Cognitive Task Analysis

Continuing/**H**igher **E**ducation in **R**esearch **M**ethods **U**sing **G**ames

CHERMUG

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Abstract (for dissemination)	Research methods and statistics are core competences across various disciplines but pose significant challenges for many students. The CHERMUG project aims to develop a digital game to support students in acquiring methodological and statistical expertise. A key issue that has to be addressed in developing a game is to identify the desired learning outcomes for students. This deliverable describes a cognitive task analysis which was carried out to identify the component cognitive skills, knowledge and competences that are required in developing a comprehensive and usable understanding of research methods and statistics.
Keywords List	CHERMUG, Serious Games, Cognitive Task Analysis, Game Design, Research Methods, Statistics

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Executive Summary

Research methods and statistics are core competences across various disciplines but pose significant challenges for many students. The CHERMUG project aims to develop a digital game to support students in acquiring methodological and statistical expertise. A key issue that has to be addressed in developing a game is to identify the desired learning outcomes for students. To try and identify component cognitive skills, knowledge and competences that are required in developing a comprehensive and usable understanding of research methods and statistics, a cognitive task analysis (CTA) was carried out.

The CTA took the form of structured interviews with research methods experts. The experts were provided with a briefing sheet which introduced them to the CHERMUG project and the aims of the CTA. In a subsequent one-to-one interview, participants were asked to describe a prototypical research problem and for this problem identify and discuss the most prominent and relevant difficulties that they as tutors experienced with their students in working on this. The difficulties discussed could include both tasks or concepts which are challenging for students to perform or understand. Respondents were asked to consider these for the four main research steps in the research cycle: research question, data collection, data analysis and discussion & conclusion. This approach to CTA focused on the experiences of experts teaching or supervising research methods and statistics and provided valuable concrete suggestions and recommendations relevant to the design of the game.

Many requirements for a game to support research methods were proposed by the respondents including:

- the game should provide an active approach to learning
- the game should start with articles
- the game should immediately engage players and provoke research interest
- the game should challenge students in their question definition and research design & show the dependencies of the full research cycle
- the game should get students to make predictions about the next stage
- the game should allow students to experience the difference between qualitative and quantitative research methods
- the game should allow students to experience being part of the experiment
- the game should allow students to visualise data
- the game should provide structured support to students
- the game should include interactions between peers

1. Introduction

In recent years universities have admitted increasing numbers of students leading to larger classes and erosions in the amount of face-to-face contact that students have with academic staff. At the same time there has been interest in how student learning can be supported in other ways. Blended learning has become popular: this combines more traditional face-to-face teaching methods with e-learning activities.

Digital games based learning provides a specific potentially useful and attractive new method of learning with electronic media (de Freitas, 2006). An important reason for this interest is the evident engagement that digital games provide. In addition games also provide activities which seem to reflect modern theories of effective learning which suggest that learning is most effective when it is active, experiential, situated, problem based and provides immediate feedback (Boyle, Connolly & Hainey, 2011). However firm evidence that games can help in learning and the ways in which different kinds of game can help has been lacking.

Developing educational games is not an easy task: it is an interdisciplinary enterprise requiring the technical skills of games developers, the domain knowledge of the subject expert (methods and statistics), an understanding of the pedagogy and psychology of games as well as knowledge of educational interventions and implementation and evaluation methodology.

It is acknowledged that a major constraint in introducing games into the curriculum is identifying the relevance of the game to the curriculum (Kirriemuir and McFarlane, 2004). There is still a lack of knowledge about exactly which features of games are most effective in supporting which kinds of learning. An important requirement for the success of a game is that the game should meet the desired learning outcomes. Understanding the match between the desired learning outcomes and the affordances offered by a game is a complex process. Despite optimism that games can support higher level skills (Dondlinger, 2007) there is more evidence that they are successful in training lower order skills.

1.1 A game for research methods and statistics

The CHERMUG project aims to develop a digital game to support students in learning about research methods and statistics. Acquiring expertise in this poses significant challenges for many students. The subject material is challenging because it is highly abstract and requires the coordination of different but inter-related knowledge and skills that 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, 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 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. However these skills are precisely those required to tackle the ill-defined problems that we face in the 21st century and students across many disciplines are expected to acquire a working knowledge of research methods and statistics in their subject area.

A games-based approach to teaching research methods and statistics is worth exploring for several reasons. Games offer a range of features that could be usefully deployed in teaching methods and statistics. Killi (2005) argued that games can offer players support by providing clarity about different stages in solving a problem. Games can provide clear goals, match challenges to the players' skill level and provide immediate feedback about the correctness of the player's response. Other 'game features' that could be incorporated into the game include the narrative structure of a game, competition, simulation and personalisation.

1.2. Cognitive task analysis

A first step in developing a game to support students in learning in specific curricular areas is to identify exactly which skills and competences students need to acquire. A technique which has been developed to help analyse the higher level cognitive functioning required in tackling complex tasks is cognitive task analysis. Cognitive task analysis is defined as "the extension of traditional task analysis techniques to yield information about the knowledge, thought processes and goal structures that underlie observable task performance" (Chipman, Schraagen and Shalin, 2000, p. 3). Cognitive task analyses have been used for a number of different purposes including the development of training. Generally a cognitive task analysis aims to identify the separate task components necessary to progress through all the necessary steps and reach a solution to a problem. CTA is regarded as one of the contributions that cognitive psychology has made to designing instructional technology.

CTA uses observations of people solving tasks, interviews and protocol analysis to capture the knowledge of experts tackling the task. The advantages of CTA over simply asking experts what they do, is that, as with other automatic responses, experts are unaware of many of the decisions they make.

