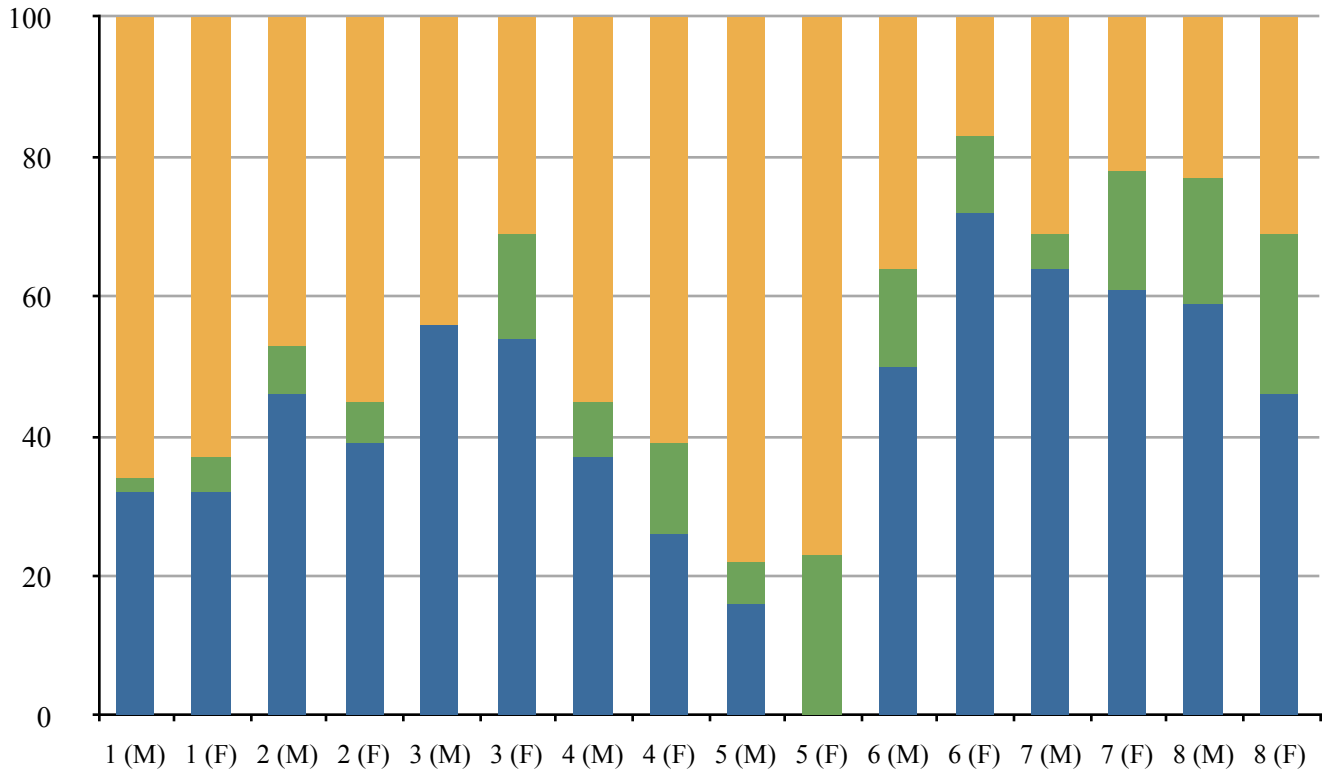


Figure 5.11 - Accumulated data for all Environmental Decision Points throughout the study (First Response) - Split by gender

In order to deduce whether there was any form of correlation between the three sets of choices (Selfish, Local and Ethical) as well as the three decisions across male and female responses, a Pearson's correlation was performed on the data set and the results are displayed in Table 5.3 and Table 5.4.

The results in Table 5.3 show that there was either a strong positive correlation between the data (Selfish and Ethical choices) and a weak positive correlation between the Local choices. However, Table 5.4 shows that there was a strong negative correlation between male participants choosing a selfish option and female participants choosing an ethical option (and vice versa). For example, when male participants chose a selfish option, there was a strong negative correlation against female participants choosing the same option and a strong positive correlation between female participants choosing an ethical option (and vice versa). This shows that there was a very high likelihood of each gender selecting opposite decisions throughout the study.

Table 5.3 - The results from Pearson's correlation data on Environmental Decision Point choices across male and female participants.

Data Series	Pearson's Correlation (3DP)
Selfish Choice	0.865
Local Choice	0.349
Ethical Choice	0.890

Table 5.4 - The results from Pearson's correlation data on Environmental Decision Points across genders and choices.

Data Series	Pearson's Correlation (3DP)
Male Selfish & Female Ethical	-0.897
Male Ethical & Female Selfish	-0.830

5.5.2.2 Environmental Decision Point Data Trends - Second Responses

Following the data on the first choice responses from all the study's participants, Figure 5.12 and Figure 5.13 display an accumulation and collation of all the second response data in the study, initially with data for all participants (Figure 5.12) and then split down by gender (Figure 5.13):

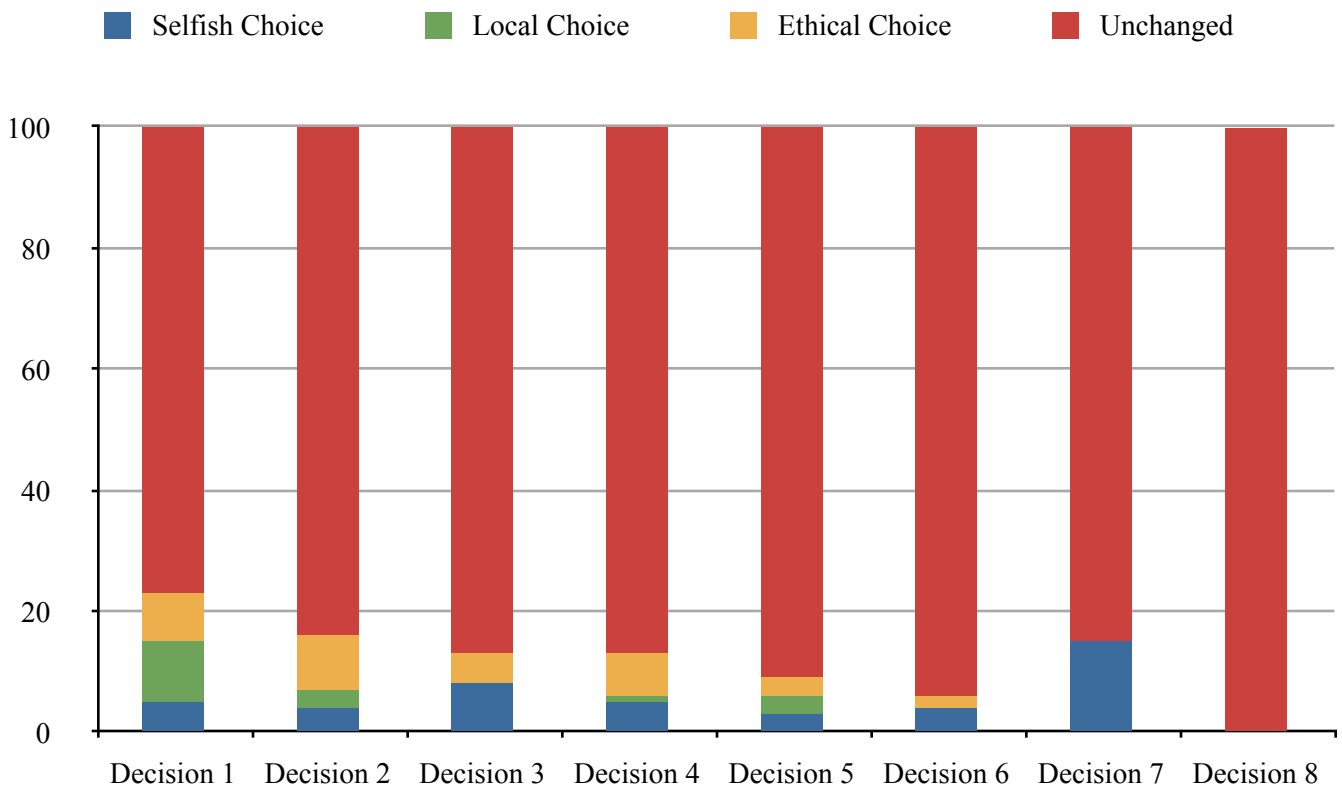


Figure 5.12 - Accumulated data for all Environmental Decision Points throughout the study (Second Response)

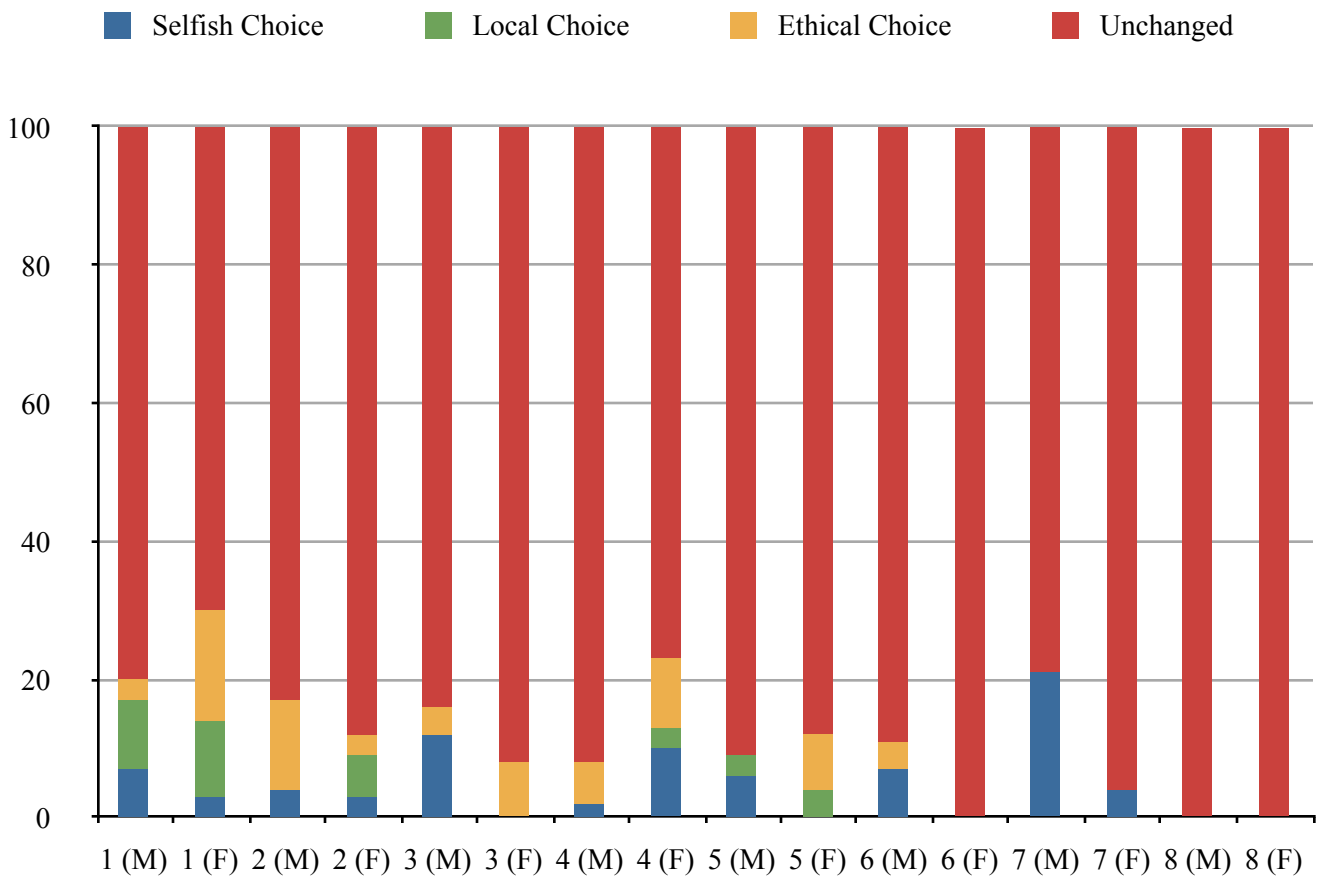


Figure 5.13 - Accumulated data for all Environmental Decision Points throughout the study (Second Response) - Split by gender

In order to investigate whether there was a correlation between the choices made by male and female participants in Figure 5.13, a Pearson's correlation was applied to the data. Table 5.5 displays the results for correlations between the male and female data sets on second choice responses:

Table 5.5 - Pearson Correlation data on the second choices for Environmental Decision Points against male and female participants.

Data Series	Pearson's Correlation (3DP)
Selfish Option	-0.066
Local Choice	0.795
Ethical Choice	0.120
Unchanged Choice	0.324

5.5.2.3 Environmental Decision Point Data Trends - % Changed Mind

Finally, Figure 5.14 displays an accumulation and collation of the % of participants who changed their mind between their first and second answers throughout the study.Figure 5.14 aims to show the proportions of participants who were influenced enough to change their mind by the extra information displayed after they'd made their initial choice; taking the first column it is possible to see that 33% of participants changed their mind whereas 67% didn't.

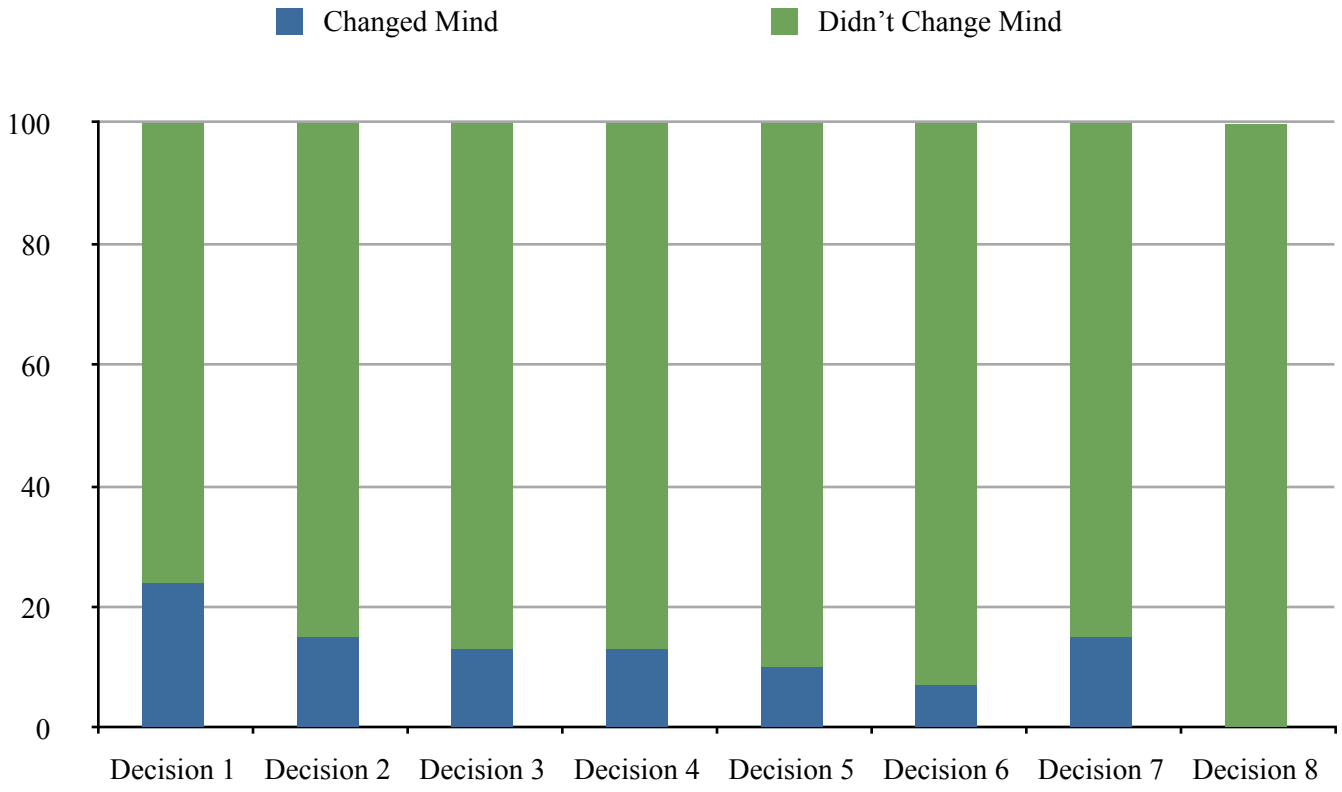


Figure 5.14 - Accumulated data for all Environmental Decision Points throughout the study (% Changed Mind)

5.5.3 - RQ3 Do participants exhibit gaming strategies within e-learning resources on environmental awareness?

