### Deliverable Report

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<td>Systematic review of the literature on computer games for education</td>
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### Abstract (for dissemination)

The CHERMUG project aims to develop a digital game to support students in acquiring methodological and statistical expertise. This deliverable describes a literature review which was carried out to identify papers which describe digital games which aim to teach research methods and statistics. Search terms included varied terms for digital games, terms relevant to the twin goals of games for learning and engagement and terms for methodological and statistical knowledge. Search terms identified 38 papers which were considered relevant. The literature review confirmed that there are relatively few papers describing the use of games for teaching research methods and statistics and even fewer which carried out rigorous evaluations of their success, although several e-learning applications and animations to teach research methods and statistics were identified as well as papers looking at how statistics should be taught.

### Keywords List

CHERMUG, Serious Games, Literature Review, Game Design, Research Methods, Statistics

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Executive Summary

This deliverable describes a literature review which was carried out to identify papers which describe digital games which aim to teach research methods and statistics. Search terms included varied terms for digital games, terms relevant to the twin goals of games for learning and engagement and terms for methodological and statistical knowledge.

Search terms identified 38 papers which were considered relevant. The literature review confirmed that there are relatively few papers describing the use of games for teaching research methods and statistics and even fewer which carried out rigorous evaluations of their success. Since interest in games for teaching methods and statistics is relatively recent, papers about games tended to be accounts of the development of the game or how it was used in learning with only limited accounts of the success in improving performance. However there is an emerging interest in using games to teach in these areas and there are reasons to be optimistic that a game-based approach might be successful as they provide activities which are congruent with the desired learning outcomes and they provide enjoyable challenges which players are motivated to solve.

The use of e-learning applications and animations to teach research methods and statistics has been around for longer than games and there was empirical evidence that these do lead to more successful learning in statistics Dinov et al (2008) and Gonzalez et al (2010). Several papers looked at recent views of how statistics should be taught. These were included in the current review since they contained guidance about effective methods of teaching statistics.

Teaching the research and statistical skills of scientific methodology would seem to be highly amenable to a game-based approach. It is interesting to note that the focus of most e-learning applications and games is on statistics rather than research methods. CHERMUG is different from these other approaches in that it does not just aim to teach statistical concepts. The proposed CHERMUG game goes beyond teaching statistical concepts to teach research methods and design and supporting students in tackling both qualitative and quantitative approaches to research.
1. Introduction

Developing an understanding of research methods and statistics is a core competence for students across a variety of disciplines. The hypothetico-deductive reasoning which underlies research methodology requires the higher level thinking skills of logical reasoning and critical thinking which are key to developing a more sophisticated understanding of the world. These skills are necessary to tackle the ill-defined problems which we face in the 21st century as described in the European Lifelong Learning Programme (LLP) and the EU 2020 Strategy "New Skills for New Jobs". Research Methods and stats have an unusual role in most disciplines in that they are skills which are vital to developing an understanding of the content area but are not part of the content knowledge for that discipline.

In nursing education there is a strong focus on learning evidence-based practice which emphasise the need for nurses to acquire useable knowledge which makes links between research and practice. The ability to understand and critically evaluate the research of others is necessary for adopting a higher level approach to evaluating research. This is necessary both in the initial stages of carrying out a research project as well as in assessing how research results fit with previous studies. In clinical practice scientific reading is important when adopting new study results and changing work.

Developing an understanding of research methods and statistics poses significant challenges for many students and many students feel anxious about their ability to understand it. The material is challenging because it is highly abstract and requires the coordination of different but interrelated issues which are all necessary to develop a coherent and usable skills base in this area. Students have to develop an understanding of how to formulate hypotheses and set study questions, identify, define and operationalise relevant variables, select an appropriate design to examine links between variables, identify an appropriate sample of participants, select informative and suitable methods of data analysis, collect and analyse data, identify relevant ethical issues and interpret and discuss the findings. Various sub-skills such as critical thinking, decision making and analysis, are required at each of these stages. Many students struggle to acquire a solid understanding of the higher level logical reasoning and critical thinking skills that underlie research methodology.

The Teaching of Research methods and statistics

In recent years there have been criticisms that traditional lecture based ways of teaching research methods and statistics have not been effective and do not seem to inspire a passion for research. Teachers are continually looking for new ways of making research methods and statistics more appealing to students and easier to learn.

Research on effective teaching and learning is converging on the view that learning is most effective when it is active, situated /real world/projects, involves problem based learning, involves extensive practice and feedback, is student centred and personalised and involves discussion in groups. There has been interest in more active methods of teaching, problem based methods of teaching, using real world data which the students can relate to. Smith (1998) argued that students learn better when they are taking part in activities which allow them to construct their own knowledge rather than passively assimilating knowledge. Games can provide activities which can support learning of statistics from very short duration exercises to much longer
semester-long projects. Gnanadesikan, Scheaffer, Watkins and Witmer (1997) advocate an activity-based statistics course and describe several activities which might be included in such a course. Cobb (1991) was an early advocate of using teaching based on getting students to analyse real data.

In addition there has been interest in teaching statistics in a more conceptual way with a focus on understanding the concepts which underlie the analyses, rather than simply teaching the statistical tests. This approach would help to provide students with the conceptual understanding which would be transferable to similar problems. There have been criticisms that students’ knowledge and understanding of statistics is not usable.

### Games for learning

An important source of support for educators in their quest to support students in learning research methods and statistics has been to utilise the potential of emerging technologies (Skiba, 2008). Many e-learning applications for supporting students in learning statistics have become available which promise to provide more effective ways of teaching students.

The CHERMUG project was conceived against this background of finding more effective and engaging ways to teach research methods and statistics and the recognition that a games-based approach might be useful in this respect. There has recently been an upsurge of interest in using digital games for educational purposes. There is growing evidence in the literature that gaming or what is sometimes referred to as “serious gaming” can be an effective tool to support learning (Joint Information Systems Committee, JISC, 2007). Nadolski et al (2008) suggests that the use of serious games can be a useful tool for Higher Education Institutions to develop and deploy, to enhance the student experience and to assist them in achieving the intended learning outcomes.