CTA is typically carried out when knowledge about how a task is performed is uncertain. However on one level the knowledge which is required in developing an understanding of research methods and statistics is quite well known and is presented in many textbooks on the subject. What is not so certain however is the best way to present this knowledge to students. Lovett (1998) argues that CTA can help in describing the curriculum to be taught and decomposing the curriculum into the knowledge and sub-skills that students must learn. She applied CTA to exploratory data analysis in statistics (EDA).

Initially two different approaches to CTA were suggested for the CHERMUG project in developing a specification of the user requirements for the game. The first approach was

similar to protocol analysis: the performance of experts and novices would be compared as they tackled very general research methods problems.

Since protocol analysis is a very time consuming kind of analysis it was decided to concentrate on the second approach. In this analysis, experts in the domains of nursing as well as methods and statistics were interviewed about the cognitive knowledge, skills and competences required in undertaking specific tasks in learning about methods and statistics. The results will provide data on the difficulties and misconceptions that students encounter and consequently where they would benefit most from support in a game.

2. CHERMUG Cognitive Task Analysis

2.1 Methods

Design

The CTA is a form of qualitative analysis focused on the experiences of experts teaching or supervising research methods and statistics.

Participants

In a period of 6 weeks during March and April 2012 a total of 13 interviews were carried out. The interviewees were selected based on their knowledge of and involvement with teaching research methods and statistics. Respondents were asked whether their expertise was in qualitative or quantitative methods or both. 11 considered themselves experts in both with 2 experts in qualitative methods only. No respondents claimed expertise only in quantitative methods. Faculties covered included Nursing and Medicine, Social Science, Psychology, Learning Sciences plus one expert who advised and supported several faculties. The experts were spread over universities and professional universities, some of them covering both. The experts consulted were located in UK (7) and Dutch (3) and Romanian (3) higher education institutions.

Materials

The briefing sheet Prior to and in preparation for the interview participants received a short document which provided a brief outline of the aims of CHERMUG project and a short description of the objectives of the cognitive task analysis and the objectives of the interview (See appendix A). The briefing sheet included a description of the different stages in the research methods cycle (the research question, data collection, data analysis and discussion & conclusion) and also a brief account of three papers which described games which may be relevant i.e. would give the interviewees an idea about possible games in relation to research methods. The articles discussed games based on scripted collaboration for the acquisition of complex skills (Hummel et al., 2011), a massively-multiplayer online environment (MMO) for scientific inquiry (Asbell-Clarke et al., 2012) and an approach based on a set of small ‘games’, so called ZAPS (Hulshof, Eysink, & de Jong, 2006).

The semi-structured interview schedule A semi-structured interview method was adopted. During the interview participants were asked to select one or more realistic and prototypical research studies, cases or projects relevant to the domain in which they provide support to students in their teaching. They were asked their views about the research cycle (Van Buuren, 2008) and guided by figure 1 they were led though the different stages in the research cycle (the research question, data collection, data analysis, and discussion & conclusion) and asked about the main tasks/concepts required at each of the stages as well as issues, problems or difficulties which arise for students at each stage. They were then asked about the skills which they thought were important at each stage in

the cycle. Participants were asked to consider the three different game approaches and asked to consider which might be useful in teaching research methods and statistics.

1. Research question
    a. …
2. Data collection
    a. ….
3. Data analysis
    a. ….
4. Discussion & conclusion
    a. ……

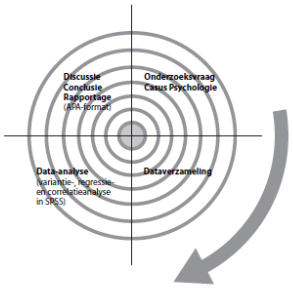

Figure 1: The four stages of the research methods cycle (Van Buuren, 2008).

Procedure

Prior to and in preparation for the interview participants were sent the briefing sheet which they read prior to the interview. The interviews took place in a mutually convenient location. The interviewer had copies of both the briefing sheet and the interview schedule which was followed. During the interview, the interviewer wrote down the participants' responses to the questions by hand. These were then word processed and sent back to the interviewee who was asked to check the response to make sure they agreed that it was an accurate record of the interviewee's views. Some interviewees added further brief explanations or clarifications of what they had said during the interview.

2.2 Results

Below, the detailed outcomes are described. They are organised into three sections (1) general findings; (2) specific findings related to the research cycle proposed and its steps; and finally (3) recommendations, either directly proposed by an interviewee or based on an analysis of the interviews, with regard to the game design or useful suggestions for the game.

2.2.1 General findings

Overall, research methods are seen as a complex and challenging topic for students. The complexity of research methods knowledge is similar to the complexity of writing described by one respondent as "one of simultaneously solving multiple, possibly conflicting constraints" OUNL13.

Students have different objectives with regard to research methods depending on the modules they are doing. Social sciences students carry out research methods modules to acquire a basic understanding of research methods prior to carrying out a bachelor or masters degree or PhD. Students studying modules such as evidence-based practice are

typically nursing students doing a research method module so that they can (a) critique research papers and (b) critically evaluate the relevance of research to their practice. Research methods students tended to have only a basic understanding of research but are now having to develop their own research proposals from scratch. This does reveal large gaps in their working knowledge especially at the initial stages. The different reasons for studying research methods tend to place different emphasis on the skills required.

At a superficial observation level statistics seem to cause the main challenges. However, in practice all steps in the research cycle are equally demanding. As one of the interviewees stated, opting for qualitative research methods in order to avoid statistics does not necessarily pay off since in practice analysing, interpreting and abstracting qualitative data appears to be very difficult. Moreover, the steps in the cycle are tightly connected. Choices made in or lack of understanding of one step directly influences the following steps.