The aim of the final research question was to assess to what extent gaming strategies were used by participants and how they were used within e-learning resources on environmental awareness.

By its inherent nature, a competitive points-based game will encourage participants to try and accumulate as many points as possible in order to complete the game. However, *Raise A Tree* introduced a new mechanism to this standard approach by providing participants with three options that they could earn points for: personal, class and environmental points. Personal points simply improved a participant's placing in their class league table, Class points were an accumulation of a whole classes points and Environmental points were an accumulation of every participant's points (across the whole study). Environmental points also dictated how well

the whole cohort's virtual trees grew (the more environmental points there were, the faster all the virtual trees took to grow).

The introduction of class and environmental points signified a change from the traditionally selfish mindset and provided participants with the ability to be selfish (if desired) or alternatively to be more social with their strategy if desired.

This section presents the results relating to participants' gaming strategies, starting with decisions made on links that were clicked during the study and then data on the hidden features that were used by some participants to use gaming strategies to accumulate large quantities of points during the study. This section then analyses, identifies and visualises patterns of behaviour that stemmed from certain participants' strategic practices and the ways that strategies were used throughout the trial.

RQ3 was broken down into the following lower-level questions:

3.1 *To what extent* to participants exhibit gaming strategies within e-learning resources on environmental awareness?

3.2 *How* are gaming strategies within e-learning resources on environmental awareness used by participants?

To start, this study featured a core points-based mechanism to provide player progression through a number of means. To earn points, pupils could answer activities successfully, water their virtual trees and choose the selfish option in the Environmental Decision Points.

5.5.3.1 Earning Points

Every page of the website (excluding the Lesson Zone) featured a right hand column that displayed a user's personal points, their class points and the overall environmental points (as is shown in Appendix 3.1). Each of these points totals included a link underneath entitled 'Earn More Points', that all linked to the educational activities. The aim of this link was to identify whether participants would choose to earn points for themselves, their class or for the wider environment. The results of the number of clicks each link received across the study period is shown in Figure 5.15:

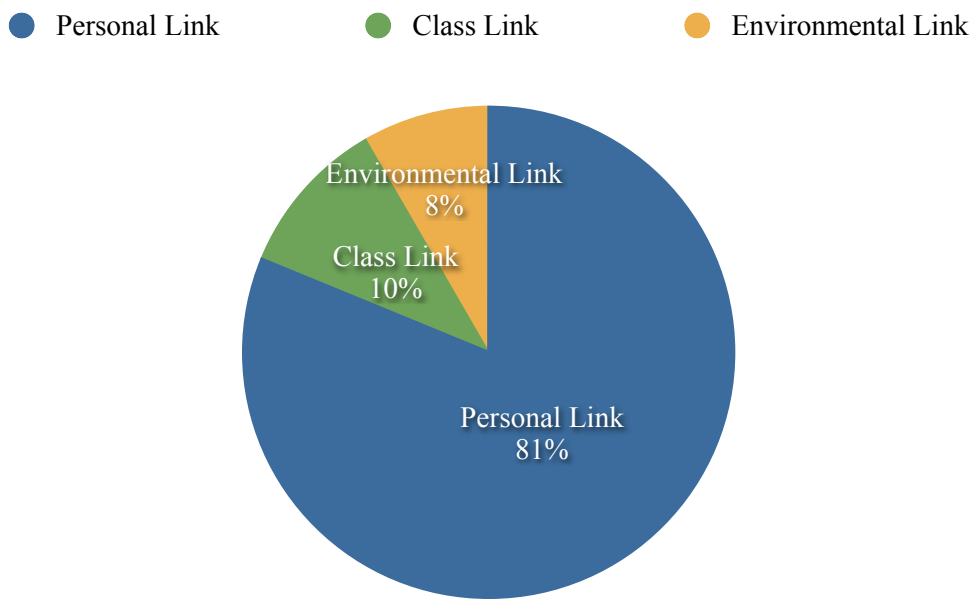


Figure 5.15 - Proportion of which links users clicked on to access the activities section of the website.

Figure 5.15 shows that there was an overwhelming amount of clicks directed at the selfish goal option of the system with an even split between the class and environmental link for the remaining data. The significance of this split is discussed in the following chapter.

5.5.3.2 Hidden Features

'Hidden Features' were functions of the system that were not explained to any of the participants throughout the study but were hidden within *Raise A Tree* for users to discover, understand and utilise to their advantage (if desired).

1. Planting Multiple Virtual Trees

The first hidden feature related to planting more than one virtual tree. By planting and raising more than one virtual tree, participants were able to generate many more points since a participants' Personal points were made up of all their trees' points (gained through a tree growing healthily) as well as points they earned through answering educational activities. Throughout the study, no participants were told how to plant more than one virtual tree (after they planted their initial tree). There was a secret link (as is shown in Appendix 3.2) that if clicked, allowed the participant to plant another virtual tree, up to a maximum of three trees.

Figure 5.16 shows the time ranges that it took for each participant to discover how to plant their second virtual tree. This data is based on the log files for each user that show the time difference between starting to use *Raise A Tree* to planting their second virtual tree. The time ranges for Figure 5.16 were set to identify the point during the first trial when participants discovered the hidden link. The first trial was split into a number of structured activities, all taking between 10-15 minutes to complete so it was decided that this should be the range for

representing data. The maximum time range is 120+ minutes due to the fact that the first trial for each class was two hours long. The data is displayed in Figure 5.16:

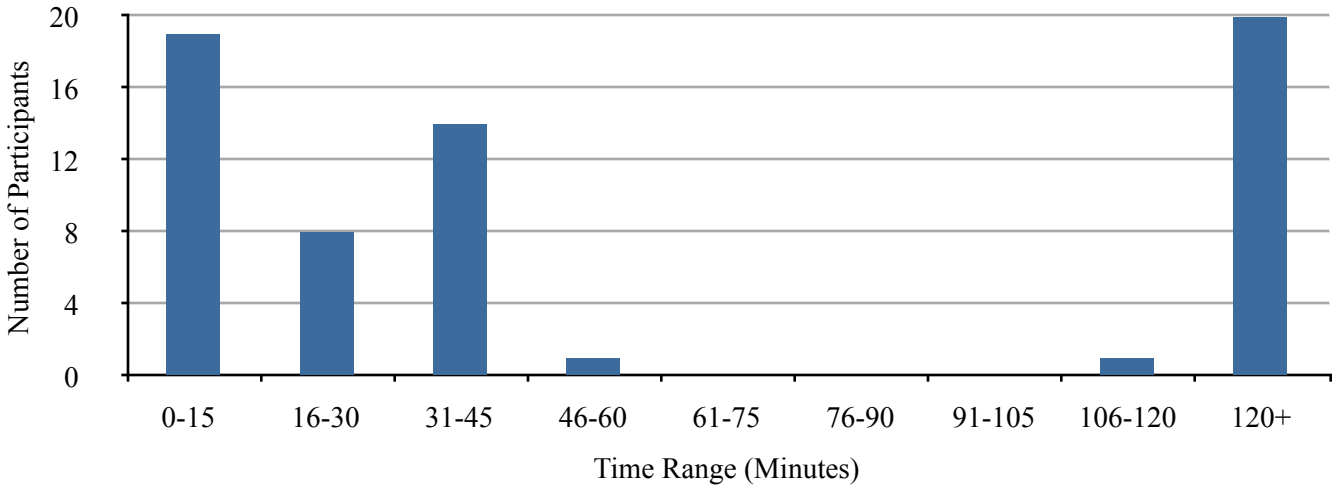


Figure 5.16 - Data on how long it took participants to discover how to plant a new virtual tree

2. High Points Blogging Activity

The second hidden feature was integrated into one of the blogging activities available that carried a reward of five times as many points as the other activities. This was implemented to see if and how participants utilised it during trials as well as in their free time to develop particular strategies or 'game' the system.

Unfortunately, the actual usage of this feature was significantly above the expected, which caused significant strain on the *Raise A Tree* website, meaning an amendment to the study had to be made after one week to prevent this feature from being used. The change that was made was that participants could only complete each activity on the website (including the high points blogging activity) a maximum of five times a day, thereby reducing the ability to 'game' the system.

The following data was collected during the first week of the study and includes the first trial for the two classes from Walkergate School who had free use of the website before the fix was implemented. All data includes data on all blogging activities, not simply the high scoring blog activity.

In the first week of the study, a total of 42,048 blog posts were submitted to the site across the two classes at Walkergate School. In comparison, the remaining five activity types had 1,237 attempts by the cohort during the same period. On inspection it was identified that a certain subset of the participants had exposed the ability to re-post the same blog post a number of times and earn the high points prize each time, which led to a scenario (as observed in the first trial) where participants would keep clicking on their mouse button frequently to keep submitting the form with their blog post on.

5.5.3.2.1 Duplicate & Irrelevant Blog Posts

The distribution of the number of blog posts submitted across the top 10 users (those who posted the most blogs during this time) is displayed in Figure 5.17 alongside the proportions of those blogs posted that were duplicates. The top 10 users were chosen as after this point the extent of use of gaming strategies dramatically fell. Users are ordered in descending order of the total number of blog posts they submitted during the first week of the study (the quantification of one gaming strategy).

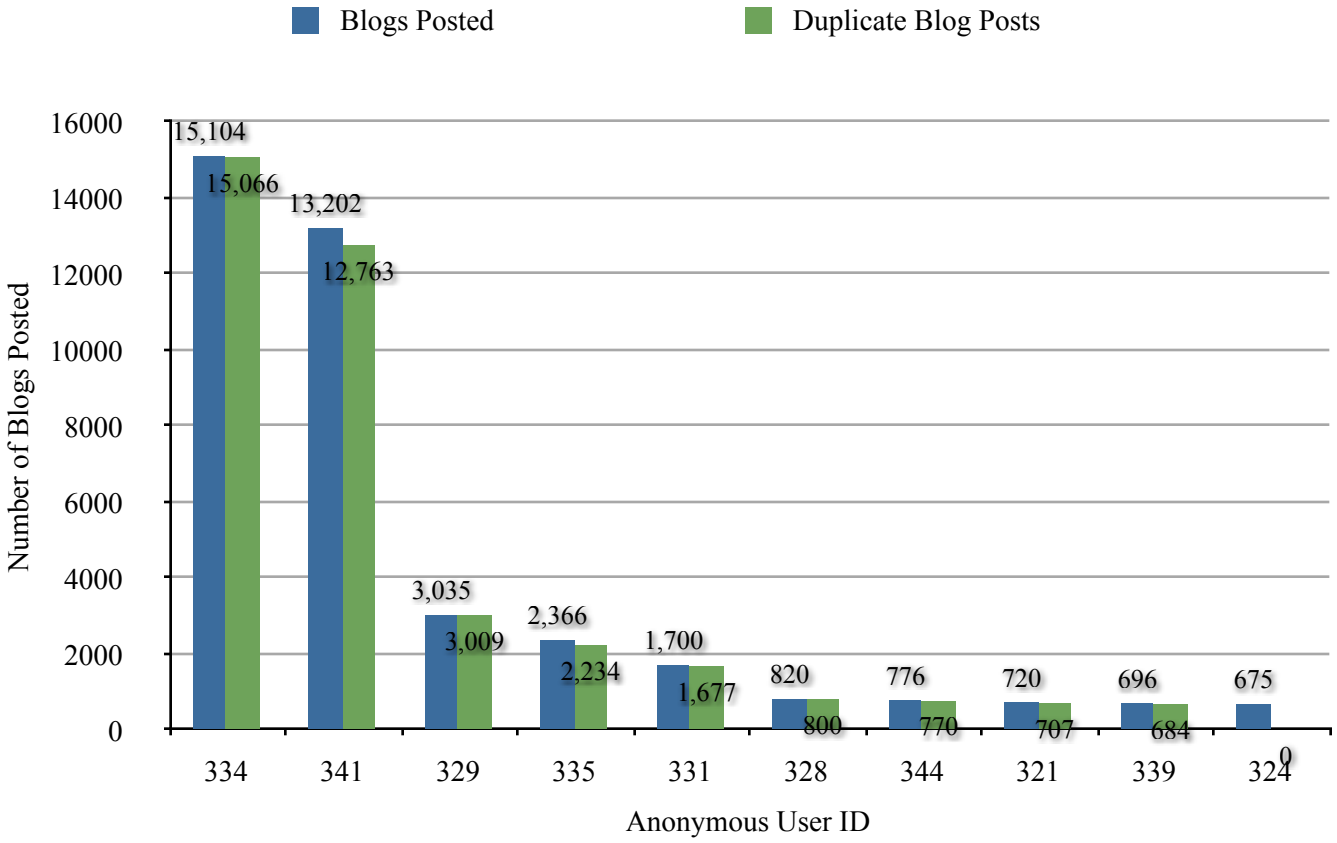


Figure 5.17 - Number of Blogs Posted (and Duplicate Blogs Posted) by the Top 10 Users (Pre-Fix)

Blog posts during the first week of the study were assessed for their relevance to the activity title - posts which had no relevance to the question being asked were marked as irrelevant. Data on the relevance of the same top 10 users' blog posts (excluding duplicate posts) are displayed in Figure 5.18:

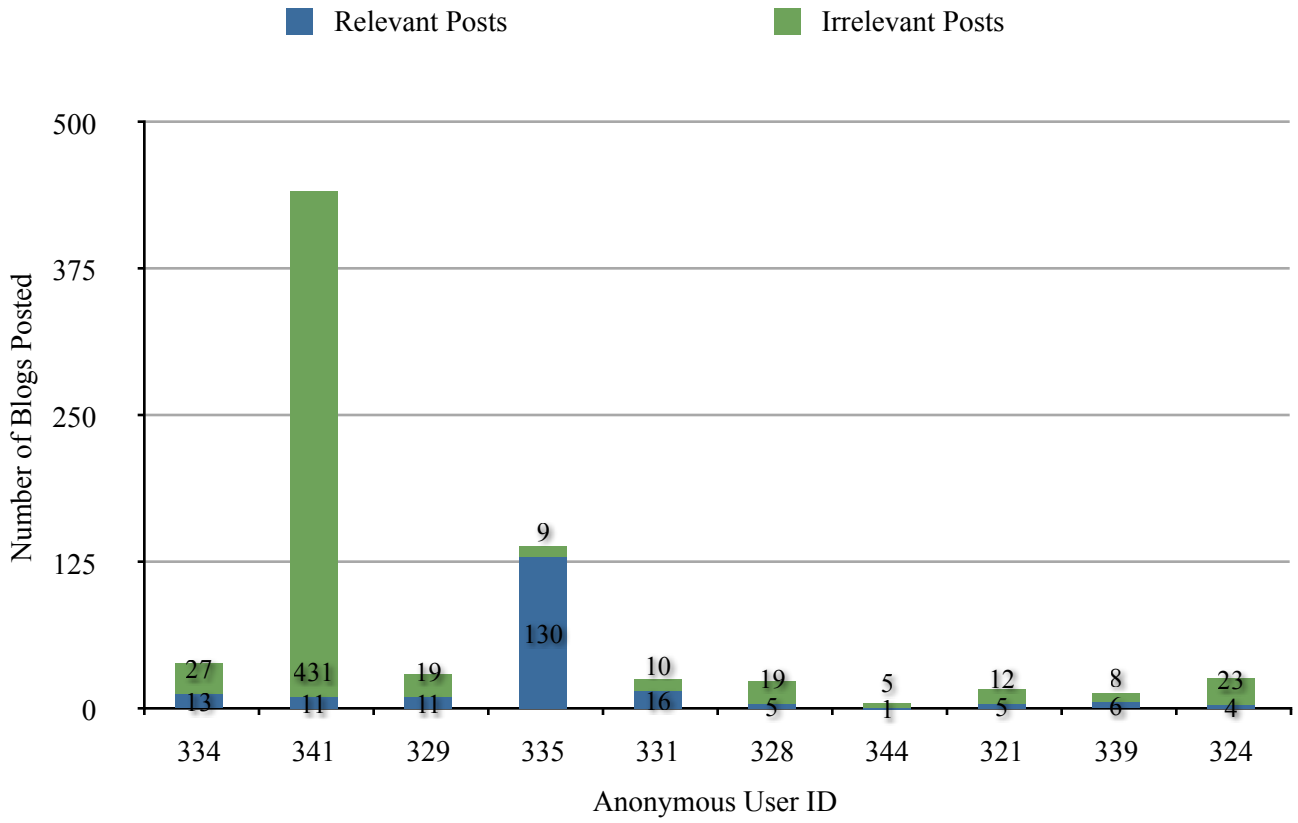


Figure 5.18 - Data on the relevance of blogs posted (excluding duplicate blog posts) for the Top 10 Users

5.5.3.2.2 Blog Post Popularity

So far, data has included all of the three different blogging activities available to the cohort. Table 5.6 breaks down this data to show number of participant blog posts spread across the different blogging activities. The high points blog post was entitled 'Why Birds Live In Trees'. This data still focuses on the top 10 users. Taking the first row in Table 5.6, user id 334 was a female who completed the first blog activity (worth 50 points) four times, the second blog activity 176 times and the third blog activity 14,924 times.

Table 5.6 - Data on how many blogs were completed by each of the top 10 users during the 1st week of the study

Anonymous User ID	Gender	'Why Birds Live In Trees' (50 Points)	'Sources Of Energy' (15 Points)	'How Do You Get To School?' (10 Points)
334	Female	4	176	14,924
341	Male	11,100	682	1,420
329	Female	3,030	3	2
335	Female	103	7	2,256
331	Female	0	277	1,423
328	Male	0	820	0
344	Male	776	0	0
321	Female	193	0	527
339	Male	561	1	134
324	Male	675	0	0

5.5.3.2.3 Participant Questionnaire Responses - Top 10 Users

Whilst post-trial questionnaire responses were collected for all users, Table 5.7 details a subset of the responses for the top 10 most prolific users (the users who interacted with *Raise A Tree* the most), analysed within this section. Starting with the top row, Table 5.7 shows that user 334 was female, rated Raise A Tree 5/5, saw *Raise A Tree* as a Learning Tool, chose the Maths Quiz as their favourite activities and the Blogging Activities as their least favourite.

Table 5.7 - Post-trial questionnaire responses for the top ten users.

#	User ID	Gender	*Raise A Tree* Enjoyment (1-5 Likert Scale)	Is *Raise A Tree* a Learning Tool or a Game?	Favourite Activity Type	Least Favourite Activity Type
1	334	Female	5	Learning Tool	Maths Quiz	Blogging
2	341	Male	5	Learning Tool	Blogging	Basic Quiz
3	329	Female	4	Learning Tool	Blogging	Video Quiz
4	335	Female	5	Learning Tool	Blogging	Maths Quiz
5	331	Female	3	Learning Tool	Blogging	Comprehension Quiz
6	328	Male	5	Learning Tool	Blogging	Video Quiz
7	344	Male	5	Game	Picture Quiz	Picture Quiz
8	321	Female	5	Learning Tool	Blogging	Maths Quiz
9	339	Male	5	Neither	Blogging	Blogging
10	324	Male	3	Learning Tool	Blogging	Blogging

5.5.3.2.4 User Activity Preferences

Whilst this chapter has already shown how blogging was the most popular activity throughout the study, Figure 5.19 shows a scatter graph of each user's most attempted activity as a percentage of the total number of activities attempted throughout the study. For example, if a user completed 10 activities in total but completed one specific activity five times, they would be awarded a score of 50%. The aim of this chart is to illustrate the high levels of participants who focussed on a narrow subset of the activities available, favouring to try and memorise all the answers to a small set of activities, rather than try their luck at mastering all of the activities.

This chart excludes activities completed during trials as these would have been completed by all participants as well as those participants who completed less that 10 activities outside of the trials, as this was a benchmark chosen to represent a third of the cohort (38 participants).

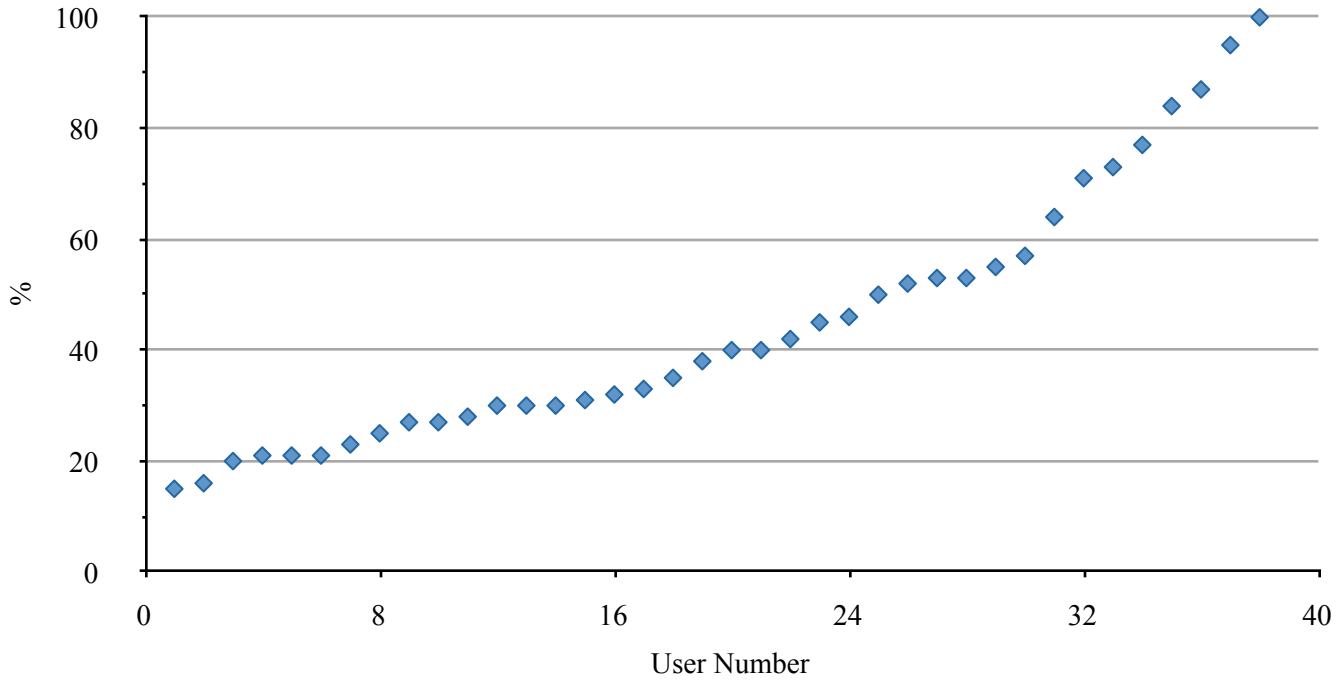


Figure 5.19 - A scatter graph displaying each user's top activity (by number of attempts) as a percentage of the total number of activity attempts they completed.

6. Analysis & Evaluation

This chapter analyses the data visualised in Chapter 5 and analyses the results compared to the hypotheses of the research questions.

6.1 - RQ1 Can e-learning resources on environmental awareness develop participant engagement?

6.1.1 Overview

RQ1 was tested through a range of qualitative and quantitative measures, primarily based on the study's questionnaires but results were also analysed from log data collected throughout the study. The research question was broken down into the following questions:

1.1 Do participants derive enjoyment from time or effort invested into using e-learning resources on environmental awareness?
1.2 Do participants perceive that they are learning within an environmental-based e-learning resource?
1.3 Can e-learning resources on environmental awareness create retention in participants?

Generally, there was an overwhelming enjoyment expressed by participants about their involvement in the study, identified throughout Figures 5.1 to 5.4. However, the first point to note is the gender-based differences evident throughout the data. Investigating participant comparisons of *Raise A Tree* against a number of other activities in Figure 5.2 creates a perception that male participants of this study appeared to be more engaged in *Raise A Tree* and less engaged in the comparable activities as represented in Figure 5.2 than their female peers. For example, opinions on whether participants prefer to use *Raise A Tree* instead of other tasks such as classroom learning, doing homework and reading were expressed more strongly by boys than girls, with boys preferring *Raise A Tree* by an average of 16% over these three activities. Taking the assumption that *Raise A Tree* was a learning tool (as was identified in Figure 5.3), male participants were on average more engaged in the e-learning system than female participants. This idea is complemented by the data that shows how males users preferred watching TV and playing video games to using *Raise A Tree* over female users by 7% and 25% respectively. However, male engagement is lessened by the data on whether participants preferred to play sport instead of use *Raise A Tree*, with boys preferring to use *Raise A Tree* by a margin of 14% over girls. With a Pearson correlation between the two gender data sets of 0.815, there is strong evidence to suggest that actually the two data sets are strongly correlated together.

Data on video games may not necessarily be entirely linked to the idea of engagement: attitudes towards whether *Raise A Tree* was more fun than playing video games may stem from participant backgrounds in playing video games and how these varied between the genders. Historically, video games have been the reserve of males (Ofcom pp. 109, 2011; Ofcom pp. 74, 2008) but whilst that trend may now be balancing there is perhaps an

argument that suggests that there is still currently a difference between the types and content of video games consumed by either gender and how that may affect where *Raise A Tree* fits within the context of the video games played by the participants of this study.

All of the activities compared in Figure 5.2 are interlinked but as alternative activities they are not homogenous, so it is difficult to draw a conclusion from their data. In addition, a critical limitation is that whilst the data represented may have been normalised across the participant population, it is not normalised across the amount of time spent on each activity by each participant. For example, participants spend a much larger proportion of their day on classroom learning than they perhaps do on watching TV or playing video games.

Overall - according to Figure 5.2 - *Raise A Tree* appears to be positioned in between academic activities (classroom learning, homework and reading) and leisure activities (playing sport, TV and video games) in terms of participant enjoyment, which correlates with its purpose as a serious educational game. However, participant perceptions of what *Raise A Tree* 'is' varied significantly between genders. In Figure 5.3 where participants were asked explicitly to classify *Raise A Tree* as either a game or a learning tool, they went overwhelmingly in favour of learning tool. Despite one of this study's aims being to introduce a large amount of game-based functionality - such as points accumulation, interactive tools and certificates - participants felt that the learning aspects of the study - educational activities, lesson plans and environmental decision points - outweighed the gaming elements. An argument to explain this classification perhaps lies with the delivery mechanism of *Raise A Tree*: since it was delivered during school time, participants perhaps automatically assumed that it was an educational product and therefore may not have considered the game-based functionality that they were using. Similar products to Raise A Tree, such as Moshi Monsters[1] and Club Penguin[2] manage to distinguish themselves more as learning assistants with an emphasis on game-functionality by presenting themselves to children outside of school hours. These sites offer the same game-based learning functionality where users accumulate points and collect awards by completing activities successfully but are utilised much more as a leisure activity than an educational one (Barnes, 2007). Two fundamental differences shared by both of these sites over *Raise A Tree* is that they offer much great 'collectibility' (in terms of virtual objects to collect) as well as an (arguably) higher level of emotional engagement with their users through bonds created with virtual objects on the site. Whilst these two examples may stand to highlight a difference between 'fun' and 'educational' activities, they also show a convergence of leisure and academic activities; something embodied by the topic of serious educational games. This point also raises the question about what defines or constitutes an educational game anymore. Despite *Raise A Tree* being largely classified by participants as a learning tool, 100% of the cohort returned to the website at least once outside of the trials, with an average of eight additional visits outside of trials (Table 5.1) in addition to a minimum of 23 minutes spent accessing the site outside of trials (average time sent outside of trials was 101 minutes). This level of engagement outside of school time either verifies the idea that serious educational games

1 http://www.moshimonsters.com

2 http://www.clubpenguin.com

can be highly stimulating and engaging for pupils to continue learning outside of school hours (and even during them) or alternatively it shows that participant perceptions of what this study was about have been skewed by some factor. This analysis is based on the understanding that learning resources and games are heterogenous when perhaps the pupils used in this study have grown up with the opposite understanding, meaning that now games are much more widely accepted as legitimate learning tools than they were a few years ago. Another analysis from this study might be to suggest that with the development and integration of serious educational games into the classroom, pupils may be confused as to what constitutes a 'game' or 'learning' anymore, which may well have repercussions for the development of serious educational games in the future. One similar criticism could lie with the concept of 'gaming the system', whereby pupils find ways of manipulating educational games to their advantage to progress individual scores or complete achievements through un-conventional methods. However, there are a number of studies that provide ways of reducing the ability of participants to manipulate and game the system (Baker et al, 2004) which should alleviate this issue, as is discussed further on in this chapter. Overall, this study has shown that there is a wealth of evidence that contradicts literature by Axe & Routledge (2011) who claim that 'the use of games in education is still rather a radical concept for many'.