Interest in serious games has emerged from optimism that the motivating features which are evident in digital entertainment games could also be deployed to motivate learning. However games also offer methods of learning which are highly consistent with modern theories of effective learning which propose that learning activities should be active, situated, problem-based, interactive and socially mediated. Gentile and Gentile (2008) argue that violent games promote aggression because they teach players to become more aggressive by systematically incorporating well-established principles of effective learning: having clear objectives; presenting tasks at multiple levels of increasing difficulty; adapting to the prior knowledge, skills and pace of each learner; presenting tasks that require active learning; providing practice and feedback to the point of mastery; over-learning both knowledge and skills and including both intrinsic and extrinsic motives.

In developing the original proposal for the CHERMUG project, a brief review of the literature was carried out to assess whether games had already been developed in this area to make sure that no similar games existed. In addition partners were asked whether they knew of similar projects. The search indicated that there was awareness of the use of simulations in teaching statistics but that there was little in the way of games for teaching research methods.

### Aim of the current paper

In writing the proposal for the CHERMUG project a brief literature was carried out to assess whether games supporting learning in the area of research methods and statistics already existed. This cursory examination confirmed that, there were many e-learning applications to teach statistics but not games. As a first step in developing the CHERMUG game it was necessary to
carry out a more extensive literature review to identify games in this area and to identify ideas about teaching research methods and statistics that might be useful in developing the CHERMUG game. It is known that there is increasing interest in serious gaming and simulations in healthcare education (Tashiro, 2009). However the focus for this project was specifically games to teach research methods and statistics.

The CHERMUG game is initially targeted at nursing and social science students, since evidence-based practice is a core requirement in their teaching. However research methods and statistics are core competences across many subject disciplines including science, social science, business and IT and it is envisaged that the game could easily be adapted for students in other disciplines by providing examples that are more relevant to the specific discipline. Consequently the game could have an impact in providing support for the teaching of methods and statistics for a large number of European students.
2. Literature Review

2.1 Methodology

Literature search was carried out for original studies concerning games in the area and to identify studies about teaching research methods and statistics.

Search terms

The search terms for the literature review were derived from a previous search carried out on the evaluation of computer games (Connolly, Stansfield and Hainey, 2008) and addressed the variety of digital games that might be played:

("computer games" OR "video games" OR "serious games" OR "simulation games" OR "games-based learning" OR "MMOG" OR "MMORPG" OR "online games")

To narrow down the search to focus on games relevant to the twin goals of games for learning, i.e. learning and engagement the following terms were also used:

AND (learning OR education OR skills OR engagement OR motivation)

and to narrow down the search to papers which were relevant to games about research methods and statistics these terms were also used:

AND statistics OR “research methods”

Nevertheless, given the very general nature of these terms and their widespread use in reporting the methods and analysis sections of empirical papers, it was predicted that many papers might be identified which were not relevant.

Databases searched

The databases searched included those identified as relevant to education, information technology and social science and nursing: ACM, ASSIA (Applied Social Sciences Index and Abstracts), BioMed Central, Cambridge Journals Online, ChildData, Index to Theses, Oxford University Press (journals), ScienceDirect, EBSCO (consisting of Psychology and Behavioural Science, PsycINFO, SocINDEX, Library, Information Science and Technology Abstracts, CINAHL), ERIC, IngentaConnect, Infotrac (Expanded Academic ASAP) and Emerald.

Grey literature

Another source of evidence about the relevant literature was the pooled expertise of the CHERMUG project partners.

Selection criteria for inclusion of papers in the current review of engagement in games

A number of further criteria were specified to select appropriate studies for inclusion in the review. To be included in the review, papers had to (a) date from January 2000 to May 2012 and (b) include an abstract. (c) Since our interest in carrying out the lit review was in finding ideas for the development of the game there was no stipulation that the papers should report empirical
research relating to the evaluation of a game. Empirical papers, review papers and papers describing the development and use of games in teaching research methods and statistics were all included.

As predicted very many papers which emerged from the search were not relevant to the review but the titles and abstracts were read to select relevant papers. Papers which were not included were those describing the use of games or e-learning materials in other curricular areas; games for economics; papers on teaching generally; papers on teaching similar curricular areas such as maths and economics. Using these conditions 38 papers met the inclusion criteria and were identified as relevant to the current review.

2.2 Results
Data extraction

As with other literature reviews in the area of games several papers were identified and these were diverse with respect to the topics which they addressed. The papers could be categorised roughly under the topics shown in table 1. The papers will be discussed under these topic headings.

<table>
<thead>
<tr>
<th>Table 1: Number of papers covering each topic</th>
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<tbody>
<tr>
<td>Games to teach research methods and statistics</td>
</tr>
<tr>
<td>The use of games to illustrate statistical concepts</td>
</tr>
<tr>
<td>Web based tools and e-learning applications for teaching statistics</td>
</tr>
<tr>
<td>Visualisation and animations</td>
</tr>
<tr>
<td>Simulations, models and virtual worlds</td>
</tr>
<tr>
<td>The nature of statistical knowledge and approaches to teaching statistics</td>
</tr>
<tr>
<td>Learning in groups / cooperative learning</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Games to teach research methods and statistics

The following studies described digital games which were in some way relevant to teaching research methods and statistics:

- Butler, Forsyth, Halpern, Graesser and Millis (2011)
- Asbell-Clarke, Edwards, Rowe, Larsen, Sylvan and Hewitt (2012)
- Ramler and Chapman (2011)
- Steinkuehler and Duncan (2008)
- Gresalfi and Barab (2011)
- Nte and Stephen (2008)
Research methods refers to the broad approach which is taken in conceptualising, designing, carrying out, analysing and evaluating a research study. There are different stages in the research cycle, including formulating the research question, designing the study, collecting data, data analysis and drawing conclusions. The research methods cycle is like a problem solving cycle with a wide range of sub-skills involved which are different at each stage. For examples skills of literature search are required in tracking down literature which is relevant; skills of precise verbal expression and developing arguments are required in formulating research questions and skills and using evidence to advance arguments are requiring in drawing conclusions.

The paper which was most relevant to teaching the broad methodological and statistical skills required in the proposed CHERMUG game was Halpern, Millis, Graesser, Butler, Forsyth & Cai (2012). These authors describe the development of a game, Operation ARA, which aims to teach critical thinking and scientific reasoning skills to undergraduates. Halpern is well known for her contribution to research on critical thinking and Operation ARA was explicitly designed using principles derived from the literature on effective learning and critical thinking. The authors point out the need to encourage people to think more critically about issues in everyday life. They elicit interest in adopting a more rigorous approach to seeking evidence and research methods by describing the $1.1 dollars spent by consumers on fitness shoes in 2010. The manufacturers claimed that the shoes help to develop “more shapely legs and a better butt” but Halpern et al argue that there was no evidence to confirm their claims.