Universities versus Professional Universities Important to notice is a fundamental difference in perception between universities and professional universities on what level of competence or skills is expected with regard to research methods. The position taken by professional universities varied between 'being able to understand research methods' or 'being able to assess research papers in function of evidence based practice' to defining and execution a research plan, however, with parts of the cycle, in particular the use of statistics, being actively supported by a supervisor. Universities, on the other hand, in principle do expect that students can define and execute all steps of a research plan. A number of the interviewees relate this difference to the different foci of the two types of universities. Moreover, for professional universities the importance of research methods is seen as relatively new. For many, first in the last decade research methods have become a regular part of the curriculum. As a consequence also the staff competences in research methods vary and, therewith, influence the demands imposed upon the students. (Note: The latter is shown - at least in the Netherlands - by the various initiatives and offerings for professionalization courses for research methods for Professional University staff).

Findings related to the research cycle First of all, important for our design, the research cycle presented in the briefing sheet was generally accepted by staff as providing a useful framework for thinking about research methods and was also seen as important for students to understand. "everybody has to know the "steps" of the research for understand and interpret what they read." ROMANIA 3.

Some minor discussion points were raised. However, they seemed to relate more to differences in the details discussed than serious disagreements about the research cycle and its importance or use. There was some discussion about the number of stages and the contents or activities required at each stage. Some respondents felt that it would have been useful to highlight other stages in the cycle as separate stages. One respondent said that he adopts an unconventional route as he wants to "*get students excited by research*"

UWS3. Another argued that: "*he would actually go back a stage to ask students what they are actually interested in?*" UWS4

Literature review was also mentioned by several respondents as an important stage but was it a precursor to or part of formulating the research question? Design was regarded as an important stage but it was not clear whether it was part of the research question or data collection or on the cusp? Another issue was to what extent the final step 'discussion and conclusion' really is one step or should be considered as two. Application to practice was variously regarded as part of the research cycle as a whole or more relevant to the latter (discussion) stage of the cycle.

Some respondents questioned whether the cycle is best regarded as linear or to some extent cyclic. The spiral nature of the cycle where the same topic was visited at higher levels where students had increasing levels of knowledge was recognised as a good metaphor. When asking participants about which level of students they felt the game would be appropriate for many thought it would be relevant for students at all stages. Given the complex nature of research methods even experts have areas where they might find it useful to revise their understanding. In the initial development of the game it was thought best to focus on the early stages.

Not surprisingly, with regard to what is a prototypical research question there was a huge variety given the varied research interests of respondents. Interests included gender differences in tattooing; double standards with respect to sexuality; promiscuity; bullying; homelessness; poverty; needs of 'family caregivers'; face book games on English vocabulary and understanding; dyslexia and text formatting/display.

Of importance is the finding that the research cycle and the different stages were seen as relevant for both qualitative and quantitative experts, although the focus, the specific contents and procedures found at each stage differed somewhat. Many students, especially in nursing, sociology and social policy, show a preference for qualitative design mainly because they want to avoid having to do quantitative statistics which they regard as very difficult. In practice however qualitative design appears to be equally difficult. It requires a deep understanding of the topic and is very demanding in abstracting the input gathered in a meaningful way. Qualitative design was much less common in psychology where quantitative design was the design of choice.

Additionally, it is important to note that in Professional Universities the research questions were expected to relate directly to concrete questions of stakeholders in their field of working. In this respect, the point was raised if our design should be generic not directly connected to a domain or, for motivational aspects, be tightly connected to a domain of study.

The research question The research question was perceived by many experts as the key challenge for students in research methods as indicated by all respondents as providing a key challenge (frequently the key challenge). "*This is the biggest stumbling block for students*." UWS6; "*I'm intrigued by the fact that over and over again the students here*

(I've not taught at many other institutions) have a conceptual block in understanding what is the purpose of the research question." UWS5; "*The Research Question is a big issue; it is a nice heading, quite simple but awash with detail.*" UWS7; Getting the research question right is very important because "*The research questions help to identify the design and methodologies to be used.*" UWS1. Students had particular difficulties in scoping the research: "*The scoping of the research objective, research questions and usable hypotheses tend to be the most problematic phase for students*." OUNL13. "*Students must be … taught how to limit or focus the question*. " ROMANIA 2.

A major difficulty is that students have little to no experience with this first step. Typically, their experience is limited to practice with analysing data which they have been given or analysing existing articles. Formulating their own problem and questions requires sufficient background knowledge of the literature, the ability to scope their research so it results in a question which is focussed, not too complex, can be operationalised in a research design including dependent (DV) and independent variables (IV), *and* fits with their time constraints and the available respondents. Difficulties in scoping are illustrated in these comments: "*The students typically want to do it all and narrowing down their research question is very important. I often do this geographically so, for example instead of looking at Britain I say well let's just look at Paisley. This is not generalizable but you have to narrow the focus to make it manageable*." UWS5; "*A common error in student design is that once the student has an idea, they tend to want to test everything.*" UWS2. Problems with narrowing down the literature review were reflected by the comment "they need to search and read almost everything about the chosen subject and to ensure that the study was not already done" ROMANIA 1. To support students in developing the research question, common practice is to offer guidance by a supervisor and/or in course settings where students discuss each others' research questions, plans and planning and/or by offering templates to be adhered to. For students it is important that they understand that the design is the foundation of their research and that all flaws will forward to the next steps.

A number of respondents said that many students knew what the broad area that they were interested in studying, but found it difficult to come up with a research question. One participant had a useful way of helping students to formulate the research question by getting students to summarise the literature: "*I often give them a sheet of A3 paper and tell them to go away and summarise 3 studies in tables, trying to identify what might account for similarities and differences if results are discrepant. I encourage them to summarise IVs in the studies e. g. age of participants, and results, looking at and summarising what's been done and this also helps to identify what hasn't been done. Summary tables help identify gaps in the literature and flush out IVs, e. g. a study might have been done with typically developing children but not with kids with problems. By the end of the 2nd/3rd meeting we would have a series of research questions*." UWS1.