Gamification - a concept of applying game mechanics or dynamics to other life problems to increase engagement and participation - is a concept embodied in serious educational games and one that school children are increasingly exposed to (Collins & Halverson, 2008). The participants in this study appear to have blurred the boundaries between what is a learning educational tool and what is a game, exemplified through the link between participants classifying *Raise A Tree* as a learning tool but then using is extensively outside of the trials. As a counter-argument, learning does not need to happen just within the boundaries of a school; it can happen anywhere and in any situation, but the point being made is that *Raise A Tree* was often more popular outside of trials than inside with participants vying to compete to earn the most points by completing activities and nurturing their virtual trees. In addition, there are authors who advocate that with different gender-based learning styles, there should be increased research and development into more innovative serious educational games because the concept of gamification (which features in serious educational games) is developing quickly and becoming more prevalent in life (Carr-Chellman, 2010; Schell, 2011).

One of the key aims and motivations of this study was to identify whether e-learning resources within an environmental context was useful in developing participants' engagement. Whilst this analysis has already identified and discussed a number of measures showing engagement throughout the cohort, there is also the need to consider whether contextualising learning affects the way that pupils identify with the topics they are being taught. To elaborate, Figure 5.9 visualises data collected on which topics participants thought they had learned something about throughout the study. Whilst it is understandable that 'Renewable Energy' came out as the highest ranked, since this study included two lessons based around Wind Power and Solar Energy. It is also understandable that topics such as 'Climate Change', 'Recycling' and 'Saving Energy' were highly ranked because a number of the activities available for pupils to complete in their own time were based on these subject

areas. The key distinction is with the disproportionately lower numbers of pupils who considered that they had learned anything about core subjects such as 'English', 'Maths' or 'Science'. Whilst each other comparisons in Figure 5.9 are inherently based on these core subjects, it seems peculiar that few pupils recognised that they indirectly had learned about these subjects through the other topics. Perhaps what this figure illustrates is a distinctive move away from a more traditional learning model and towards a more contextualised education where pupils are taught the applications of topics rather than the fundamental basics behind them. Alternatively, this result could demonstrate how pupils don't necessarily think that they are learning explicitly if they are playing games. Pupils' focus may be on knowledge accumulation and mastery (memorising the answers to activities in order to gain the most points), rather than the actual skills that are being developed. Whilst the merits of either approach is a subject outside the scope of this study, it is certainly quite pertinent to observe opinions of learners who are currently experiencing this change. Aside from the debate on contextualised learning's usefulness in the classroom, strong evidence has been provided within this study to suggest about its ability to engage with pupils and provide a platform for greater independent learning when combined with serious educational gaming.

There are a number of limitations from this research question that have limited the analysis that can be drawn from the data collected. One such limitation was the comparison of *Raise A Tree* to other activities (Figure 5.2). Whilst this question produced results that were useful in analysing the position of *Raise A Tree* as a learning tool and game, it was not fair to make strong assumptions due to the varying amounts of time spent by participants on each activity (ie a user may spend much longer involved in *Classroom Learning* than they do *Watching TV* during a standard week). Another limitation that affected this study was in the 'extensiveness of gaming strategies exhibited by some participants throughout the first week of trials. This limitation specifically affected the outcomes of some engagement aspects, such as Figures 5.7 and 5.8. The analysis of RQ3 will expand on this issue and how it was managed throughout the study.

The key points to evaluate this research question are that this study has produced a variety of evidence to suggest that participants not only derive enjoyment from using e-learning resources on environmental topics but also how participant perceptions of learning were discovered throughout the study. There are several key distinctions between the ways that male and female participants approached and used the educational website that was developed and questions over the definition of what constitutes an effective serious educational game have been raised. Potential extensions to this research question include further analysis of the data collected to analyse the different uses and learning value of contextualised serious educational gaming across both male and female participants: there have been calls for the use of more educational games in order to (re)engage male pupils particularly in education through a means that they can relate to (Carr-Chellman, 2010) and it would be enlightening to test this hypothesis, especially within the context of an contextualised learning environment. This study has also alluded to a number of features tested that led to a greater level of interest and emotional engagement with this cohort but also suggested a number of other commercial game sites that feature additional functionality, such as the notion of collectibility. As an extension to this study, monitoring and quantifying the

benefit and value that 'collectibility' can bring to a serious educational game would add significant benefit and retention to the development of more useful, fun and engaging tools in the future.

6.2 - RQ2 Do pupils conform to social norms when answering Environmental Decision Points?

6.2.1 Overview

RQ2 was tested through a series of Environmental Decision Points, aimed at discovering participants' perceptions of global social issues as well as their desire to progress in a competitive, points-based serious game. Decision points featured a set structure of a question and three answers; points for each choice varied per decision point and are all detailed in Appendix 2.

Analysis of this research question will be split down across the following two questions:

2.1 To what extent do male and female participants focus on selfish and ethical decision making within e-learning resources on environmental awareness?

2.2 Do participants' ethical decision making choices vary over time in e-learning resources on environmental awareness?

Overall, informal feedback from participants during trials suggested that the decision points were quite fun and there were a number of calls for more 'quizzes' as they became to be known to be added. Discussion in this section will be split between first and second choice answers, followed by analysis of some of the reasons participants decided to change their minds.

6.2.2 First Choice Responses

The expected result for this research question was that participants would initially choose the selfish option from the Environmental Decision Points in order to gain more personal points and rise higher up the league tables. It was then expected that participants would change their minds to the ethical (socially responsible) option after they were provided with more information. However, the results show that the majority of people chose the ethical option straight away and then (generally) maintained their initial choice even when presented with extra information.

Considering gender-specific outcomes that can be recorded from the data on the decision points, the Pearson correlation detailed in Table 5.3 shows that there was a strong positive correlation between male and female participants on the selfish and ethical choices, but much less so on the local choice. The Pearson correlation was taken to see whether the data on male and female participants was linked in any way. The results of a Pearson correlation will tend towards -1 for a strong negative correlation, +1 for a strong positive correlation and 0 for no correlation.

The results for the selfish and ethical choices in Table 5.3 (0.865 & 0.890) show that the two data sets had a strong positive correlation, indicating that they were linked to one another. However, the results for the local choice decisions (0.349) were weaker indicating there was little correlation between the two at all. Figure 5.11 shows in more detail the choices made by both genders throughout the study. If only the local choices are observed, the results in Figure 5.11 show that girls outvoted boys consistently in six out of the eight decision points.

Analysing the gender data further, it appears that there is a near perfect negative correlation between when male participants chose a selfish choice and when female participants chose an ethical choice and vice-versa (see Table 5.4). What this means is that during the course of the experiment, whenever a male participant chose the selfish choice, a female participant was almost entirely likely to choose a ethical choice and vice-versa. There does not appear to be any explanation for this outcome. Figure 5.10 shows that the effect that this study had on participants was to make them less socially responsible, identified through a switch from ethical choices to more selfish choices over the course of the study. There are a number of reasons why this may have occurred:

1. As participants began to understand more about the study and its aims, their interest may have switched from sociability to greed and personal success. This outcome was validated by informal comments noted during trials about why participants were choosing particular options. In addition, it was observed that in some classes when the latter decision points were activated, some participants did not even stop to read the question text before choosing the option they wanted to have. One reason for this problem was that the structure of the questions was generally quite similar and so after answering a certain number of decision points, participants perhaps realised that they knew that the structure would be the same and it was just the context that had changed. When analysing the results of individual decision points and the amount of points available for each choice, it is clear to see in Figure 5.10 that for decision five - where participants who chose the selfish option received 0 points - there were 9% of the total cohort (10 participants) who chose the an option that benefitted no one. From decision points six to eight (inclusive), the points awarded remained equal across the three options but instead the wording on the screen that provided additional information changed to see whether participants would change their mind if the country who had experienced the environmental problem stated that they no longer required any help. The point to note here is that this is probably the reason for the increase (and stabilisation) of selfish and ethical choices in these points.

2. Another potential reason for the switch away from being more socially responsible could be the number of decision points that participants were required to answer throughout their three planned trials. Two decision points were activated during the first trial with three more in each subsequent trial. Informally, it was observed during trials that the competitive atmosphere that developed throughout the trials as participants were completing other activities may have led participants to more selfish choices being made in order to advance personal development in the league tables.

Overall - as is shown by the results in Figure 5.10 - there is a clear transition from ethical decision choices to selfish decision choices between decision points one and five. It is quite pertinent to observe the change that happened between decision points six and eight when the points and text changed.

6.2.3 Second Choice Responses

The second choice responses detail the options chosen by participants after being provided with more information in the environmental decision points. The purpose of providing more information was to try and influence participants into changing their mind from their original choices. The analysis from the outcomes of the second choice responses (Figures 5.12 and 5.13) appears to show that as the study progressed, participants seemed to become more knowledgable about the repetitive nature of the environmental decision points. There is a steady downward trend throughout all three indices as is displayed in Figure 5.12 with the exception of the selfish choice for decision seven which appears to be an anomaly.

With regard to gender differences, the data on Pearson's correlation calculated and displayed in Table 5.5 shows the opposite effect to the first choice decisions. Instead of there being a **strong positive correlation** between the selfish and ethical options, the second-choice data had almost **no correlation** between the selfish and ethical choices at all. Additionally, the local choice option showed a **strong positive correlation** in the second choice data between the genders, compared to a **weak positive correlation** in the first choice data. What this shows is that whilst participants exhibited similar patterns of first choice decisions, they **differed significantly** with their second choice decisions, such that male and female participants were almost certain to choose opposite second choice answers **if** they changed their minds, perhaps alluding to the idea that female participants concentrated or remained focussed for longer.

Perhaps the most logical reason for the steady downward trend in all three indices (as well the increase in the number of participants not changing their mind) is defined by the increasing awareness and strategic or competitive behaviour of participants. As was mentioned in Section 6.2.2, the structure of the decision points was relatively strict, perhaps allowing the participants to begin to understand the structure quickly and change their behaviour accordingly.

Overall, there was an overwhelming trend of initially choosing an ethical decision point at the start of the study but this changed as the study progressed in a downward trend towards both genders favouring more selfish choices by the end. On gender differences, there were strong correlations between the decision made with the first choices but when participants changed their minds each gender was likely to choose a different option. The most curious of results recorded was with first choice data where there appeared to be a near perfect negative correlation such that when a male participant chose a selfish choice, a female participant was almost always likely to choose an ethical choice (and vice versa).

Arguably the main limitation of this research question was that the language of the decision point questions was deemed retrospectively to be too extreme. To try and maintain continuity, large-scale environmental disasters were chosen for each decision point to create an scenario of severity. In retrospect, the use of scenario text such as, 'There have been severe floods in Pakistan and millions of people have had their homes swept away' as well as, 'There has been a chemical explosion in the Amazon rainforest' perhaps may have shocked participants at first but then reduced in significance as the study progressed. As an extension, the content of the decision points could be amended to contain an environmental scenario closer to home and be toned down slightly. An example may be: 'Several schools in your local area have been flooded - would you like to contribute to the general relief efforts', or further the names of particular neighbouring schools could be used to add in an emotive, Selfish Response to the decision point. The hypothesis for this extension would be that participants would be much more likely to choose a **less selfish option** if they knew that they or people around them had been personally affected. However, the aim of this research question was to test participants' decisions based on their global social awareness and so within this context, the results seem to match their purpose.

Another limiting factor that must be acknowledged is the influence of external factors to decisions made during individual trials. The extent to which competitive factors or peer-based pressure influenced particular cohorts throughout the study has not been quantified during this analysis but may have affected the results to some extent. Retrospectively, there is very little that could have been amended on the experimental decision to limit the impact of competitive behaviour on this research question apart from perhaps reducing the volume of decision points tested during each trial. Additionally, removing the points incentive in the decision points - which appears to have generally influenced participants to switch from ethical choices to selfish choices - could lead to a much more accurate reflection of participants thoughts and motivations.

As an extension to this research question, the complete removal of a points-based incentive could prove significant with a new cohort of participants; data from this study has shown how the points incentive appeared to be the driving force behind participants changing their minds and so removing it could perhaps identify a truer reflection of the decisions participants would make in the scenarios posed. The other influencing factor that would be recommended for change in a new study would be the choice of contexts for the individual decision points to vary from being very distant (eg 'A school in New Zealand') to being very personal (eg 'A neighbouring school has been affected') to being. Decision points could also vary based on developing and developed countries to see if participants' opinions varied depending on the particular development of the country in need.

6.3 - RQ3 What gaming strategies are used in a competitive points-based online game?

6.3.1 Overview

Similarly to RQ1, RQ3 was tested through a mix of qualitative and quantitative measures and aimed to test the extent to which participants engaged in gaming strategies as well as what the motivations for those strategies

were. ‘Gaming strategies’ were defined as actions or traits that participants exhibited during the trials that formed some form of logical process towards winning in a points-based environment.

Analysis of this research question will be split down across the following two questions:

3.1 To what extent do participants exhibit gaming strategies within e-learning resources on environmental awareness?
3.2 How are gaming strategies within e-learning resources on environmental awareness used by participants?

Overall, there were a significant number of strategies documented within the first week of the study, which included just two classes from Walkergate Primary School. Due to the extent and volume of usage of the website during the first week, the majority of this analysis will focus on this early period. In general, the first week of the study experienced a significant level of gaming strategies: participants using the points based mechanism on the website to artificially improve their positions’ within the study’s league tables. One particular gaming strategy stemmed from the ability to re-submit blog posts multiple times simply by clicking the ‘Submit Blog Post’ button continuously. Every time the submit button was pressed, the points were awarded to the user and the blog post was registered in the system’s database but the code to stop the user re-posting duplicate blog posts was not triggered. Whilst this mechanism for promoting gaming strategies may not have been initially envisaged on this scale, one of the aims of the study was to promote a competitive, points-based environment to assess gaming strategies and as such this practice alone has provided a vast quantity of data to analyse and evaluate. It would be inappropriate to make real conclusions based on the practices of just two classes in this study over a one week period, but still the results are significant enough to potentially move forward to a more controlled second experiment.