Operation ARA aims to teach players statistical and methodological concepts such as theories and hypotheses, science and pseudoscience, operational definitions, independent and dependent variables, random assignment to condition, sample size and experimenter bias. Operation ARA was an adventure/mystery game where players were provided with an engaging narrative about helping the FBS to identify extra-terrestrials who are carrying out poor research. This provides the rationale for developing a more rigorous approach to research. The game also helped players to adopt an evaluative approach in determining whether particular research studies are reliable or flawed. During the game the players are tutored by avatars who are sensitive to players’ previous responses. At the end of the game players generate their own questions to determine the quality of different types of research. An early evaluation of the game suggests that students who played Operation ARA learned more than those who did not play the game. Halpern et al (2012) designed their game to promote deep learning by requiring students to be active in learning, providing repeated practice where students benefit from tackling many examples of problems with spaced rather than massed practice and including personalised learning and feedback.

Another paper by Butler, Forsyth, Halpern, Graesser and Millis (2011) described Operation ARIES which is a game similar to, probably a precursor of Operation ARA.

Asbell-Clarke et al (2012) were influenced by their observations that players of MMOGs are actively engaged in activities which have close parallels with the problem solving and reasoning activities of professional scientists in tracking down and analysing data. They developed a mystery game, Martian Boneyards, which aimed to help players develop skills of systematic scientific enquiry in the area of paleontology. In the game, players take part as scientists in a scientific inquiry to tackle problems collaboratively with the help of a range of tools. The game had different stages including data collection, exploration, data-gathering, analysis and theory-building. For example players collaborate in looking for evidence about the ancient civilisation in the form of bones which could be found with the help of a PDA. Players could then click on work stations designed for data analysis where they could measure and make notes about the bones to share with others. The results showed that players spend a lot of time gathering data, but also
have opportunities to analyse data and look at how the evidence that they collected supported specific theories. This study was interesting in showing that a collaborative game could be used in the same way as science develops by players collaborating to collect evidence which might support or contradict specific theories.

An intriguing example of a game which was used to teach the different stages in the design and execution of a research project (data collection, hypothesis testing, data analysis and dissemination of results) was Ramler and Chapman’s (2011) account of the use of the popular entertainment game, Guitar Hero. Students played this game to provide an opportunity to collect data, develop hypotheses about the data, analyse the data and draw conclusions. Although it was called a project about teaching statistics it did in fact teach the different stages in the research cycle and was more related to research methods. The paper described the use of Guitar Hero in a project where students developed a hypothesis about the distribution of missing notes in playing: “Notes are missed completely as random”. An interesting point about Ramler and Chapman’s game was that, in contrast with most games for teaching statistical constructs which are short games, this was a long lasting game, extending over the duration of a semester.

An important skill required in research methods is the ability to express ideas in the form of a coherent argument using evidence to back up the claims. There has been much speculation that players playing entertainment games informally might actually be acquiring such skills. Steinkuehler & Duncan (2008) were interested in the kinds of reasoning demonstrated by players on massively multiplayer online game (MMOGs) as they play these games. They predicted that MMOGs have the capacity to help players develop higher level reasoning and argumentation skills. To investigate this Steinkuehler & Duncan (2008) looked at players’ contributions to online discussion fora in the (MMOG) World of Warcraft. They found that players demonstrate higher order scientific reasoning skills, such as using data and argument, building on others’ ideas and using system-based reasoning. The used a random sample of 1,984 posts across 85 threads of 4,656 threads total. The final sample included discussion posts made by 1,087 unique WoW characters. National benchmarks for scientific literacy including American Association for the Advancement of Science (1993), Chinn and Malhotra’s (2002) theoretical framework for evaluating inquiry tasks and Kuhn’s (1992) epistemological framework were used to code the posts. The results showed that 86% of forum discussions were posts engaged in “social knowledge construction” rather than social banter. Over half of the posts evidenced systems based reasoning, one in ten evidenced model-based reasoning and 65% displayed an evaluative epistemology in which knowledge is treated as an open-ended process of evaluation and argument. Such findings support the view that virtual worlds can provide platforms which encourage players to display higher level thinking in solving complex problems. A criticism might be that the design of the paper was qualitative and consequently does not compare performance against a non-game alternative.

Steinkuehler & Duncan carried out a qualitative analysis of their game, but none of these papers reported a rigorous quantitative evaluation of the success of the game. This reflects the stage that we are at in developing these games and also the challenges of designing learning outcomes which match the game mechanics.

Games which focused more on statistical construct included Gresalfi and Barab (2011) and Ancker, Weber and Kukafka (2010) and Nte and Stephen (2008). Gresalfi and Barab (2011) report the use of a game which helps students to learn about statistics by allowing them to make
decisions and to experience the consequences of decision. They argue that this facility creates consequential engagement where students can see the outcomes of making a decision.

Ancker, Weber and Kukafka (2010) used a game to convey information about risk which is difficult to understand when conveyed verbally. Ancker et al used an interactive graphical presentation of a game to allow players to experience rather than simply read about the frequency of occurrence of an event to see whether this improved participants’ perceptions of risk. Disappointingly they did not in fact find a main effect of the different graphical representations on risk feelings for either the low-risk or the high-risk stories.

Nte and Stephen (2008) described the development and use of a game which illustrated the principles of the normal distribution by allowing students to see the construction of a normal distribution from data. In the game a virtual scientist collects data from virtual characters as they come out of a virtual pub about how many drinks they have consumed. Each participant’s datum is represented as a single block with a number depicted on it which drifts down to be included in a graphical representation of the normal distribution of the number of drinks consumed by all drinkers in the pub. The game illustrated a number of points. It was designed to be appealing and cute as this is thought to increase the game’s usability and also helped to ease students’ anxiety as many students have an anxiety about statistics. While there was no objective evaluation of the impact of the game on students’ performance, questionnaire responses indicated that students agreed that the game was a useful method for helping them learn about statistics, and did not provoke anxiety although players agreed that they normally did feel anxiety about statistics.