The need to use different examples and to return to the research question having been through the whole cycle was proposed by one respondent: "I observe that it is not so easy to formulate a research question for the novices; I need to choose different scenarios for demonstrate if the proposed question is possible or not to be formulate like this. Usually

the research question is better understood if we go back to this subject after passing the rm cycle." ROMANIA 3.

Students had frequently decided on whether to adopt a qualitative or quantitative approach prior to starting the research. However they still had difficulties in formulating the research question. Qualitative researchers provided useful advice to students about narrowing down the scope of the study or the research question: "*The focus of the Research Question is the main problem – focusing narrowly and directly so that it's not ambiguous and so that it doesn't cover the whole world but more a specific angle or issue. Eg "What causes alcoholism?" is not a good research question but "Why do some young people want to binge drink?" is a better question as it is narrower and do-able*." UWS5. The same respondent also offered an approach she uses to help students narrow down the research area: "First of all they have to think about specific issues and key concepts in that area. I then get them to ask "I wonder" questions (based on x??), eg I wonder why x happens. Or "I wonder what causes y". The students select the xs and the ys they are interested in following up. The "I wonder" question leads them into the formulating the research question."

One participant considered how both qualitative and quantitative approaches could be used to address a research question: "*You could use either approach (qualitative or quantitative) to address a research question or a hypothesis. For example the "Is there a double standard" question could use either a qualitative or a quantitative approach. A quantitative approach might ask 3,000 people their views about this. It would be superficial but generalizable. It looks at large systemic patterns and clustering of wider groups. The focus is more in groups and patterns than in individuals. A qualitative understanding would look at more in-depth understanding, knowledge and practices of the informants, i. e on notions of gender, promiscuity, sexuality, etc. That is, it would attempt to explore in more detail the opinions and attitudes and practices of the individual interviewed and it allows for further prompting in the interview setting which quantitative methods do not. You could develop both (research questions and hypotheses) with both qualitative and quantitative approaches and, often, some research can use both methods to gather data. (qualitative and quantitative)."* UWS5

Design Many participants regarded design as very important. Some felt it was better viewed as a separate stage in the cycle while others regarded design as part of formulating the research question: "*Is design an entity in itself or on the apex of research questions and data collection? You need to know the design before you move on to the next stage (data collection*)" UWS7. The very close links between the research question and design were also evident in this response: "*The design, whether it be qualitative, quantitative or mixed, would be determined by the research questions or hypotheses; for example experimental studies seek to understand the relationship between IVs and DVs; qualitative studies seek illumination from participants*." UWS1

Success in formulating the research question and specifying the design are fundamental to the success of the project. Both qualitative and quantitative experts viewed design as important and impacting on subsequent stages of the cycle.

Most respondents acknowledged that both qualitative and quantitative approaches were important and could provide complementary insights. Qualitative and quantitative were both recognised as useful but different approaches to research. Several respondents felt that a game to distinguish qualitative and quantitative approaches to research would be useful. One nursing interviewee made it clear that while he thought that both approaches are useful, quantitative research could tell us things that qualitative can't. For example in his research on homeless people: "*quantitative methods made it clear that they were homeless because they were depressed not the other way round*." UWS3. The complementarity of the two approaches was noted: "*Qualitative research can offer insights which illuminate the broader brush approach of quantitative research*." UWS1

Students have many problems with quantitative design especially around identification and operationalization of variables and levels of variables. "*They're ok with gender but even with something like age they have no idea how to use age as a variable- age brackets for example. They don't seem to know what appropriate age categories would be, why group age into bands like 16-24 or 17-29 for example. They also find the choice of within between and mixed design very difficult. The design will not be correctly set out because they haven't thought it all through"*. UWS2. "*Operationalising variables is a sensitive aspect for all the students*." ROMANIA 3.

Students also have difficulties with levels of measurement: "Students tend to come out with questionnaire data as that is easier to do but the data that they have thought of and the data that they produce don't match up. For example often they come up with frequency data and they were going to run a two-way ANOVA. If they have a questionnaire, they often have yes/ no answers rather than scale data and there is no variability." UWS2.

Understanding variance was also regarded as problematic: "*Understanding variance causes problems at all stages in the research methods cycle. I try to conceptualise it for them in terms of individual differences. Variance is what you get when you have lot of individual differences in particular measures and if we don't have such variance then we don't have anything to account for. It's important to have measures which display variance so we can explain underlying IV variables which account for variance*." UWS1

Although students perceive qualitative research as easier, it still presents problems. Students have problems with qualitative design. In some cases this is due to lack of knowledge about which method is appropriate for collecting which kind of data: "*They don't have a sense of philosophy of data collection. They would find it difficult to choose between a focus group approach or an interview. They wouldn't know that there are 3 different kinds of interview: closed, semi-structured and open. They don't appreciate that some designs would be better to answer their question than others*." UWS5. Another respondent also reflected difficulties that students have with designing surveys: "*Therefore, it would be of interest to put emphasis on how to design surveys. Currently, common practice is to adapt an existing survey. Giving better insight on how to fit the survey and its questions with the research design and its variables would be very useful*." OUNL30

Data collection It was emphasised that this phase, like all the following phases, inherits the unresolved or unclear choices made in the first phase. Students tend to go through the research cycle step by step, only addressing problems as they arise. At a practical level, in particular planning is the problem in this phase. Student projects have limited execution time. At the conceptual level, it is hard to understand, how many respondents and what is a representative set of respondents. For quantitative studies there is a preference for surveys/questionnaires. However, it is difficult to assure the right questions and scales to be able at the next stage to answer the research question. Finally, ethical issues influence both the planning (permissions required) and e.g. how data are collected and stored.