6.3.2 Earning Points

Figure 5.15 details the amount of times throughout the study when users clicked on the right-hand column of the *Raise A Tree* site (see Appendix 3.1) to earn more points. The three links were identical but were grouped under the participant’s personal, class and environmental points to see which would be the most popular option. Overwhelmingly, personal points was shown as the most popular, carrying 81% of all links clicked with the class link at 10% and environmental link at 8%. It is understandable to see why the personal link may have been the most popular: it’s position on the page was the first that participants would see and the closest to the top of the page. However, such a large difference between the personal and class link and the class and environmental link perhaps give weight to the argument that participants were more focussed towards personal points collection, which correlates with the rest of the data analysed in Section 6.3.

6.3.3 Competition & Gaming Strategies

Due to the extent of the use of gaming strategies by submitting blog posts, data for this research question compares the strategies employed across the whole site during the first week for the **top ten users** who posted the most blogs.

The first point to analyse within RQ3 is what the motivation was behind participants using gaming strategies during the study. Evidence of certain motivations are disclosed in Appendices 5.7 - 5.10 where participants were asked about the best and worst features of the website and any features they would add or remove to make it better. As can be seen, there are a number of participants who explicitly mention competitive behaviour and points accumulation as a motivator during their usage of the system ('competitive points' and 'compete against your friends and other classes'). Whilst there are a number of participants who mention being able to cheat as the best part of the system, there were also some participants who deplored the practice either through informal remarks or through the post-trial questionnaire. Informally, one participant was heard explicitly lamenting the 'cheats' during a trial as she felt that it made it less fair on everyone else that people were solely focussed around collecting points.

An analysis of the top ten blog posters indicated some unusual statistics: whilst the top ten participants were made up five male and five female participants, the top five users were made up from one male and four female participants, showing that the practice of posting excessive numbers of blog posts was much more prevalent amongst female participants, contradictory to prior research (Ofcom, 2008; Ofcom, 2010). In addition, Figure 5.17 which displays the number of blogs posted by each user in the top ten clearly shows that the number of blogs posted by the top five users differs significantly from the second five participants showing again that the use of gaming strategies was carried out disproportionately by female participants.

Despite female participants being much more likely to use gaming strategies like re-posting blogs, the actual blogs that they chose to duplicate their posts in were generally not in the highest scoring activity (the 'Hidden Gem' blog post, detailed in Section 3.4 - Table 3.2 - Feature 9). Table 5.6 shows that only one female participant in the top ten users posted the majority of their blogs in the maximum scoring activity (User 329), compared with four out of the five male participants who found the highest scoring blog and focussed their attention on it. Additionally, Table 5.6 shows that only one female participant in the top ten users managed to implement a successful gaming strategy by re-posting the highest scoring blog post. Whilst seven out of the ten top users posted duplicate blogs across a number of different activities, three users exhibited what appeared to be a very strategic approach to gaming strategies by focussing almost solely on the blog post with the highest number of points. These users - 329 (female), 344 (male) and 324 (male) - are curious to investigate because the two male users didn't post in any blogging activity other than the highest scoring one, and the female user only posted 5 posts in blogs that **weren't** the highest scoring. There are a number of potential reasons why these users may have chosen the highest scoring blog initially, such as overhearing peer feedback within the classroom that indicated which was the highest scoring activity to do, although unfortunately due to the lack of audio and video

recordings this hypothesis will not be able to be tested. Another reason may have been that after discovering the high scoring blog (and potentially comparing it to their activity scores from other quiz activities) they made the decision to focus all their efforts on this one activity. Whilst this strategy may seem slightly narrow-minded, it was also identified when analysing the logs from all user activity during the study (a subset of which is detailed in Appendix 6).

Continuing to analyse the completion rates of different activities completed during the study, Figure 5.19 shows a scatter plot of all users against their favourite activity (defined by the highest number of attempts) as a proportion of their total number of activity attempts. For example, if a user completed one activity four times and eight activities in total, their proportional score would be 50% on the scatter plot. Whilst Figure 5.19 only includes the most active third of the cohort, the significant statistic is that approximately 12% of participants (14 out of 113 users) completed just one activity over 50% of the time. Considering this study's methodology that stated that the number of questions in each activity was designed to be around 20 questions and for each activity attempt 10 questions would be selected randomly, statistically each participant only needed to complete each activity five times before getting the same questions over again. With the average number of maximum attempts throughout the top third of the demographic (as detailed in Appendix 6) at 15 attempts, there is a clear indication that users were repeating activities that they had memorised the answers to in order to gain more points. The only counter-argument to this point is the duration between the attempts as a participant's memory which may have served as a factor against rote repetition.

Looking at an analysis of the post-trial questionnaire results from the top ten users in Table 5.7, only one participant considered *Raise A Tree* to be a game. On average - as is displayed in Figure 5.3 - 82% of participants of this study considered *Raise A Tree* to be a learning tool, rather than a game. The reason this point is highlighted is that the top ten users analysed in this research question have all exhibited the 'gaming' functionality of *Raise A Tree*: actively progressing through the system by collecting points and increasing their level as well as competing with one another to succeed. The focus of the study had a strong educational undertone as the activities linked to educational material. This perhaps leads to the conclusion that with serious educational games, pupils can be highly engaged but generally are not able to recognise that what they are actually doing is simply playing a game. Serious educational games rose in popularity because of their highly engaging nature and there are a wealth of studies that point to their success at providing ways of delivering and teaching material in an innovative and interactive way. However, perhaps the direction of research should now focus on the extent of what can be achieved through the illusion of an educational resource: how far can the boundaries of serious educational games be pushed before their novelty expires or participants understand the reasoning behind the delivery platform of the game.

To summarise, this discussion has shown that gaming strategies were used extensively by a small proportion of the two control groups at Walkergate School. The use of gaming strategies (by both genders) was mixed with some participants executing points-accumulation strategies more successfully than others.

Overall, the most limiting factor from the analysis of RQ3 is that the extent to which gaming strategies were used by participants impacted upon the study's planned data collection. Whilst the study's experimental design had to be amended, extensive data was still collected throughout the first week that shows how several significant gaming strategies were adopted by the participants of the first two classes at Walkergate School. It was a difficult decision to fix the technical vulnerability with the site during the study but the validity of the data collection for the remaining research questions were in jeopardy if the practice of posting excessive numbers of blog posts were to continue.

6.4 Study Limitations

6.4.1 Technical Limitations

The main technical limitations of this study can be summarised as:

1. User access vulnerabilities
2. Platform load issues.

User access relates to the simplified username and password system adopted for the purposes of this study to make access to the website easier for participants. However, with the simplification came the vulnerability that participants may have been able to access other user accounts. Although this was not reported, it is not clear whether this happened and whether any of the results were affected as a result.

Secondly, the platform upon which the website was delivered strained under the amount of use given to it throughout the first week of the study. As a result, the technical setup had to be amended slightly to prevent users from posting more than five blog posts per day in order for the remainder of the study to be carried out successfully. The result of this amendment was that data for the third research question could only really be considered before the amendment was made as this would have then become an influencing factor for the rest of the study.

6.4.2 Experimental Limitations

With regards to experimental limitations, these can be split into three areas:

1. Participant demographics
2. Time intervals between trials
3. Trial school levels

Firstly, the method for selecting schools was very open in order to maintain fairness and not restrict access, it resulted in three schools located very close to each other participating in the study. Achievement results and metric information is detailed for each school in Appendix 1 but this information was not considered for the

purposes of this study, which means that there may be external factors that could have affected results based on individual school results.

Secondly, during the experimental planning for this study, it was envisaged that each participant school would follow a strict schedule for trials to ensure that equal amounts of time existed between pupils accessing the website in a formal environment. Unfortunately, due to school commitments and industrial action, the dates of some trials had to be moved in order for them to go ahead and so the time between each trial was different for each school, which may have affected results through a level of familiarisation with participants.

Finally, a cancellation meant that only one secondary school participated in this study resulting in an unequal measure of Year 7 pupils tested for comparison purposes.

6.5 Threats To Validity

One factor not considered during the experimental setup of this study was the setup of the computer rooms upon which the study was carried out across the three schools. Whilst this point remained outside of the scope of the study, Cragside and Benfield School featured slightly older horseshoe-shape setups where pupils sat next to each other in a line of desks around the room whereas Walkergate School featured four octagonal tables. The result of this distinction may have affected the way that participants communicated with each other and shared information throughout the study.

7. Conclusions

This study aimed to answer the following questions:

1. Can e-learning resources on environmental awareness develop participant engagement?
2. Can e-learning resources on environmental awareness be used to develop ethical decision making?
3. Do participants exhibit gaming strategies within e-learning resources on environmental awareness?

7.1 - Can e-learning resources on environmental awareness develop participant engagement?

Firstly, the quantitative and qualitative data collected from this study has indicated that a high level of engagement can be gained from this contextual game-based learning system. All of the metrics measured throughout this study point to a positive response from the participants and most illustrate an overwhelmingly positive response. However, perhaps the key result from this part of the study was the identification by the cohort that this game-based system was more of a learning tool than it was a game for them, which identifies an additional area of research based around the convergence of serious educational games and e-learning systems. This study has identified and corroborated research that suggests game-based learning systems can be highly engaging, interactive and fun whilst also maintaining an educational hook as well. The key question for any future work is in identifying whether this engagement can be used effectively in the longer-term effect or whether as serious educational games become more mainstream whether the engagement levels will diminish. In addition, a question remains as to whether if the delivery of this study had been altered to be less of a classroom-based activity that could also be accessed from home, whether participants' perceptions of *Raise A Tree* as a learning tool might change more towards being a game. From an e-learning perspective, the balance of *Raise A Tree* being highly engaging whilst also being classified as a learning system is perhaps ultimately more advantageous since it allowed participants to continue learning outside of the classroom. An extension to this study could be to investigate the longitudinal effects of such a learning system, especially within the motivation of male participants and how serious educational games may help them to increase their educational engagement further. Monitoring and evaluating educational value or emotional engagement in serious educational games that feature more 'collectability' as a route to enhancing and prolonging the educational engagement experience may prove to be useful longer term.

7.2 - Can e-learning resources on environmental awareness be used to develop ethical decision making?

With regards to developing ethical decision making, this study has suggested that serious educational games can be used to manipulate participants' opinions so that they want to change their mind, as was exhibited in the results from the Environmental Decisions Points. However, as was stated in Section 6.2, the expected results were actually reversed with participants favouring more ethical choices initially and then changing them to more selfish ones afterwards. The most intriguing result from RQ2 was displayed in Table 5.4 with a comparison of Pearson correlations between the choices made by male and female participants. The results showed that when a male participant chose a selfish choice, a female participant was almost always likely to choose the ethical

choice. This pattern also happened in reverse as well for when female participants chose selfish choices and male participants chose ethical choices. The reasoning behind this result is still unclear so it would be prudent to assess this result again in another controlled experiment to identify whether a pattern could exist.

As this study progressed, participants were observed to change their minds less on Environmental Decision Points, perhaps due to participants' growing familiarity with the concept or perhaps because they more more focussed around accumulating points to compete against their peers. Changing the format of the Environmental Decision Point questions might help to identify true participant motivations around this functionality: one change suggested in Chapter 6 would be to change the format of the questions to reflect an environmental disaster much closer to home for the participants in order to identify whether a more personal nature might affect their responses. In addition, making the second-choice information more personal may affect the decisions of participants into changing their mind more than in this study. An example could be suggesting that the school just down the road had made a decision, would the participants like to change their mind as well.

One of the biggest problems with the Environmental Decision Points feature was their diminishing effect as the study progressed but no data was collected to evaluate whether participants were necessarily reading the questions each time or whether they were just choosing an option and continuing. To verify this assumption, data could be collected on the time between showing participants a question and receiving their response.

What this study has shown is that it is possible to influence participants of this demographic through different scenarios but looking at this with a wider view it may be useful to plan an experiment to see what impacts this kind of study has on wider participant behaviour and the results of real-life decisions made outside of *Raise A Tree*.

7.3 - Do participants exhibit gaming strategies within e-learning resources on environmental awareness?
Owing to the technical issues faced during the early part of this study, data was unfortunately limited to the two classes of the first school. However, the analysis of the results collected form just the first two classes showed that there were several variations between genders when it came to using gaming strategies within this study as well as variations in gaming strategies implemented. Tables 5.6 and 5.7 give good overviews of the demographic traits of the users who used gaming strategies most within this study's opening fortnight, showing that it is not necessarily implicit that if a participant uses a gaming strategy, they are necessarily going to execute it in the most advantageous way. The result of this process is that additional studies could be designed to explicitly try and trick participants into adopting certain strategies throughout the usage of a system such as *Raise A Tree* in order to identify how long a participant could be manipulated before they realised the truth behind what was going on.

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9. Appendices

Appendix 1. Participant School Performance Data

1.1 - Walkergate Primary School

Collected from: http://www.education.gov.uk/cgi-bin/performancetables/school_10.pl?Mode=Z&Base=p&Type=SC&Year=10&Phase=p&Begin=f&No=3912880&Num=391

Last accessed: 13th September 2011

Walkergate Primary School

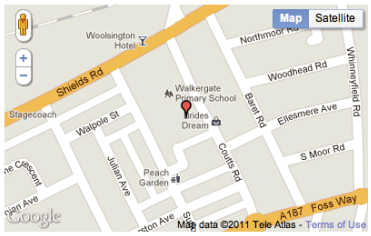
Print ›

Address:
Sutton Street
Walkergate
Newcastle-upon-Tyne
NE6 4SD

Phone:
0191 2655737

Age range:
4-11

Attributes (click for explanation):
CY
R



Background Information

Total number of pupils on roll (all ages)	451
Pupils with statements of SEN or supported at School Action Plus: number	37
Pupils with statements of SEN or supported at School Action Plus: percentage	8.2%
Pupils with SEN, supported at School Action: number	78
Pupils with SEN, supported at School Action: percentage	17.3%
Number of pupils on roll aged 10 as at 31 August 2009	80

Contextual Value Added

KS1-2 CVA Score	~
Lower Limit of CVA Confidence interval	~
Upper Limit of CVA Confidence interval	~
Coverage indicator - % of pupils at the end of KS2 included in CVA calculation	~

Key Stage 2 Test Results 2010

Published eligible pupil number	78
Eligible pupils with SEN with a statement or supported at School Action Plus: number	13
Eligible pupils with SEN with a statement or supported at School Action Plus: percentage	16.7%
Eligible pupils with SEN supported at School Action: number	7
Eligible pupils with SEN supported at School Action: percentage	9.0%

both English and Mathematics

Percentage achieving Level 4 or above in both English and mathematics	~

English

Percentage of pupils achieving Level 4 or above in English	~
Percentage of pupils achieving Level 5 in English	~
Percentage of pupils absent from or not able to access the tests in English	~

Mathematics

Percentage of pupils achieving Level 4 or above in mathematics	~
Percentage of pupils achieving Level 5 in mathematics	~
Percentage of pupils absent from or not able to access the tests in mathematics	~

All subjects

Average point score	~

Year on year comparisons

Average point score

Average point score 2007	27.4
Average point score 2008	26.8
Average point score 2009	26.7
Average point score 2010	N/A