Table 2. Studies/projects of games to teach research methods and statistics (n=8)

<table>
<thead>
<tr>
<th>Author</th>
<th>Game</th>
<th>Study aim</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halpern 2012</td>
<td>Operation ARA for undergraduates</td>
<td>To find out - critical thinking &amp; scientific reasoning - statistical and methodological concepts were supported by Operation ARA game</td>
<td>Students who played Operation ARA learned more than those who did not play the game</td>
</tr>
<tr>
<td></td>
<td>Adventure/mystery game which provided narrative Player was tutored by avatar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butler 2011*</td>
<td>Operation ARIES</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Asbell-Claire 2012</td>
<td>Mystery game, Martian Boneyards</td>
<td>To find out how the game develop skills of systematic scientific enquiry in the area of paleontology</td>
<td>The results showed that players spend a lot of time gathering data, but also have opportunities to analyse data and look at how the evidence</td>
</tr>
</tbody>
</table>
### Literature review

<table>
<thead>
<tr>
<th>Authors</th>
<th>Game Description</th>
<th>Goal</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramler 2011</td>
<td>Guitar Hero</td>
<td>In the project the aim was to help students develop statistical thinking concerning e.g. data collection, hypothesis development, data analysis, concluding</td>
<td>No formal data collection was made.</td>
</tr>
<tr>
<td>Steinkuehler 2008</td>
<td>Massive multiplayer online game (MMOG) World of Warcraft</td>
<td>To find out the reasoning and the argumentation skills of the players by a qualitative study design</td>
<td>The players demonstrated high level scientific reasoning skills; using data and arguments, system-based reasoning</td>
</tr>
<tr>
<td>Gresalf 2011 *</td>
<td>Statistical game</td>
<td>To study how the players learn</td>
<td>The students ...</td>
</tr>
<tr>
<td>Ancker 2010</td>
<td>A game-like interactive graphics of presentation of statistics</td>
<td>To assess effects of interactive graphics on risk perception and decisions in health Obs! Online or urban hospital respondents</td>
<td>The interactive graphics can effect risk perception in health decisions</td>
</tr>
<tr>
<td>Nte 2008</td>
<td>Virtual scientist in game environment</td>
<td>To evaluate the game usefulness for learning statistics</td>
<td>No objective measures. The survey showed that students agreed that the game helped them and caused no anxiety</td>
</tr>
</tbody>
</table>

**The use of games to illustrate statistical concepts**

- Chow, Woodford and Maes (2010)
- Burguillo (2010)

Games, such as traditional board and card games are frequently based upon basic characteristics of probability or chance. For example board games such as snakes and ladders or trivial pursuit, involve throwing a dice and progress in the game is determined to a greater or lesser degree by
the random nature of dice throws. These games do not in themselves teach players statistical principles but people are familiar with the ideas behind throwing a dice or playing cards and the games are frequently used to illustrate basic principles of randomness and probability in teaching introductory statistics.

An example of a game being used to illustrate statistical principles in the classroom was Chow, Woodford and Maes (2010). They used the popular non-digital game “Deal or no deal” to help students understand the principle of expected value. In this game the contestant is asked to choose one of 26 briefcases which are identical except that each contains a different monetary value ranging from one cent to one million dollars. The contestant is allowed to keep the money in each briefcase but does not learn of its value until the end of the game. He keeps selecting briefcases until, at a certain point in the game, contestants are presented with a choice of whether to accept the dealer’s offer of money or not (deal or no deal). The offer should be accepted when it is equal to or greater than the contestant’s expected value and this can be calculated from the sum of the remaining amounts divided by the number of briefcases. This is a simple statistical concept which is probably not so useful in itself but the game illustrates that getting students to make a prediction which is either subsequently fulfilled or not can help students to understand simple statistical concepts. Chow et al carried out a basic evaluation of their game and found that 33 of the 35 students who played the game made the correct decision, and one week later 30/32 students remembered the construct compared with only 59% of students who had not played the game. In addition students found the game interesting to play.

Another paper which reported the use of games which are based on more or less probable outcomes was Burguillo’s (2010) paper which looked at the use of game theory for motivating students to learn. Game theory looks at decision making between two different groups of individuals under conditions of cooperation or conflict. Game theory is an academic theory separate from theories about digital games, but it is relevant to designing cooperative decision making in games. In a game the outcomes are determined probabilistically by the decisions which players make to either cooperate or not. Burguillo looked at how game theory used in conjunction with competition was found to be highly motivating for students. This is relevant to the development of a game in statistics not so much from the point of view that it illustrates the probability of different outcomes but more from the point of view of cooperative learning.

Nordmore (2004) provides a tongue-in-cheek but interesting example of a famous game from our knowledge of children’s literature AA Milne. He argues that Poohsticks, a game invented by Pooh where he makes predictions about which cone will emerge first from the other side of a river based on its size provides a very simple analogy which can help us to understand the principles of hypothesis testing.

Table 3. Studies of games which were used to illustrate statistical concepts (n=3)

<table>
<thead>
<tr>
<th>Author</th>
<th>Game</th>
<th>Study aim</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chow 2010</td>
<td>Non-digital “Deal or no deal”</td>
<td>To find out - how the game enhances student understanding and retention by playing the game to learn expected value in an introductory</td>
<td>The retention rate of students using the game was 95% and students not playing had 59%</td>
</tr>
</tbody>
</table>
### Literature review

<table>
<thead>
<tr>
<th></th>
<th>Statistics course</th>
<th>How the game fosters development of critical thinking skills necessary to succeed in the modern business environment</th>
<th>To find out how the game motivates players to learn</th>
<th>Cooperative learning was shown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burgillo 2010*</td>
<td>?</td>
<td>?</td>
<td>To find out how the game motivates players to learn</td>
<td>Cooperative learning was shown</td>
</tr>
<tr>
<td>Nordmore 2004*</td>
<td>Poohsticks by AA Milne</td>
<td>?</td>
<td>?</td>
<td>*</td>
</tr>
</tbody>
</table>

*had not the article

### Web-based tools and e-learning applications for teaching statistics

- Bush, Menzies and Thorp (2009) web tools
- Burruss and Furlow (2007) flash
- Archee and Gurney (2006) flash
- Basturk (2005)
- González, Jover, Cobo and Muñoz (2010)
- Dinov, Sánchez and Christou (2008)

Although few examples of serious games being used to teach statistics were found, several papers were identified which described the use of e-learning applications for helping students acquire an understanding of statistics. e-learning applications have been around for longer than games and there has been more time to accumulate evidence about their effectiveness. Although these applications were not games, they have game-like qualities and are relevant to this review.