One respondent had a very specific idea about the data collection stage: "*I have a good idea about this. At the start of the methods course we should spend half an hour collecting all sorts of data about themselves, personality, counting things, no of people in the library, no of cars of specific colours etc; data about everything and anything. This would give us a class data set. Currently we give them simple datasets with a short scenario but these don't mean anything to the students. If we give them a dataset it's like personalised dataset and we can ask e. g. is there a gender difference in x? Currently we fail to let them feel that the data is their own*." UWS2

Data analysis The data analysis step is complex and (as discussed above) the expectations towards the students vary depending on the study taken. Many problems which emerge with quantitative research at the data collection stage are related to lack of clarity at earlier stages. Students need to understand links between stages: "*They need to hold design, flow chart, terminology, levels of data, normal distribution in their mind; we expect them to know these but these skills are not embedded*." UWS2

Two respondents felt that data analysis was the most difficult step: *"It is an obscure aspect for us and the most difficult part of the research"*. ROMANIA 1. *"This is the most difficult part for doctors also"* ROMANIA 3. Students do not seem to have a good conceptual understanding of data analysis: **"***Students can be competent at using SPSS but lack conceptual understanding of what it is doing*." UWS2. This suggests that a focus on previous stages might help students in the conceptual analysis stage.

Since understanding inferential stats depends upon having a good understanding of descriptive stats, a number of respondents felt that it was imperative to provide students with a solid grounding in descriptive stats prior to teaching inferential statistics: "*For grounding the interest of the students in statistics it would be sufficient if the data analysis part emphasises descriptive statistics and pays only limited attention to evaluative statistics*." OUNL16. Therefore, in our case, a preliminary conclusion might be to restrict the design to descriptive statistics to give students insight (and interest) in the data available and include evaluative statistics only voluntary and limited. One respondent had useful ideas for demonstrating variance: "*They are very poor on normal distribution and standard deviation. I demonstrate this by asking them to think about themselves on a motorway flyover. They should count the number of cars passing per minute over the course of one hour. Plotting this data shows a normal distribution with a*

real life example rather than a purely theoretical, abstract understanding. They can cope with means but no idea about sds (standard deviations)." UWS2

The same respondent had another example to demonstrate different sources of variance: "*Understanding variance, ie how things vary, is difficult. I try to use visual examples in class. I use this example where the students have to image it in their head. Imagine an amateur and a seasoned professional golfer standing off the green and they have to chip balls into a hole. Imagine the distances away that balls land – there is high variance. Now imagine the differences between the amateur and the professional – the professional has a lower mean distance from the hole as well as less variability between their shots.*" UWS2

There are also pragmatic problems at the data analysis stage. The problems encountered include the quality of the data sample (both flaws in the data collection method applied as well as with problems getting enough respondents in the available time) and the understanding, knowledge of and practical experience with statistics itself. More or less all students face problems due to too limited hands-on experience or their backgrounds in both concepts of descriptive statistics (means, variance) as well as in selecting and applying evaluative statistics. So Stats might be more about doing than about knowing what is done.

Qualitative analysis presents problems too. It is at this stage that students begin to realise that the qualitative approach is not easy. Students have difficulties in coding data. One respondent offered useful advice about two different approaches to data analysis: "*With the first you generate the codes as you go along based on what interviewees say. With the second you already have the codes and you try to locate aspects in their responses which fit these codes. In an open ended interview the responses will vary considerably and will provide often huge amount of information and you need to manage the flow of information. This contrasts with quantitative research which is very focused on one question, whereas qualitative is much less focused and more open ended. Quite often I take a big sheet of A3 paper and I write participants as rows on the left hand side and the subtopics of the research question along the top as columns with their codes for analysis, so that I have a big grid of participants and their responses to subtopics. Pre-conceived codes to categorise or incorporate bits and pieces is essential for the managing and tidying of the data so that then it can be looked at and critically analysed.*" UWS5

Discussion and Conclusion This stage was seen as less problematic if the previous stages had been carried out correctly. "Generally there are not so many problems at this stage."; "They seem to realise that they have to link their research to research in the field. These are not big problems. It is methods and analysis which are bigger problems."

Although problems which did emerge were that students found it difficult to understand that: "***the*** *most important role of the discussion & conclusion is to report back on the research question started with and next, discuss plus and minuses of the research which may be if importance*." OUNL13. Or as two of the interviewees stated: "*there is a*

tendency to just repeat and put together all findings. To take a step aside and reflect over the findings as a whole demands too much of the students" and "*they tend to make too much of the data; they over-interpret it, making interferences which are too strong or not valid*". Finally, students get personally attached therefore giving "*the need for results priority above a critical reflection*".

The discussion is different for quantitative and qualitative approaches in that there was more continuity between the tasks of analysis and discussion with a qualitative approach: "*Identifying patterns in the data is kind of moving into the discussion. Data analysis is tidying the data. The data analysis requires a degree of interpretation of what participants are saying so this is sort of the discussion.*" UWS5

2.2.2 Design and Game Recommendations

In each of the interviews special attention was paid to discussing and eliciting suggestions and game ideas fitting with the design of the game as a whole but also for specific tasks or concepts. With respect to suggestions for games from the three papers identified, there was most support for the ideas of ZAPS or "mini games" similar to those described in the domain of psychology by Hulshof, Eysink, & de Jong (2006). Most respondents regarded such as an approach as viable and useful for teaching research methods and statistics where there are very many different but relatively discrete sub-skills to acquire. Several respondents identified areas where such Stats-zaps might be useful including: Lit review; formulating research question; differences between quantitative and qualitative approaches; data collection; quantitative and qualitative data analysis ZAPS.