% level 4+ in both English and maths

Percentage achieving Level 4 or above in both English and maths 2008	69%
Percentage achieving Level 4 or above in both English and maths 2009	64%
Percentage achieving Level 4 or above in both English and maths 2010	N/A

Key Stage 2 Teacher Assessment 2010

English

Percentage achieving Level 4 or above in English TA	79%
Percentage achieving Level 5 in English TA	44%
Percentage absent or disapplied in English TA	0%

Mathematics

Percentage achieving Level 4 or above in maths TA	77%
Percentage achieving Level 5 in maths TA	26%
Percentage absent or disapplied in maths TA	0%

Science

Percentage achieving Level 4 or above in science TA	81%
Percentage achieving Level 5 in science TA	27%
Percentage absent or disapplied in science TA	0%

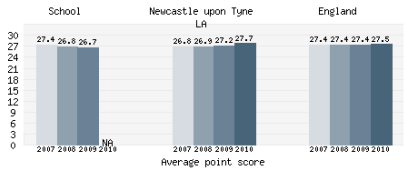
Progress Measures from KS1 - KS2

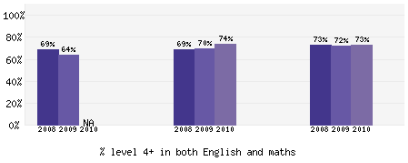
Percentage of pupils achieving the expected level of progress in English	~
Percentage of pupils included in the calculation of the English progress measure	~
Percentage of pupils achieving the expected level of progress in maths	~
Percentage of pupils included in the calculation of the maths progress measure	~

Absence record for day pupils of compulsory school age (Autumn term 2009 and Spring term 2010 combined)

Overall absence	5.5%
Unauthorised absence	1.3%
Persistent absence	2.8%

School statistics





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1.2 - Cragside Primary School

Collected from: http://www.education.gov.uk/cgi-bin/performancetables/school_10.pl?Mode=Z&No=3912170&Type=LA&Begin=f&Num=391&Phase=p&Year=10&Base=p

Last accessed: 13th September 2011

Walkergate Primary School

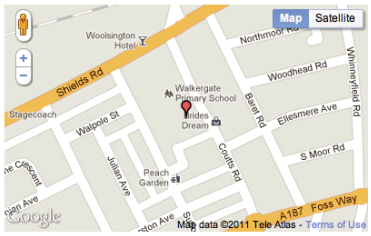
Print ›

Address:
Sutton Street
Walkergate
Newcastle-upon-Tyne
NE6 4SD

Phone:
0191 2655737

Age range:
4-11

Attributes (click for explanation):
CY
R



Background Information

Total number of pupils on roll (all ages)	451
Pupils with statements of SEN or supported at School Action Plus: number	37
Pupils with statements of SEN or supported at School Action Plus: percentage	8.2%
Pupils with SEN, supported at School Action: number	78
Pupils with SEN, supported at School Action: percentage	17.3%
Number of pupils on roll aged 10 as at 31 August 2009	80

Contextual Value Added

KS1-2 CVA Score	~
Lower Limit of CVA Confidence interval	~
Upper Limit of CVA Confidence interval	~
Coverage indicator - % of pupils at the end of KS2 included in CVA calculation	~

Key Stage 2 Test Results 2010

Published eligible pupil number	78
Eligible pupils with SEN with a statement or supported at School Action Plus: number	13
Eligible pupils with SEN with a statement or supported at School Action Plus: percentage	16.7%
Eligible pupils with SEN supported at School Action: number	7
Eligible pupils with SEN supported at School Action: percentage	9.0%

both English and Mathematics

Percentage achieving Level 4 or above in both English and mathematics	~

English

Percentage of pupils achieving Level 4 or above in English	~
Percentage of pupils achieving Level 5 in English	~
Percentage of pupils absent from or not able to access the tests in English	~

Mathematics

Percentage of pupils achieving Level 4 or above in mathematics	~
Percentage of pupils achieving Level 5 in mathematics	~
Percentage of pupils absent from or not able to access the tests in mathematics	~

All subjects

Average point score	~

Year on year comparisons

Average point score

Average point score 2007	27.4
Average point score 2008	26.8
Average point score 2009	26.7
Average point score 2010	N/A

% level 4+ in both English and maths

Percentage achieving Level 4 or above in both English and maths 2008	69%
Percentage achieving Level 4 or above in both English and maths 2009	64%
Percentage achieving Level 4 or above in both English and maths 2010	N/A

Key Stage 2 Teacher Assessment 2010

English

Percentage achieving Level 4 or above in English TA	79%
Percentage achieving Level 5 in English TA	44%
Percentage absent or disapplied in English TA	0%

Mathematics

Percentage achieving Level 4 or above in maths TA	77%
Percentage achieving Level 5 in maths TA	26%
Percentage absent or disapplied in maths TA	0%

Science

Percentage achieving Level 4 or above in science TA	81%
Percentage achieving Level 5 in science TA	27%
Percentage absent or disapplied in science TA	0%

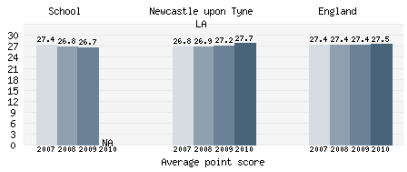
Progress Measures from KS1 - KS2

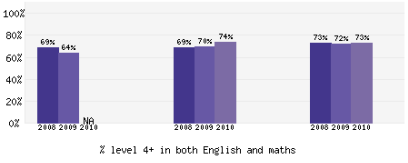
Percentage of pupils achieving the expected level of progress in English	~
Percentage of pupils included in the calculation of the English progress measure	~
Percentage of pupils achieving the expected level of progress in maths	~
Percentage of pupils included in the calculation of the maths progress measure	~

Absence record for day pupils of compulsory school age (Autumn term 2009 and Spring term 2010 combined)

Overall absence	5.5%
Unauthorised absence	1.3%
Persistent absence	2.8%

School statistics





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1.3 - Benfield Secondary School

Collected from: http://www.education.gov.uk/cgi-bin/performancetables/school_10.pl?Mode=Z&No=3914480&Type=LA&Begin=b1&Num=391&Phase=1&Year=10&Base=b

Last accessed: 13th September 2011

Benfield School

Address:
Benfield Road
Newcastle-upon-Tyne
NE6 4NU

Phone:
0191 2656091

Age range:
11-18

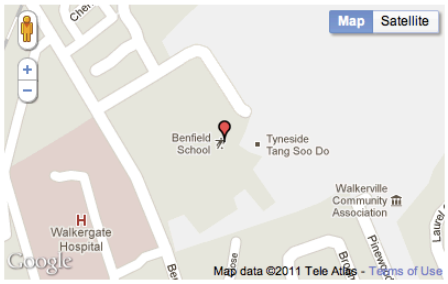
Gender:
MIXED

Attributes (click for explanation):

CY

Sp

COMP



School can be found in the Key Stage 5 tables ›

Background Information

Total number of pupils (all ages)	838
Total number of pupils with SEN, with statements or on School Action Plus	102
% of pupils with SEN, with statements or on School Action Plus	12.2%
Total number of pupils with SEN, supported at School Action	173
% of pupils with SEN, supported at School Action	20.6%

Cohort Information for pupils at the end of Key Stage 4

Number of pupils at the end of Key Stage 4	143
% of pupils at the end of KS4 aged 14 or under	0%
% of pupils at the end of KS4 aged 15	100%
Number of pupils with SEN with statements or on School Action Plus	14
% of pupils with SEN with statements or on School Action Plus	9.8%
Number of pupils with SEN supported at School Action	34
% of pupils with SEN supported at School Action	23.8%

GCSE and equivalent achievements of pupils at the end of Key Stage 4

% of pupils at the end of KS4 achieving Level 2 including English and maths	39%
% of pupils achieving the English Baccalaureate	6%
% of pupils achieving A*-C GCSE in English and mathematics	40%
% achieving English and maths Skills at Level 2	40%
% achieving English and maths Skills at Level 1	89%
% achieving Level 2 threshold (the equivalent of 5+A*-C)	75%
% achieving Level 1 threshold (the equivalent of 5+A*-G)	89%
% of pupils at the end of Key Stage 4 who achieved two GCSEs or equivalent at grades A*-C which cover the Key Stage 4 science programme of study	71%
% achieving A*-C in one full MFL GCSE or equivalent	15%
% achieving A*-G in one short course MFL GCSE or equivalent	20%
% achieving at least one entry level qualification	96%
Average total point score per pupil (uncapped)	389.6

Key Stage 2 to 4 Contextual Value Added Measure

Key Stage 2 to 4 contextual value added measure	1012.1
Upper limit of CVA confidence interval	1022.8
Lower limit of CVA confidence interval	1001.4
Coverage indicator - % of pupils included in Key Stage 2 to 4 CVA	97%
Average number of qualifications (equiv to GCSE) taken by pupils included in Key Stage 2 to 4 CVA	9.6

Key Stage 2 to 4 Progress Measure

% of pupils achieving the expected level of progress in English	53%
%of pupils at the end of Key Stage 4 included in the calculation of the English progress measure	87%
% of pupils achieving the expected level of progress in maths	55%
% of pupils at the end of Key Stage 4 included in the calculation of the maths progress measure	92%

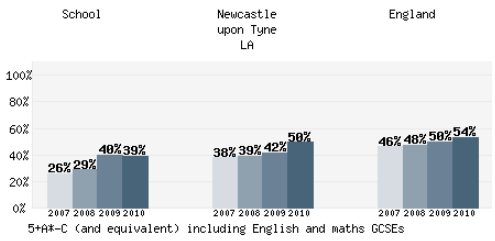
Absence

% of half days missed due to overall absence	10.9%
Unauthorised absence	4.8%
Persistent absence	11.6%

Year on year comparisons

5+A*-C (and equivalent) including English and maths GCSEs results over time

% of KS4 achieving Level 2 threshold including English and mathematics - 2007	26%
% of KS4 achieving Level 2 threshold including English and mathematics - 2008	29%
% of KS4 achieving Level 2 threshold including English and mathematics - 2009	40%
% of KS4 achieving Level 2 threshold including English and mathematics - 2010	39%



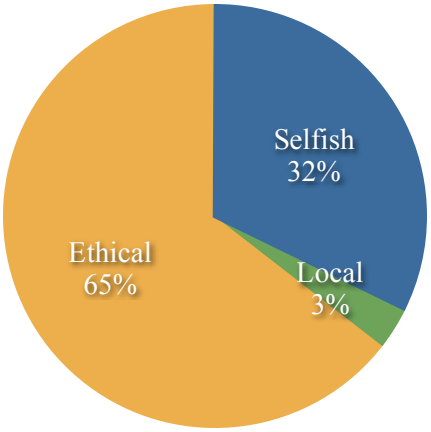
Appendix 2. Environmental Decision Point Questions

2.1 Floods in Pakistan

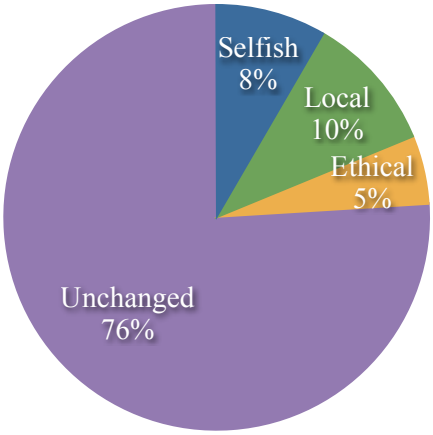
Question: *There are severe floods in Pakistan and millions of people have had their homes swept away, resulting in a reduction of 200 Environmental Points. You come across 100Kg of seeds - what would you like to do with them?*

Selfish Response: Plant them yourself (200 Points)
Local Response: Donate them to your Class (200 Points)
Ethical Response: Send them to Pakistan to help people grow more crops (200 Points)

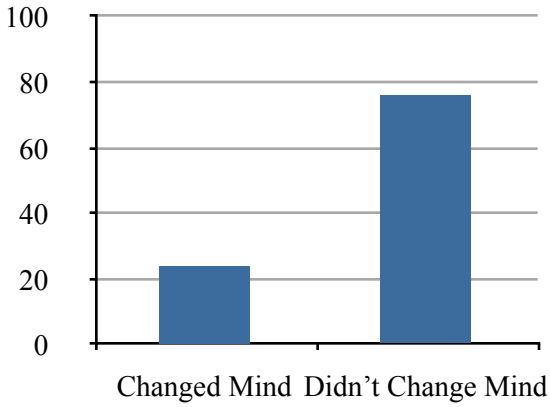
First Choice Responses



Second Choice Responses



% Changed Mind

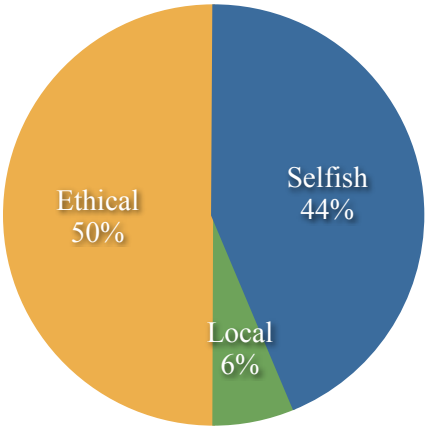


2.2 Earthquake in New Zealand

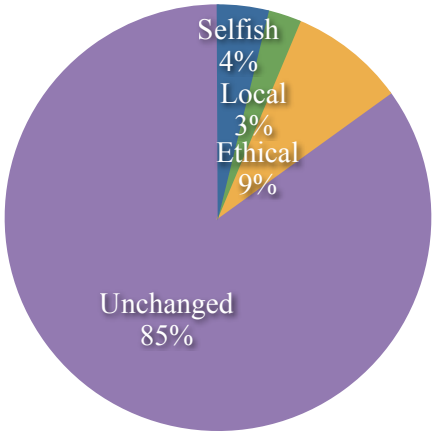
Question: *There has been a huge earthquake in New Zealand and thousands of people's homes have been demolished, resulting in a reduction of 200 Environment Points. You come across 100Kg of bricks - what would you like to do with them?*

Selfish Response: Keep them yourself (150 Points)
Local Response: Donate them to your Class (200 Points)
Ethical Response: Send them to New Zealand (200 Points)