Bush, Menzies and Thorp (2009) describes the huge array of web-based tools and teaching resources, ranging from class surveys to individual simulation experiments, which are which are available for teaching statistics.

Burruss and Furlow (2007) demonstrated key statistical concepts via Microsoft Excel spreadsheet and Macromedia Flash movies and compared the performance of this group with a control. They found no difference in performance on a skills test but the Flash group performed better on the conceptual questions. Archee and Gurney (2006) also used interactive online Flash video tutorials to teach students SPSS. There was no formal evaluation but students found that this blended learning approach provided personalized learning that they could proceed at their own pace.

It is frequently assumed that using statistical packages help students to acquire a better understanding of statistics. Basturk (2005) carried out a study to evaluate this assumption, looking at whether SPSS, the data analysis program, does support students’ understanding of statistics. Students were allocated to a lecture only group or a lecture plus SPSS group. Results showed that those in the lecture plus SPSS group gaining higher averages on the midterm and final exams than the lecture only group. This difference was even larger for inferential statistics.
than descriptive statistics. This confirms that giving students the opportunity to carry out analysis with a data analysis package assists them in understanding statistics.

González, Jover, Cobo and Muñoz (2010) and Dinov, Sánchez and Christou (2008) reported empirical studies on the effectiveness of e-learning applications for teaching statistics. These include statistical packages such as SPSS, as well as simulations of statistical data. González et al claim that there are very many web-sites which support students in learning statistics from those which help perform simple calculations to complete web-based courses. However they also point out that there are very few rigorous evaluations of the effectiveness of this web-based material in improving learning. González et al make the interesting point that these packages look at how statistical applications can make learning easier but they don’t always look at whether they make learning more effective, i.e. better.

González et al evaluated the impact of a web-based tool, e-status, to teach statistics. The tool is a web-based application that provides statistical exercises for students as well as providing immediate feedback as they tackled these exercises. The evaluation of this program had an interesting design as González et al felt that ethically all students should be given the opportunity to use the application. To make this possible the course content was divided into Part A and Part B where the difficulty and length of course content in each part was reasonably equal. Approximately half the students had access to e-status on Part A and half on Part B. Results indicated that performance on the problems where students used e-status was significantly better than that on problems where e-status was not used by 4.8%. For the 94 students who actually employed e-status, the effect size was 0.63.

Dinov et al looked at how the availability of a large online resource for teaching probability and statistics, the Statistics Online Computational Resource (SOCR), helped undergraduates. The resources comprised a range of e-learning facilities including instructional materials, statistical calculators, interactive tools for data analysis and visualisations, computational and simulation applets etc. The evaluation involved three different undergraduate classes, which all included a treatment group which used the SOCR resources and a control group which received classical instructional methods. Pooling the results across all courses the impact of the SOCR resources was large. There was also a decrease in the variance for the treatment groups suggesting that many students benefited from the resources. The e-learning resources were varied but Dinov et al did not report which were more useful than others.

In seems likely that there are many more e-learning applications which are relevant to teaching statistics but this is beyond the scope of the current review since the focus here is on games for learning research methods and statistics.

Table 4. Studies/articles of web-based tools and e-learning applications for teaching statistics (n=5)

<table>
<thead>
<tr>
<th>Author</th>
<th>web-based tool/e-learning</th>
<th>Study aim</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bush 2009</td>
<td>Several web-based tools introduced</td>
<td>To review the existing internet sources for teaching statistics</td>
<td>There exits several tools ranging from class surveys to individual simulation experiments</td>
</tr>
</tbody>
</table>
### Literature review

<table>
<thead>
<tr>
<th>Burruss 2007</th>
<th>Excel vs. flash movies</th>
<th>To find out the group differences when using either excel or flash movies to learn statistics</th>
<th>The study results indicate that statistics introduction should include visual cues to aid learning the concepts and more conceptual test questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archee 2006</td>
<td>Interactive Flash video in teaching SPSS (for Social Sciences)</td>
<td>No aim</td>
<td>Students found that method provided personalized learning</td>
</tr>
<tr>
<td>Basturk 2005</td>
<td>Computer Assisted Instruction (CAI ) SPSS data analysis programme</td>
<td>To find out if SPSS programme supports student’s understanding of statistics</td>
<td>The group with SPSS programme + lecturing gain higher skills level and understanding</td>
</tr>
<tr>
<td>Gonzalez et al 2010</td>
<td>e-status; a web-based tool</td>
<td>To evaluate how e-status improves the statistical abilities of the students</td>
<td>e-status had a positive effect on students’ performance, it had a direct effect on learning numerical operations</td>
</tr>
<tr>
<td>Dinov 2008*</td>
<td>the Statistics Online Computational Resource (SOCR)</td>
<td>To find out the effectiveness of SOCR compared to classic instructional method</td>
<td>The impact of SOCR was large and many students benefited the online learning (less variance in results)</td>
</tr>
</tbody>
</table>

### Visual representations, animations and modelling

- Xie (2008)
- Bowman (2010)
- Forbes (2010)
- Dominguez-Dominguez and Dominguez-Lopez (2010)
- Wender and Muehlbook (2003)

There is a long tradition of using visual representations in statistics to support students’ understanding of statistical concepts such as central tendency, variance and distribution and relationships between variables. Graphs, bar charts and pie charts are all visual representations which were first introduced in the early nineteenth century to help us to display data in a way which is easier to understand (Lewandowsky and Spence, 1989).
Many papers identified in the literature search described animations which go beyond static illustrations to support statistical understanding. Xie (2008) described a variety of animations in statistics and also described how they are made. Bowman (2010) argued that animations can be used to teach a range of statistical concepts ranging from the elementary to the more sophisticated. Forbes (2010) provided examples of how new data visualization techniques provide a way to demonstrate statistical concepts visually and allow statisticians working with official statistics to interrogate and interact with data in new ways. Dominguez-Dominguez and Dominguez-Lopez (2010) described CalEst, a package that provides supporting material in the form of animations to illustrate statistical and probabilistic concepts. The authors did not carry out a formal evaluation but argued that this presentation would greatly improve the understanding of statistical concepts and probability and would help to motivate students.