Respondents found it more difficult to understand the relevance of the other two approaches, but some respondents could see that the data collection approach of Martian Boneyards (Asbell-Clarke et al, 2012) could in itself be a mini-game where players were looking for medical evidence which supported specific hypotheses. Perhaps due to the more abstract nature of evidence in social science, social science experts found it more difficult to appreciate the relevance of this game. Some respondents could also see that the scripted collaboration approach of Hummel et al (2011) might be relevant in bringing together for example the two differing perspectives of qualitative and quantitative research.

Respondents also came up with more specific suggestions and ideas for a game-based approach:

Active approach Respondents liked the idea of an active approach to learning. For the beginning students it is important to correlate the RM courses with a project (a published study) and to use practical methods (for understanding the theory).

Start with articles The Romanian respondents commented that it was useful to start with an article/published paper*: "For the students (the novice) I consider necessary to start from the article already published, from the conclusion of this one and we look back for*

understand how it was possible to arrive to this point." ROMANIA 3. *"for the beginning students it is important to correlate the RM courses with a project (a published study)"* ROMANIA 2. "I think that is better to start, in the case of the novices students, with a publication (a conclusion of a study) that the student has to solve (and of course he need to see the key in the final)." ROMANIA 3

Provoking research interest The first impression of what research is all about (and also of a game) is important. As two interviewees stated things are not always what they seem and this should motivate us to examine the world in detail. The suggestion is to open the game with a potpourri of quick, enticing introductions (e.g. as video) to research grouped under the motto "things are not always what they seem", e. g.:

- The example: "makes money happy". This example is used by one interviewee to illustrate how research findings can vary depending of the respondents and what is measured.
- The Lamb watch example. This example is used by one interviewee to illustrate that perceptions change when we know the 'truth'. A farmer is shown attending lambs being born in the winter. It suggests that farmers are good courageous chaps to attend. It turns out however that sheep can have lambs at any time but the spring market is the most profitable.

Challenge students in their question definition and research design & show the dependencies of the full research cycle The first step in the research cycle is of particular importance because it defines also the other steps "a research design house is as stable as its foundation". At the same time students have no experience in setting up their own research. The suggestion by many interviewees is to make use in an interactive game-alike way use of a flow chart / decision diagram or to employ a polyphonic approach of criticising by questioning the design from various view points (e.g. Wiemer-Hastings & Graesser, 2000).

Domain specific content A number of participants reported that research methods and statistics should be taught using content specific to the discipline "students must be oriented through their domain of activity" ROMANIA 2.

A game flow line/ Getting students to predict results/next stage Related to the above is developing a game which requires students to make predictions about the next stage given the specification at the current stage. A number of respondents talked about getting students to predict the next stage from where they are now: *"A device I use to encourage trainees is to represent hypothetical data relating to that problem and to think of what the descriptive stats might look like (means and SDs) and predict some hypothetical inferential stats. I also emphasise the importance of unpredicted findings. Science only progresses as a result of unexpected findings. Sometimes we need to tell students that in*

reporting the results of their discussions in fourth year that it's not a problem to have unexpected findings." UWS 1; "*It would be of interest to help students to become aware of the importance of 'forecasting' over the individual research steps taken. This means e.g. in each step to be aware of how this step and its outcomes will affect your discussion and conclusion and the importance of taking notes about issues that may be of importance later on.*" OUNL30

Experience the difference in research methods: qualitative or quantitative? Several respondents suggested that it would be useful to illustrate in some way differences between qualitative and quantitative approaches. Qualitative and quantitative research approaches both have their merits: exploring to gain insights or focusing on specific questions. The two methods face different specific challenges. To give a feeling why / what to choose two small games based on the following ideas are proposed:

- For qualitative data create a context which influences the meaning of statements and have students categorise them and subsequently face them with their results. One respondent provided a seminar which she uses for this purpose which might be useful in this respect.
- Illustrate the same research question by analysing the input of 5 one minute interviews (variety and ambiguity) in contrast to 20 people mini-questionnaire answers (focused and limited).

Experience by being part of the experiment Abstract data will be easier to apply over the domains. However, a personalised dataset might be more appealing and intuitive. The proposal is to put students' own data in focus, i.e. have them participate in the data collection and open up the opportunity to represent & understand it by 'playing' with it" including the opportunity to experience the statistical aspects of the data: e.g. the meaning of randomisation, variability, variance, mean, median etc. and as an advanced option to allow for some testing with data that they have generated from themselves, for example via a brief questionnaire. The questionnaire could also be presented as a game. (what kind of data? - Data which is amenable to both qualitative and quantitative analysis. Scoring personal ads; sweeties in a tin: class of students select favourite from a tin of mixed sweeties: quantitative stats and qualitative analysis of preference; are there double standards with respect to sexuality; homelessness).

Visualisation Several respondents mentioned the capacity of a game-based approach to help students visualise the data. Several respondents regarded visual demonstrations as especially useful and felt that games have the capacity to support visualisation. As discussed above one respondent mentioned examples of how variance could be illustrated by thinking about (a) number of cars passing per minute and (b) expert and novices putting. These examples could be illustrated graphically. Other suggestions included: "*To include in the game perspectives to enable 'understanding before analysing' data e. g.*

looking at extremes, making use of graphical representations as part of the process to get a global understanding of the data before making use of evaluative statistics." OUNL13

Structured approaches Respondents mentioned a number of structured approaches which might help to in categorising information or making links between categories. Examples included: Templates for literature review where papers are analysed with respect to prescribed criteria; Templates for qualitative data analysis where codes are data is analysed by generating and extracting codes; providing constraints: "*Maybe it is possible to make use of the constraints imposed by a particular statistical methods and have the students create a "visual sudoko" fitting and giving insight in choices which fixate the kind of methods available*." OUNL13. Or in line with this a flow diagram for selection of appropriate tests based on their design. A number of respondents felt it might be possible to include a decision making game for quantitative stats to help students to select the appropriate statistical test. ***"****Many stats books (eg Green and d'Olivera, 2005) include a flow chart about which stats to use dependent on the design. Students seem mystified by this but it is really very useful*." UWS2; "*What is currently available with respect to design are various flow charts in books which could be converted into a game based on decision making. Learning by doing*." UWS1

The Discussion and Conclusions step Several interviewees pointed out that students tend to make too much out of their data". The suggestions discussed above such as e.g. in '*Provoking research interests*', '*Experience the difference in research methods' and 'Experience by being part of the experiment'* can also be used to illustrate the importance of critically reflecting on and positioning one's own results.