First Choice Responses



Second Choice Responses



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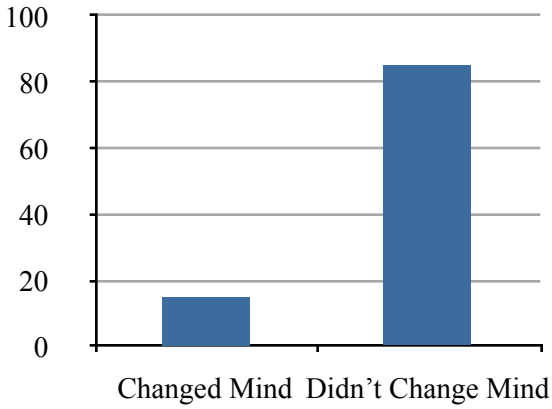
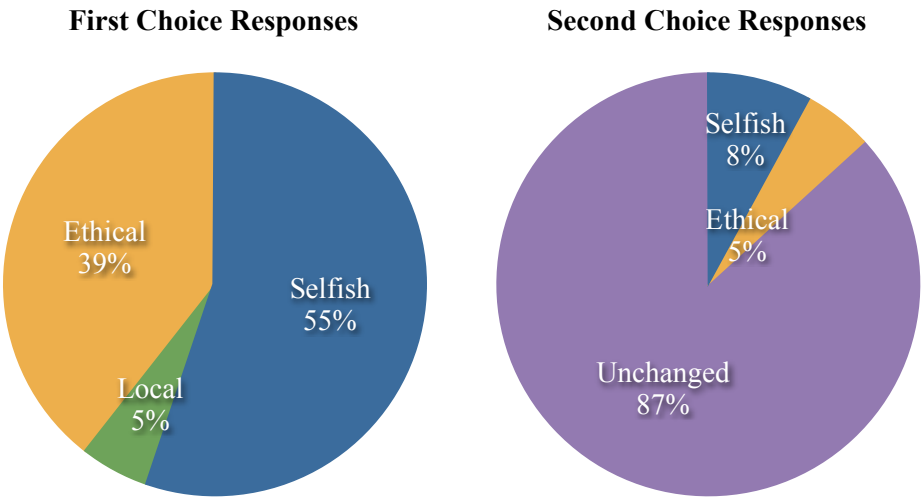
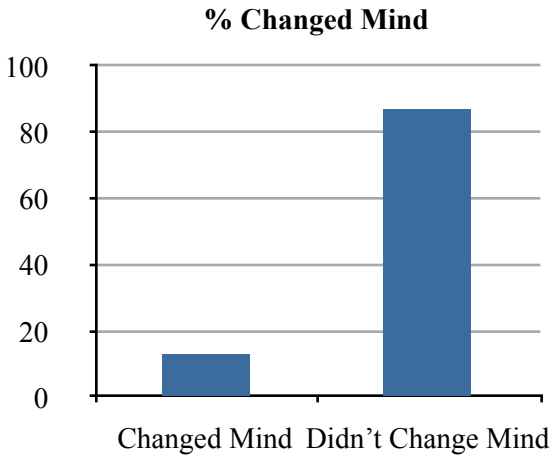


2.3 Drought in Africa

Question: *The biggest drought on record has hit Africa and millions of people are without access to fresh water, resulting in a reduction of 200 Environment Points. You come across 100 Litres of water - what would you like to do with them?*

Selfish Response: Keep it for your trees (150 Points)
Local Response: Donate it to your Class (150 Points)
Ethical Response: Send it to Africa (200 Points)



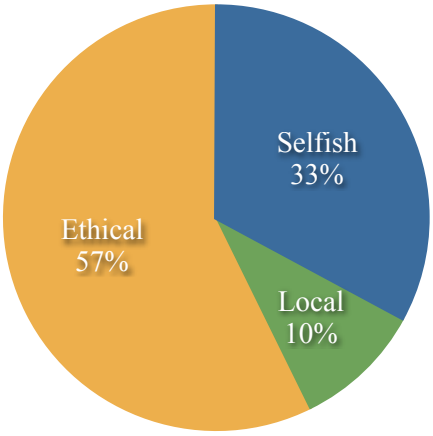


2.4 Tsunami in China

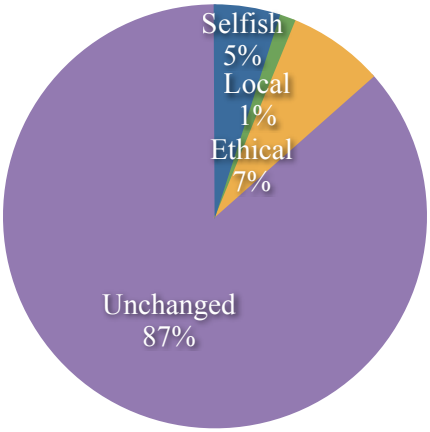
Question: *There has been a tsunami in China and 1000 people have had their homes flooded, resulting in a loss of 200 Environmental Points. You come across 100Kg of food and supplies, what would you like to do with them?*

Selfish Response:	Keep them for yourself (50 Points)
Local Response:	Donate them to your class (100 Points)
Ethical Response:	Send them to the people of China (100 Points)

First Choice Responses



Second Choice Responses



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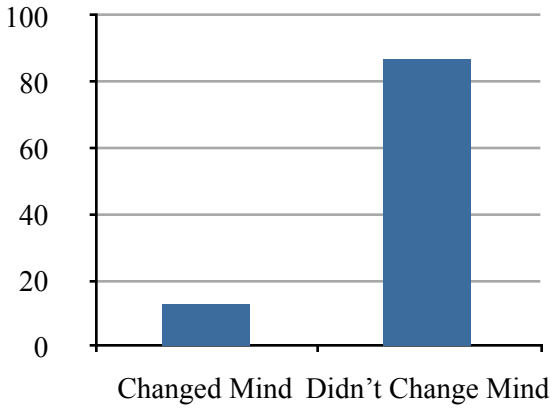
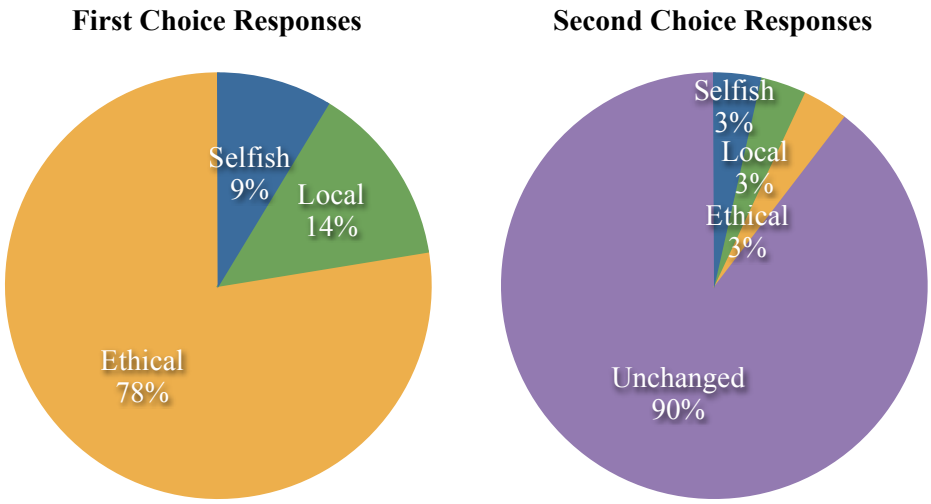
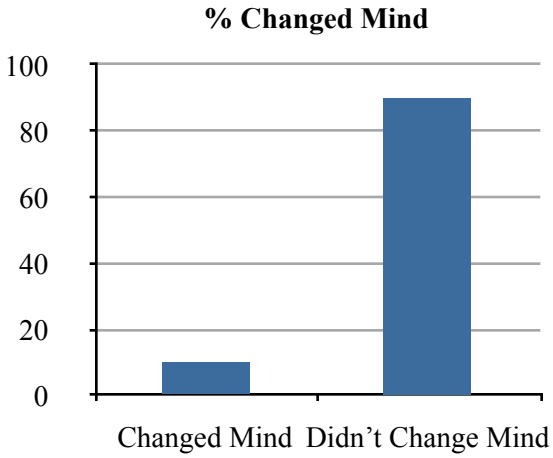


2.5 Famine in Egypt

Question: *A huge famine has hit Egypt and hundreds of people are starving everyday, resulting in a loss of 200 Environmental Points. You find a hidden supply of food, what would you like to do with it?*

Selfish Response:	Keep the food for yourself (0 Points)
Local Response:	Donate the food to your class (100 Points)
Ethical Response:	Send the food to the people of Egypt (100 Points)



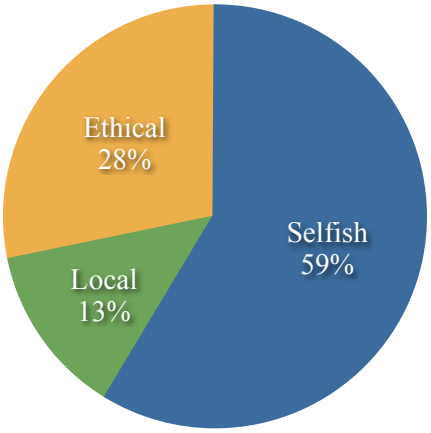


2.6 Fires in Australia

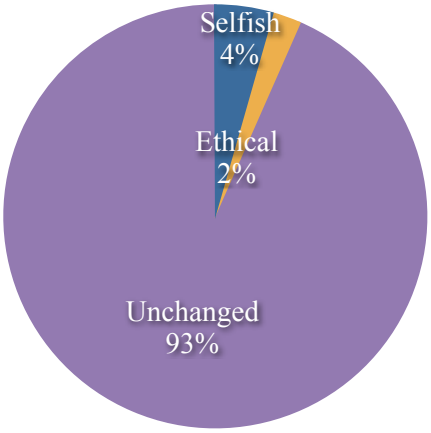
Question: *A huge fire has hit the Australian Outback and thousands of trees have burnt down, which has resulted in a reduction of 1,000 Environmental Points. You find a 100 seeds tucked away in a garden shed, what would you like to do with them?*

Selfish Response: Keep them for yourself (100 Points)
Local Response: Donate them to your class (100 Points)
Ethical Response: Send them to Australia (100 Points)

First Choice Responses



Second Choice Responses



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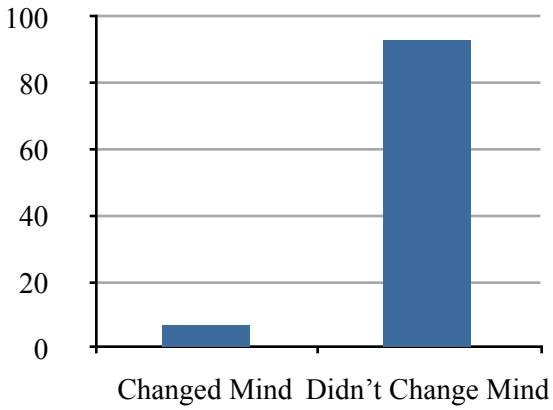
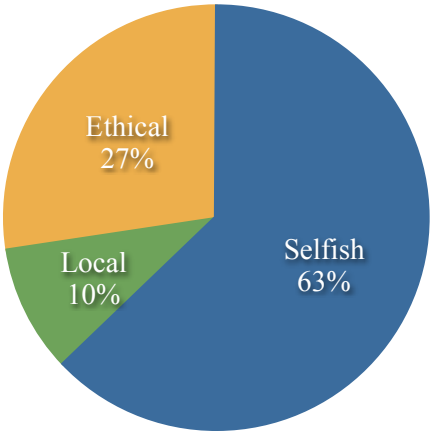


2.7 Acid Rain in the Amazon

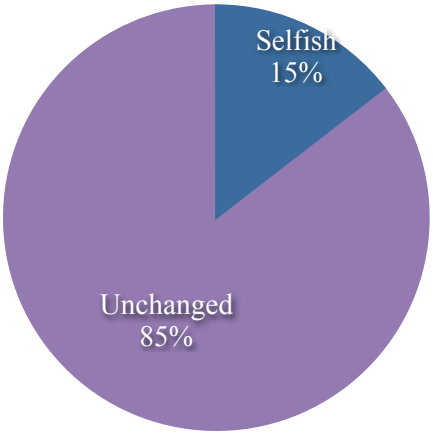
Question: *After a chemical explosion in the Amazon Rainforest, lots of acid rain is falling causing damage to plants, trees and animals as well as reducing the Environmental Points total by 1,000. You remember that you have lots of plant covers that could help protect the trees, what would like to do with them?*

Selfish Response:	Keep them for your own forest (100 Points)
Local Response:	Give them to your class (100 Points)
Ethical Response:	Send them over to the Amazon Rainforest (100 Points)

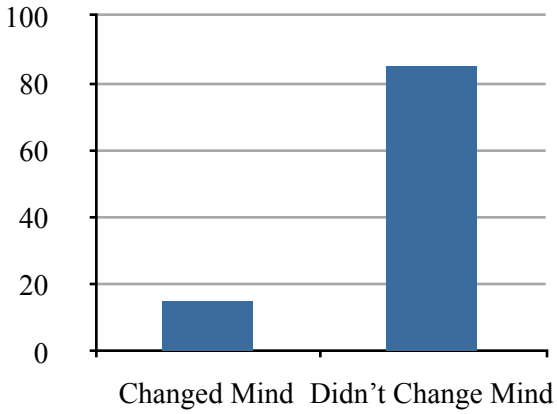
First Choice Responses



Second Choice Responses



% Changed Mind

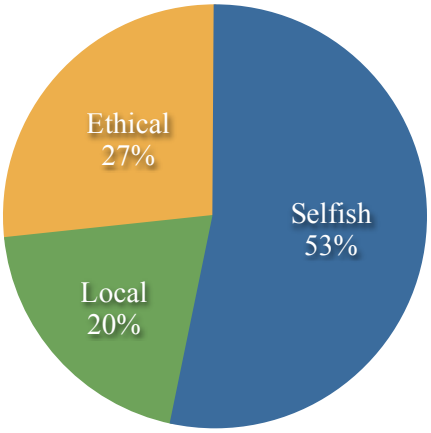


2.8 Disease in Canada

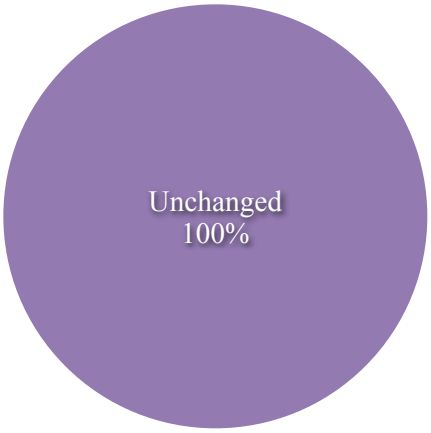
Question: *Disease has hit parts of Canada killing thousands of trees. You discover a way to stop trees dying by giving them a special compost mix. What would you like to do with the compost?*

Selfish Response: Keep them for your own trees. (100 Points)
Local Response: Share the compost with your class (100 Points)
Ethical Response: Send the compost to Canada to stop trees dying (100 Points)

First Choice Responses



Second Choice Responses



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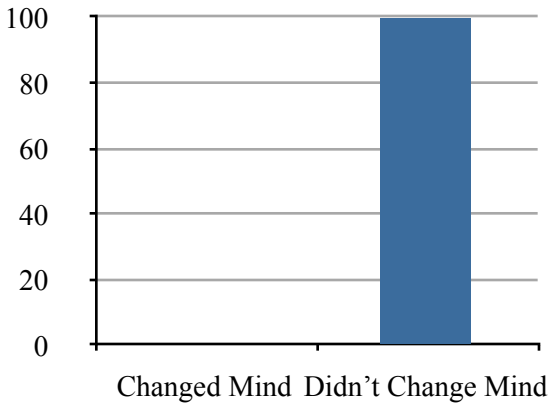
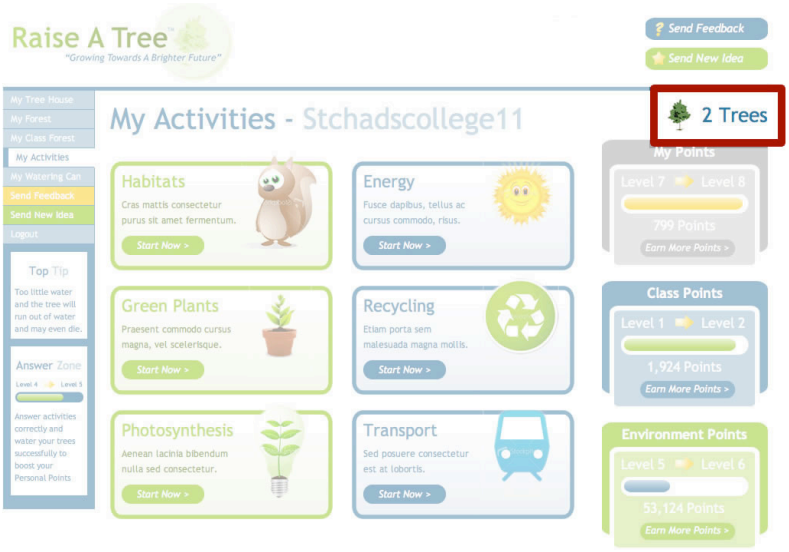


Appendix 3. Raise A Tree Screenshots

3.1 - My Tree Dashboard

3.2 - Hidden Feature - Plant New Tree Link



Appendix 4. Pre/Post Trial Questionnaires

4.1 - Pre-Trial Questionnaire

Q1) Please select the activities you are interested in (you may select more than one answer):

- Recycling waste at home
- Turning lights off when they're not in use
- Growing your own fruit and veg
- Growing or planting trees

Q2) How do you mostly travel to school or work in the morning?