In an empirical evaluation, Wender and Muehlbook (2003) compared the use of animated diagrams with static graphics to teach statistical concepts. The found a significant advantage for animated graphics on retention and understanding of the concepts presented as well as a significant effect of spatial ability on performance.

Animations are visually appealing and they do seem to help users to understand statistical concepts more easily. Their visual appeal seems to make statistical concepts easier students to understand and helps to allay some of the fears that many students have in understanding statistical concepts as it. To make the best use of these it helps if students can interact in some way with the animations.

Table 5. Articles of visual representations, animations and modelling (n=5)

<table>
<thead>
<tr>
<th>Author</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xie 2008*</td>
<td>Variety of animations in statistics</td>
</tr>
<tr>
<td>Bowman 2004</td>
<td>Statistical cartoons Animation had a potential as a teaching device</td>
</tr>
<tr>
<td>Forbes 2010</td>
<td>Data visualisation A new way to visually demonstrate statistical concepts</td>
</tr>
<tr>
<td></td>
<td>Increased ability to link data with its underlying issues for analysis and teaching</td>
</tr>
<tr>
<td>Dominguez-Dominguez 2010</td>
<td>CalEst a solution for assisting teaching/learning of statistics and probability</td>
</tr>
<tr>
<td></td>
<td>The visual environment and animations encourages students to learn more and explore</td>
</tr>
<tr>
<td>Wender 2003</td>
<td>Animated diagrams The aim of the study was to investigate if computer-animated graphics are more effective than static graphics in teaching statistics</td>
</tr>
<tr>
<td></td>
<td>The results showed that animated graphics facilitated learning better than static graphics and also lead to higher performance</td>
</tr>
</tbody>
</table>
Simulations, models and virtual worlds

More sophisticated game-like approaches have the potential to go beyond visual representation to provide richer and more compelling visual representations of information including game-like features which might support learning.

- Wang, Brandon and Liu (2011)
- Bulmer (2004)
- Stirling (2002)
- Nte and Stephen (2008)
- Lane and Peres (2006)
- Valanides and Anglei (2008)

Wang, Brandon and Liu (2011) carried out an experimental study which examined the impact of animation interactivity on novices’ learning of introductory statistics. This was not a game, but the interactive animation was game-like and allowed the students to practice with examples on the traditionally difficult topic of Hypothesis Testing (including p-values and type I and type II errors). Wang et al evaluated the effects of increasing animation and interactivity on performance on statistics questions. 123 college students were randomly assigned to four different levels of support and increasing animation and interaction from (1) static, to (2) simple animation to (3) input to (4) practice. The results showed that animation interactivity significantly improved students’ understanding and lower-level application of concepts, but not significantly improve student confidence and program perception.

Stirling (2002) argued that Web browsers are useful methods of presenting teaching materials because Java applets can be easily added to provide interactive content. He argues that it is the interactivity rather than the videos or animations per se that lead to improvements in performance.

Lane and Peres (2006) argue that we need to structure students’ interactions in simulation carefully if we want them to maximally effective. One way in which this can be accomplished is by getting students to predict the results of a simulation before interacting with it.

Bulmer (2004) examined the advantages of using virtual worlds to introduce statistical concepts but also cautions that students might get too involved in the virtual world at the expense of learning the task at hand.

The term modelling is used to describe the construction of a simplified representation of the key information in a problem. Modelling is useful at the early stages of research design in helping to identify relevant variables and make predictions about how they relate to each other. Statistical
modelling refers to the adoption of a more formal mathematical approach to understanding variables, relationships between variables etc.

Valanides and Anglei (2008) described the use of a computer modelling tool to help pre-service primary school teachers in learning and teaching about scientific models. Modelling is useful in trying to build a simplified but coherent understanding of reality. The study was carried out with primary school science teachers using the modelling tool (Model-It). The tool allowed the teachers to build qualitative models of a domain by creating objects that correspond to observable entities in the real world, such as sun, soil, plant air etc. The teacher then represents variables associated with each object such as light, water, growth, carbon dioxide etc and then identifies these as causal or not. Relationships between variables (increases, decreases etc) could also be modelled and represented graphically. The results of the study showed that teachers did manage to build models but the teachers found the task rather complex and their models tended to be very simple. This modelling approach has the potential to help players tackle complex scientific concepts and problems, the difficulties suggested that there are constraints on the viability of the model in teaching science. This kind of modelling approach might be useful in qualitative analysis as it is similar to concept mapping which is increasingly viewed as a useful tool for representing constructs.

Table 6. Studies/articles of simulations, models and virtual worlds (n=6)

<table>
<thead>
<tr>
<th>Author</th>
<th>Simulation, model, virtuality</th>
<th>Study/article aim</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wang 2011</td>
<td>Interactive animation programme by Adobe Flash to facilitate hypothesis testing</td>
<td>To understand the affordance and constraints of interactive animation in the statistics education setting</td>
<td>Animation interactivity impacted students’ improvement of understanding but did not had an significant impact on confidence or program perception</td>
</tr>
<tr>
<td>Bulmer 2004</td>
<td>Visual worlds</td>
<td>To describe visual worlds used in sciences and in statistics</td>
<td>The aim of the virtual worlds was to allow students to have some control over design and data collection. The students might have focused too much to virtual reality than to the statistical issues.</td>
</tr>
<tr>
<td>Stirling 2002</td>
<td>Web browsers</td>
<td>To present teaching materials and adding interactive content</td>
<td>The interactivity is the key to improvement in performance not the videos or animations.</td>
</tr>
<tr>
<td>Nte 2008</td>
<td>Virtual scientist in game environment</td>
<td>To evaluate the game usefulness for learning statistics</td>
<td>No objective measures. The survey showed that students agreed that the game helped them</td>
</tr>
</tbody>
</table>
The nature of statistical knowledge and approaches to teaching statistics

- Gal (2005)
- Pfannkuch and Wild (2004)
- MacGillivray and Pereira-Mendoza (2011)
- Tishkovskaya and Lancaster (2010)
- Garfield and Ben-Zvi (2007)
- Garfield, delMas and Zieffler (2010)
- Diekema, Holliday and Leary (2011)
- Leppink (2010)

Several papers identified in the review did not discuss games or e-learning but aimed to characterise the nature of statistical knowledge and understanding more precisely with a view to developing more effective methods of teaching. While not specifically about games these papers were extremely helpful in thinking about game design since the first step in designing a game is to specify the desired learning outcomes. Statistical literacy refers to the skills required to demonstrate a higher level statistical understanding and Gal (2005) argued that statistical literacy skills involve “the ability to interpret, critically evaluate, and communicate about statistical information and messages”.