Interactions between peers Research methods and statistics are a tough topic. Likely it will be impossible to foresee, include and put into focus on all important aspects in a proper way. Many interviewees mentioned the importance of proposing, discussing and exchange ideas between peers. For example, the main steps could be complemented with discussion and idea sharing alike games (see e.g. digital dialogue games: http://www.interloc.org.uk/about.htm (Ravenscroft, Mcalister, & Sagar, 2010)).

Game as a safe place Finally, many of the suggestions mentioned relate to the importance of giving students the opportunity to experiment on their own pace and while not having to worry about mistakes. "*They would like to gamble on PC with a correct story and a wrong story about how to make an appropriate research (on the same subject) – and see where they can arrive in the two situation.*" ROMANIA 1. In this way they can see what may be right, wrong or misleading, instead of being directly confronted with it in a classroom or by their supervisor. Relevant examples are for eg the examples

mentioned in 'provoking research interests', the exploration of qualitative versus quantitative research, the use of stats.

Finally, the respondents mentioned the following resources/systems/approaches which might be of interest to look at and/or to link to:

- Virtual Research Environment: http://wiki.surf.nl/display/VRE/VRE+Starters+Kit
- Study Coach. The Study Coach gives tips and suggestions on how to study (http://www.studiecoach.ou.nl/algemeen/index.php) It addresses topics ranging from 'how to find information', 'writing', to 'time management' (note: in Dutch only).
- HBO-Kennisbank contains more than 15.000 open access knowledge products from Dutch universities of applied sciences (http://hbo-kennisbank.nl/en/page/home/) It is suggested that students orient themselves on products of their peers within the scope of their research.
- Select-a-Kibitzer [see: 'Peter Wiemer-Hastings, Arthur C. Graesser (1999)
- ***MythBusters*** is a science entertainment TV program created and produced by Australia's Beyond Television Productions[1] for the Discovery Channel.
- Rudestam, K. E. and Newton, R. R. (2007). Surviving your dissertation: a comprehensive guide to content and process.
- Green, J. and d'Olivera, M. (2005). Learning To Use Statistical Tests in Psychology. Open University Press.

Conclusion

The structured interviews with experts in research methods and statistics achieved their objectives in providing a clear overview of the processes required in developing a coherent understanding of research methods and statistics and identification of the main problems and difficulties that experts felt that students encountered in doing this. The interviews also provided various concrete suggestions and recommendation for the design of our game. While CTA is time consuming it is felt that the results produced were worth the effort.
Research methods and statistics is complex and there are very many different components where a game based approach might help in learning.

A general conclusion of the CTA was that, even more than expected, our target audience is extremely heterogeneous. There are different demands with regards to research methods depending of university type, country and domain. Therefore, we should be clear about our prerequisites (e.g. being able to do and report on a literature study), the choice between qualitative and quantitative research and our demands with regard to statistics.

Respondents did not appear to view the level of expertise at which the game was targeted as a problem. While initially it was thought that the game should be targeted at beginners, it seems that it could potentially be useful for students at all stages. "*The spiral (progressive) nature of the model would also describe well the idea of students coming in with different experience of, knowledge of and participation in research. It recognises the journey with respect with respect to academic level and progression.*" UWS7. Given the complex nature of research methods even experts have areas where they might find it useful to revise their understanding. In the initial development of the game it was thought best to focus on the early stages.

Some respondents were very outspoken, nevertheless shared by all, in stating that maybe the most important aim is trying to increase student motivation and get them excited about research and interested in being part of the research community. Many students lack confidence in their ability to do research methods. As one respondent stated, one of his students "*was frightened of SPSS initially but when showed how to use it he suddenly found it was wonderful and became quite evangelical about it*". UWS2.

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Appendix 1. CHERMUG Cognitive Task Analysis Briefing sheet

1. Introduction to Chermug

Research methods and statistics are core competences across various disciplines but they pose significant challenges for many students. The material is challenging because it is highly abstract and requires the coordination of different but inter-related issues that 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, 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.

CHERMUG is a project which aims to develop a game-based approach supporting students as they learn about research methods and statistics. Developing educational games is an interdisciplinary enterprise requiring the technical skills of games developers, the domain knowledge of the subject expert (methods and statistics), an understanding of the pedagogy and psychology of games as well as knowledge of educational interventions and implementation and evaluation methodology.

1.1 The Interview

This interview is part of the Cognitive Task Analysis (CTA) for the Chermug project. The CTA is one of the 5 deliverables of the Chermug project relating to the Requirements and Design of the Educational Game task. The other deliverables focus among other things on literature, technical requirements, attitudes towards game-based learning and the final design.

The objective of the CTA is to ensure that the Chermug game will meet the desired learning outcomes. To this end, experts in the domain of nursing, social sciences as well as methods and statistics are being interviewed to identify the component cognitive skills, knowledge and competences required in developing a comprehensive and usable understanding of research methods and statistics.