- Car
- Bike/Scooter
- Bus
- Train/Metro
- Walk

Q3) Thinking about other journeys you make generally, are these mostly by:

- Car
- Bike/Scooter
- Bus
- Train/Metro
- On Foot

Q4) If you could, how would you like to travel?

- Car
- Bike/Scooter
- Bus
- Train/Metro
- On Foot

Q5) On a scale of 1-5 (where 1 is not at all important and 5 is very important), how important do YOU think it is to REDUCE the number of cars we have on the roads?

Q6) On a scale of 1-5 (where 1 is not at all important and 5 is very important), how important do YOU think it is to REDUCE the rubbish we put in the dustbin and INCREASE the amount we recycle?

Q7) On a scale of 1-5 (where 1 is not at all important and 5 is very important), how important do YOU think it is to try and save energy by switching lights, TVs or Games Consoles off when they're not in use?

4.2 - Post-Trial Questionnaire

Q1) On a scale of 1-5, did you enjoy using Raise A Tree?

Q2) What do you think Raise A Tree is?
- A game website
- A learning website
- Neither
- Both

Q3) What was your FAVOURITE type of Raise A Tree activity?
- Basic Quiz
- Picture Quiz
- Video Quiz
- Maths Quiz
- Comprehension Quiz
- Blog Post

Q4) What was your LEAST FAVOURITE type of Raise A Tree activity?
- Basic Quiz
- Picture Quiz
- Video Quiz
- Maths Quiz

- Comprehension Quiz
- Blog Post

Q5) Did Raise A Tree help you learn about any of the following topics?
- Renewable Energy
- Climate Change/Global Warming
- Recycling
- Sustainable Transport (Buses, trains, bikes etc.)
- Wildlife & their Habitats
- Saving Energy
- Saving Water
- English
- Maths
- Science

Q6) In each of the following questions, please select which activity you prefer doing:
a) Using Raise A Tree OR Classroom Learning
b) Using Raise A Tree OR Watching TV
c) Using Raise A Tree OR Playing Sport
d) Using Raise A Tree OR Playing Computer Games
e) Using Raise A Tree OR Reading
f) Using Raise A Tree OR Doing Homework

Q7) What's the BEST thing about Raise A Tree?

Q8) What's the WORST thing about Raise A Tree?

Q9) If you could ADD ONE thing to Raise A Tree, what would it be?

Q10) If you could REMOVE ONE thing to Raise A Tree, what would it be?

Q11) How would you describe Raise A Tree in ONE word?

Q12) Do you have any other comments or suggestions you'd like to mention?

Appendix 5. Post-Trial Questionnaire Data

5.7 - What's the BEST thing about Raise A Tree?

- you can raise a tree
- MATHS
- everything including cheats
- dunno
- qizes
- EVERYTHING
- activtes
- you get to do quis.
- the blog post
- you could compete with your friends and other class'
- to beable to create your own tree
- having your own trees to look after
- planting and nameing the tree
- Planting my trees
- placing my trees
- planting trees
- THAT YOU CAN PLANT TREES AND WATER THEM TO RAISE POINTS FOR YOU AND YOUR CLASS.
- quiz
- you get your own tree
- Growing your own tree.
- the competitive points
- the habitats quiz
- You can own your very own tree
- you learn more
- you learn more things and it helps you in life !
- envoiromental disition points
- The Tree growning thing
- beter than class
- It's helpful
- the tree because you get to water it
- You don't know your learning
- you can choose you classroom or my points
- probably the activitys
- Everything

- The picture quiz
- the questing
- f
- blog posts
- blog post
- blog post (the glitches)
- it's helpful
- bloging
- you get to water your tree
- Posting blogs
- you level up and grow trees
- getting up levels
- competition with me friends
- growing the trees
- the growing a tree
- learning all of the games
- quizzes
- planting my tree
- blog post
- levels
- the points
- i dont know
- learning new things
- the tree part
- Its fun growing a tree
- NEARLY EVERYTHING
- The question quiz
- The points
- i dont know
- its about the enviroment
- learn new things
- reading the blog post and finding out what other people think
- That rais a tree is fun and it helps you learn.
- it is fun and it helps you learn
- Competing in the raise a tree leage
- education
- quizes
- You can name your own tree.

- The best thing about raising a tree is looking after it.
- Planting(making) the tree and choosing the name and place
- Watching the tree
- Its very fun and you learn and enjoy it.
- its just fun
- Evrey thing
- quize
- The best thing is its fun and you learn.
- the best thing was choesing the tree
- It is quite fun and you get deturmined to have many points.
- The virtual trres and how they grow
- The lessons
- It helps you learn lots of things and its really fun.
- It is fun and helps you learn
- The quiz
- The best thing is probabaly the quizes
- its realistic
- it helps you learn
- Its just fun
- you can plant trees
- trees
- Blogging
- vidios
- ponts
- the watering can
- The best thing is that you learn how important it is to look after the enviorment and our world.
- That younger and older children are learning about the environment and things to do that link to the environment.
- ?
- the tree
- you get to look after trees
- that you get to raise your own tree
- how I can grow a virtulal tree
- games
- the activety
- bloging
- planting the tree
- its fun

- ?
- PLANTING AND LOOKING AFTER MY TREES
- Blog posts
- it is fun

5.8 - What's the WORST thing about Raise A Tree?

- blog
- BLOB NOTES
- no more cheats
- not many games
- losing
- NOTHINYING
- nothink
- BLOG
- only having 3 trees
- it was to slow and boring because there could have been some games
- theres no games
- some points are long and difficulity to complete
- not having your owen little space
- Writing the blog post
- the blog post
- lessons
- BLOG POSTS.
- nothing
- Comphension
- There wasnt many fun aspects about it, mostly learning.
- having to water every day becase some people have no computer
- all
- All the same type of games
- the maths part
- no offence but the quizes
- quiz
- Some of the Blogs
- its boring sometimes
- It's helpful
- the lessons e.g quizis
- Comprehenshion
- the blog posts

- the actual tree
- Nothing
- The maths quiz
- the blog
- h
- my tree wont grow
- blog post
- getting the glitch patched
- the lessons
- learning
- when you do you blog post
- When it signs you out when your half way through a lesson
- some questions i hardly no
- blog posts
- writing
- the blogs
- the quiz
- having to do all the comprehension
- blog post
- the quizes
- comprehension
- nothing
- that you could only have three trees
- i dont know
- the basic quiz
- quizing
- nothing
- SOMETHINGS
- the blog post
- Blog posts
- dont know
- it gets boring after a while
- blog post
- being loged of all the time
- sometimes it can be slow but nothing is rong with it.
- slow
- The blog post quiz
- the blog post

- trees lose health
- It is slow.
- its anoying when it says sorry dont be naught next time
- When it goes off and you have to restart it
- Reading loads and loads
- nothing
- nothing
- nothing
- maths
- The worst thing is if you lose points.
- the worst thing is the quiz
- You can not chat to your class mates and it is pretty slow.
- If the tree decreases in something
- The blog post
- Somtimes slow but its still fun.
- the blog post and it is slow
- The blog post
- Probably that you can only have 3 trees
- blog post
- Nothing
- ...
- nothink
- reading quiz
- maths quiz
- blogposts
- blog
- blog post
- The worst thing about raiseatree is that when you clik water my tree,it takes 10 minutes and there were some problems with the website.
- That in the blog there was somthing to write about and I found it slightly hard at first.
- ?
- the blog
- blog post
- blog post
- nothing it is great
- doing blogs
- nothing
- quiz

- the blog powst!
- nothing
- ?
- TEXT QUIZ
- The text quizzes
- I FORGET MY PASSWORD

5.9 If you could ADD ONE thing to Raise A Tree - what would it be?

- more trees
- SQUIRRELS
- more cheats
- games at the end of every quiz
- games
- MORE CHEATS
- infmation
- some topik games
- a game
- games for after the activities
- games
- games after each sessions
- your owen little space
- Being able to plant more than three trees at a time
- to plant one more tree
- more trees
- MORE GAMES.
- play games at the end of the leson
- items to buy with your points
- A game after every quiz.
- fun games
- bounes questions
- Be able to grow more than 3 trees
- to conect with friends
- Being able to actualy look at your tree in a virtual forest
- games when you win (good ones)
- Mini games
- games
- It's helpful

- a tree shop for spending your persinol points
- Fun Games
- mour games on it
- nothing
- Aloud More Than 3 Trees
- To plant more trees at least 5
- ?
- p
- chat
- football quiz
- either more trees or have your own pet
- games
- more games
- put fruit on your tree
- more devolpment on raising an actual tree
- buy trees
- nothing
- nothing
- games to help you learn
- games to help you learn more
- games
- more activity
- Games
- games
- nothing
- more trees
- i dont know
- chatroom
- less bugs
- video quiz
- GAMES
- games
- Games
- dont know
- my name
- more activitys
- a chat option or an avatar
- they could put in chat so you cold talk to your friends

- more fun games and chat
- Some games
- games
- tree waters itself
- Add more games to it.
- to have a chat room and a animal game
- Have some animals who live in the tree
- More fun games
- you chould get to design and put things around your tree.
- nothing
- to see your tree and you can test on it.
- more games
- NOTHING
- FUN games
- You could customize your homepage to your own style.
- A game
- To have more fun games
- More exciting games and a chat room.
- playing games
- Some games
- Ir would be to be able to plant up to 6 trees
- more games
- how to save poor people quiz
- ...
- more trees
- games
- platform game
- un learning games
- more games
- a wildlife game (not quiz)
- that there would be more games and lessons and that it wouldn't take so long to load.
- Maybe out of the whole that we had games to play on the website that were fun but also about the environment and you learn while doing the game.
- that you could have more trees
- you cud get a person
- To put raise a tree games
- raise a tree games
- If it could be faster

- a chat room
- more gamas
- games
- more games
- more games
- ?
- HAVING UNLIMITID TREES
- Being able to tell your friends how tree is doing via email on raise a tree
- NOTHING

5.10 - If you could REMOVE ONE thing from Raise A Tree, what would it be?

- blog
- BLOB NOTES
- cheat blocks
- nothing
- lesins
- CHEAT BLOCKS
- nothink
- BLOG
- comments
- the hard blogs that you have to write
- remove the blog posts
- hard acticities
- all the little gliches
- The blog post
- blog post
- lessons
- BLOG POSTS.
- nothing
- The comphension
- Nothing!
- blogs
- everithing
- My Activities
- nothing
- nothing its great the way it is !
- tree

- Nothing
- maths
- It's helpful
- the lessons e.g questions
- Comprehenshion
- nothing
- nothing
- Nothing
- The comphension
- Nothing!
- z
- maths quiz
- questions
- watering your tree
- the lessons
- leasings
- blog post
- remove comprehension
- naming your planrt
- blog posts
- writing bologs
- blogs
- the blogs
- maths quiz
- blog post
- Some of the quizes
- comprehensions
- nothing
- comprehenshion
- i dont know
- watering can
- quizing
- comprehensize quiz
- BLOG POSTS
- blog post
- Blog Post
- dont know
- the fact that it gets boring after a while

- blog post
- the points
- the blog post
- blog poste
- The blog post quiz
- nothing
- tree loseing health
- The maths quiz.
- nothing
- Nothing
- Nothing
- some blog post.
- nothing
- nothing
- maths
- I would remove the blog post
- The quiz
- Nothing.
- The video quiz
- The blog post
- The blog post.
- blog post
- The blog posts
- not sure?
- blog post
- Blog post
- ...
- podcast
- nothing
- maths
- blogposts
- the blog
- blog post
- The learning!
- Not sure
- LESSONS!
- the blog
- to remove your user name put your own

- to remove your user name and put your own
- how you can buy a real tree
- the blogs
- blog powst!!!
- quiz
- blog porst!!
- nothing
- ?
- NOTHING
- Nothing
- NOTHING

Appendix 6 - User Activity Preferences

UserID	Max Attempts at Favourite Activity	Total Attempts at All Activities	% of Total Attempts
286	2	13	15
12559	3	19	16
275	10	49	20
300	3	14	21
12591	3	14	21
281	3	14	21
12562	9	39	23
276	5	20	25
334	6	22	27
12547	6	22	27
12581	5	18	28
333	6	20	30
12862	3	10	30
12599	3	10	30
277	15	48	31

UserID	Max Attempts at Favourite Activity	Total Attempts at All Activities	% of Total Attempts
293	6	19	32
12854	5	15	33
12567	35	100	35
12582	5	13	38
12569	6	15	40
278	6	15	40
12596	5	12	42
343	5	11	45
273	37	81	46
302	5	10	50
301	22	42	52
295	8	15	53
280	26	49	53
274	26	47	55
321	16	28	57
335	72	113	64
337	15	21	71
332	8	11	73
299	54	70	77
320	36	43	84
297	20	23	87
12561	40	42	95
339	13	13	100
Average:	**15**	**30**	**44**