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<td>Interactive simulations</td>
<td>To describe the effects of simulation in learning</td>
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Some papers focused on problems in traditional methods of teaching statistics and suggestions for improving the teaching of statistics. Pfannkuch and Wild (2004) developed a four dimensional model for statistical thinking in empirical enquiry. The components included investigative and interrogative cycles, types of thinking and dispositions. The investigative and interrogative cycles reflect the cyclic nature of the research methods cycle: the investigative cycle describes the procedures a statistician uses at different stages of the problem, while the interrogative cycle is similar but reflects a more critical approach that statisticians take to the problem and the data.

Pfannkuch and Wild (2004) argue that students do not have the ability to apply their statistical knowledge and to overcome this they argued that teachers’ courses on statistics should be designed around five major themes: developing understanding of key statistical concepts (and especially variation); developing the ability to explore and learn from data; developing statistical argumentation; using formative assessment and learning to understand students’ reasoning.

Tishkovskaya and Lancaster (2010) identified several problems that are traditionally found in teaching statistics. Traditional courses have focused on mathematical and mechanical aspects of knowledge at the expense of using that knowledge. Students perceive statistics as difficult and uninteresting and this leads to anxiety and fear about their ability to learn it. Statistics is taught as a stand-alone module, making it difficult for students to relate their statistical knowledge to their subject discipline and to statistical concepts in everyday life.

Tishkovskaya and Lancaster also summarized strategies to help students learn statistics more effectively. These include: shift the focus of statistics curricula from mathematical calculations to tasks of a practical nature; implement problem-based learning strategies; use real life examples in project work; develop statistical literacy, critical thinking skills and the skill of communicating statistics; use of technology and on-line resources; target misconceptions through discussion and assessment. MacGillivray and Pereira-Mendoza (2011) supported the view that student projects provide a way of supporting student in acquiring usable statistical knowledge.

Several papers aimed to find more effective ways of teaching statistics. The extensive research of Garfield and Ben-Zvi (2007) for example on the characteristics of Statistical Reasoning Learning Environments (SRLEs) has been especially useful in identifying principles which help students to learn about statistics. These principles include using real data sets in classroom activities, using appropriate technological tools to allow students to test their hypotheses and providing opportunities to explore and analyze data and develop their statistical reasoning. Another principle is to get students to work in groups of three or four to discuss the problems and generate written descriptions and explanations and solutions to the problems. The judicious use of assessment to assess what students know and to monitor the development of their statistical learning as well as to evaluate instructional plans and progress is also important to effective learning of statistical concepts.

Garfield, delMas and Zieffler (2010) used the knowledge that they had developed in an interesting way to teach statistics which, while not a game, could have relevance for developing a game-based approach to statistics. They developed model-eliciting activities (MEAs) which were developed in mathematics education as “open-ended problems that encourage students to build mathematical models in order to solve complex problems”. In MEAs students are presented with authentic problems which they might face in the real world and they have to build a model to solve the problem. The examples of models provided by Garfield et al were (a) establishing that a
dataset is really random and (b) developing rules to distinguish spam from non-spam emails. Garfield et al argue that this modelling approach allows students to “experience the statistical enquiry cycle” by considering a real-world problem, a set of data, and the need for a solution. Research on the modelling of methods and statistics problems is at an early stage but Garfield’s ideas about modelling, principles and activities to teach statistics offer suggestions which should be useful in designing a game-based approach to teaching statistics.

Presenting material at the right level of difficulty, not too easy and not too difficult, for the student to learn can help to allay anxiety and boredom and motivate students to learn. Leppink (2010) proposed the method of propositional manipulation where tutors extract the key relevant propositions which need to be learned in learning statistics and present these to students in the form of questions so that students are clear about what they need to know. Presenting the information in this way will diminish fear and avoidance behaviour on the part of the students and help them to engage in meaningful learning (i.e. relating and integrating important elements of the subject matter).

Research methods is also congruent with problem based learning defined as “learning with authentic, ill-structured problems” (Diekema, Holliday and Leary, 2011) where students are given a complex problem with many different facets to solve. The research cycle and the different stages of the research process mirror the stages involved in solving problems. Games could be devised to take students through each step in the research methods cycle providing a good overview of the different stages and skills required at each stage.

Table 7. Studies/articles concerning statistical knowledge and teaching statistics (n=8)

<table>
<thead>
<tr>
<th>Author</th>
<th>Statistical knowledge</th>
<th>Study/article aim</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gal 2005*</td>
<td>Statistical literacy</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Pfannkuch 2004*</td>
<td>Statistical thinking</td>
<td>4-dimensional model</td>
<td>Courses should be designed around 5 themes; developing understanding of key statistical concepts, developing the ability to explore and learn from data, developing statistical argumentation, using formative assessment to understand students’ reasoning</td>
</tr>
<tr>
<td>MacGillivray 2011*</td>
<td>Statistical thinking</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Tishkovskaya 2010</td>
<td>Statistical literacy</td>
<td>Review of the statistics educational literature</td>
<td>Curriculum should take into account student motivation ...</td>
</tr>
<tr>
<td>Author</td>
<td>Topic</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Garfield 2007</td>
<td>Teaching and learning statistics</td>
<td>Review of current research Students learn -by constructing knowledge -by active involvement in learning activities -to do well only what they practice doing It is easy -to underestimate the difficulties of basic concepts -to overestimate how well students understand basic concepts Learning is enhanced by having students to become aware of and confront their errors in reasoning ICT should be used to help visualization and exploring data Consistent and helpful feedback on performance</td>
<td></td>
</tr>
<tr>
<td>Garfield 2010</td>
<td>Statistical reasoning</td>
<td>A model for an interactive statistical course SRLE class model -big ideas, read and take notes, student centred, facilitation through discussion and activities, to explore data, teacher poses questions and guides to discussion</td>
<td></td>
</tr>
<tr>
<td>Diekema 2011*</td>
<td>Problem based learning</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Leppink 201</td>
<td>The method of propositional manipulation (MPM)</td>
<td>Structuring material to be learned and guiding self-explanations of 4 steps -instructor subdivides the subject matter into</td>
<td></td>
</tr>
</tbody>
</table>
what is learned | limited number of propositions (questions)  
- students study these propositions (answers)  
- cognitive schema is developed based on answers  
- students self-explain and they are provided by false or true statement

### Learning in groups / cooperative learning 1

- Krause, Stark and Mandl (2009)

An important question for educational games is whether they are more effective if they are played alone or in teams. There is much interest in modern educational practice in the value of working alongside other learners. Working together is proposed to have many benefits both for less able students who can benefit from more able peers’ explanations and for more able students who can benefit from having to articulate these explanations. Another of Garfield’s ideas about teaching statistics was to get students working in groups.

Krause, Stark and Mandl (2009) noted that students typically find statistical concepts and procedures difficult to understand. Given the emerging evidence about the effectiveness of cooperative learning, Krause et al thought it was worth applying this to learning about statistics in their e-learning environment, Koralle. In Koralle students were required to respond to worked examples on statistics concerning correlations and scatterplots. In their study Krause et al also examined the impact of feedback on student performance. The results showed that feedback led to improved performance but that working in dyads did not. In spite of this, the evidence for the benefits of working in groups in other areas is strong and it would be useful to pursue the idea of collaborative learning in research methods.
3. Conclusion

3.1 Discussion
The literature review confirmed that there are few papers describing game-based approaches to teaching research methods and statistics and even fewer which carried out rigorous evaluations of the success of such games. The closest games to the proposed CHERMUG game were Halpern et al’s Operation ARA and a variant of this, Butler et al’s Operation Aries. Most papers about games for research methods were accounts of the development of the game or how it was used in learning with only limited information about its success in improving performance. It seems likely that this reflects the relatively recent interest in the use of games for learning as well as the acknowledged challenges of aligning learning goals with games mechanics. The relative absence of games in this area is quite surprising given the recent upsurge of interest in using games for learning and given that the skills required in understanding research methods and statistics are highly generic core skills. However there is an emerging interest in using games to teach research methods and statistics and there are reasons to be optimistic that a game-based approach might be successful in supporting learning.

Several papers provided in-depth analyses of the problems students have in learning about statistic and suggestions for supporting students in this. Games provide methods of learning which are highly consistent with modern theories of effective learning which propose that learning is active, constructivist, project based and problem based. Teaching research methods is highly amenable to problem based learning, where students tackle complex, ill-structured, multi-faceted problems with a range of tools and project based learning.

As with all games for learning there is a need to match the desired learning outcomes with the affordances of a game. It seems that a game-based approach is highly appropriate for teaching research methods because the activities of a scientist in following the research cycle, i. e. proposing a hypothesis and looking for and evaluating evidence to test this hypothesis are structurally similar to the cycle of activities involved in many games and especially adventure/mystery games (such as Cluedo). Games also provide enjoyable challenges which players are motivated to solve. The games described by Operation ARA (Halpern et al, 2012), Martian Boneyards (Asbell-Clarke et al, 2012) and Ramler and Chapman’s (2011) use of Guitar Hero to teach research methods were all games where players had to propose a hypothesis, look for evidence and evaluate whether the evidence supported the hypothesis. Collecting data for oneself is highly motivating too and the Guitar Hero project allowed students to collect data from their own experiences of playing the guitar hero game (Ramler and Chapman, 2011).

The use of e-learning applications and animations to support teaching in research methods and statistics has been around for much longer and is more established than the use of games. There was empirical evidence about the success of these evaluations, with several evaluations finding that elearning and animations lead to more successful learning than traditional methods. Dinov et al (2008) and Gonzalez et al (2010) for example reported fairly rigorous evaluations reporting the effectiveness of e-learning applications in teaching statistics. While these applications were not games they included many game-like features. For example animated graphics and interactivity can be especially useful to illustrate the graphical properties of statistical distributions and Wang confirmed that increasing levels of interactive animations in an e-learning application led to better
performance. There were also suggestions (Valanides and Angeli, 2008) that modelling could help in the identification of variables and understanding links between variables. This kind of modelling may be useful in developing qualitative models.

The games described above are examples of long duration games where players have to take part in an extended project with different stages and skills required. However games can provide short or longer duration activities. The subject matter of research methods and statistics is also suitable for using examples which players can practice many times over and receive feedback about their answers. For example mini games could provide short exercises devoted to carrying out a t test.

It was interesting that two of the games which were identified as potentially useful in teaching aspects of research methods and statistics were actually entertainment games. Steinkuehler and Duncan found impressive levels of scientific argumentation in World of Warcraft, while Ramler and Chapman (2011) suggested that guitar hero could be used to test hypotheses. Players demonstrate skills in these informal contexts which are highly valued in the more formal context of higher education.

One of the main reasons for interest in games for learning is that they provide activities which players find highly appealing and on which they are prepared to invest a good deal of time. The engaging nature of games for learning about research methods and statistics was mentioned in several papers. For example Butler, Forsyth, Halpern, Graesser and Millis (2011) claimed that games provide “hard fun” meaning that players experience great satisfaction after completing tasks which are very challenging, while Burguillo (2010) found that students found game theory and competition-based learning highly motivating.

Like other literature reviews, the current review has a number of limitations. It was limited by the search terms used, the journals included and the time period of papers published, although the focus on the past twelve years ensured that the review covered the most recent research. The review revealed that there are currently few games directed to teaching research methods and statistics although there are many e-learning applications which look at statistics. To summarise many features of would seem to be highly compatible with

Teaching the research and statistical skills of scientific methodology would seem to be highly amenable to a game-based approach. It is interesting to note that the focus of most e-learning applications and games is on statistics rather than research methods. CHERMUG is different from these other approaches in that it does not just aim to teach statistical concepts. The proposed CHERMUG game goes beyond teaching statistical concepts to teach research methods and design and supporting students in tackling both qualitative and quantitative approaches to research.

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5. References


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Appendix 1 Lit review papers


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