The interview will be aligned around the question “how would a researcher (student) go about developing a research proposal in their area, the stages they would need to go through, issues they would need to tackle and what problems they might encounter”. The focus of the interviews will not be to define and discuss all details required to become a skilled researcher. But rather the focus is on:

- one or more realistic and prototypical cases relevant to your domain;
- the research process as a whole;
- essential tasks/concepts of this process. The tasks/concepts should be relevant to Methods and Statistics; they should be clearly embedded in the cases and they should be suitable for a game or for gamification (this is clearly more difficult for you to decide!).

During the interview you will be asked to expand on the cases, the process and the tasks to determine the cognitive knowledge, skills and competences required in developing a coherent approach to research methods and statistics.

The interviews will be in two parts. The first part of the interview should establish one or two prototypical research studies (as discussed above), consider the different research stages (the Research question, Data collection, Data analysis, Discussion & conclusion) and the main tasks/concepts required at each of the stages (guided by figure 1). The second part will zoom into the actual tasks and concepts and the component cognitive skills, knowledge and competences required and a first scoping of the game. In the third part (*note: outside this interview*) we will consider some suggestions for the game.

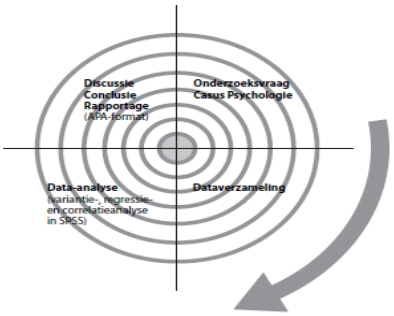
Research cycle: 1. Research question a. … 2. Data collection a. …. 3. Data analysis a. …. 4. Discussion & conclusion a. ……	

Figure 1 (source: Van Buuren, 2008)

2. Positioning CHERMUG – Initial Constraints

To guide the interviews, this section contains a brief overview of the assumptions and constraints under which CHERMUG will be designed and developed.

2.1 The position of Research Methods and Statistics (M&S) in the curriculum

Research Methods and Statistics is seen as being an integral part of a curriculum (e.g. Psychology, Nursing, Sociology, Educational Science) not as one or more M&S domain specific courses. (see e.g. Van Buuren, 2008).

2.2 Game-based approach

It is proposed here that a games-based approach to teaching methods and statistics is worth exploring for several reasons. Games offer a range of features that could be usefully deployed in teaching methods and statistics. Killi (2005) argued that games can offer players support by providing clarity about different stages in solving a problem. Games can provide clear goals, match challenges to the players' skill level and provide immediate feedback about the correctness of the player's response. Other 'game features' that could be incorporated into the game include the narrative structure of a game, competition, simulation and personalisation. The proposed game will use a range of "game based features" to support learning. The game will be a role-playing game (RPG) where players take on the role of a researcher who has to design a study to test specific research questions.

2.3 Blended Learning

The game and its elements – in principle- can be used independently. However, teacher are expected to position and integrate them in their regular courses (class-room and/or online). (Note: the main focus of the project is to develop a game. However, examples of

best practice on how to use the game in a course or curriculum will be designed in parallel with the actual game development and deployment).

2.4 Target group & level

- The students chosen for participation in this project are nursing and social science students in higher education. Both groups of students are required to undertake teaching on research methods and statistics so that they can understand and evaluate research evidence, design effective research studies and apply their knowledge to their practice (bachelor level). Note: To which degree this is useful for and/or excludes other disciplines will be investigated separately.
- CHERMUG will have to operate under different cultural, educational and institutional settings. Attitudes, motivation and expectations may vary between countries and domains covered. (Note: CHERMUG will become available in seven different languages i.e. English, Spanish, Dutch, Romanian, Finnish, French and German.)
- CHERMUG will limit itself to establishing a comprehensive, motivating *introduction*, i.e. enabling students to develop an understanding of and interest for research. The game will familiarize the students with doing research. It will actively engage students with the how and why of tasks and concepts underlying a research process starting from problem description and research question to data analysis and reporting including the most commonly concepts and techniques from descriptive and descriptive and evaluative statistics.
- It will not seek for completeness but instead focus on key concepts/tasks part of the research process and embedded in 'authentic' cases and e.g. stick to one level of measurement to ease the introduction in statistics (Van Buuren, 2008) [For a similar example see the OUNL M&S introduction course "S13121 Kwantitatieve Data-analyse" which introduces the basic set of statistical techniques in the context of 'real' studies and at the same time includes tasks related to the reading of sources, formulating objectives and hypotheses, analyzing data, interpreting results and drawing conclusions].

2.5 The type of game

Serious games exist in many 'shapes and sizes'. To exemplify below 3 games formats are shown relevant for CHERMUG.

Example 1:

Game alike cases for the acquisition of complex skills:

Hummel, H.G.K., Van Houcke, J., Nadolski, R.J., Van der Hiele, T., Kurvers, & Löhr, A. (2011). Scripted collaboration in serious gaming for complex learning: Effects of multiple perspectives when acquiring water management skills. *British Journal of Educational Technology*, 42(6), 1029-1041. [See also www.emergo.cc**]**

The first example suggests a scenario alike approach. The game players step into their role of a researcher and complete their research step by step following a given script. The use of media is varied, the game-element, however, is limited.

Example 2:

Scientific inquiry in a massively-multiplayer online environment (MMO):

> **Jodi Asbell-Clarke, Teon Edwards, Elizabeth Rowe, Jamie Larsen, Elisabeth Sylvan and Jim Hewitt (2012) Martian Boneyards: Scientific Inquiry in an MMO Game. *International Journal of Game-Based Learning* (IJGBL), Volume 2, Issue 1**.

The second example 'Martian Boneyards' resembles a common game environment most. The game offers all ingredients to do scientific inquiry. The user is in control and decides what to do and can e. g. also decide to divide tasks with other players.

Example 3

An approach with a set of small 'games' illustrative for M&S essentials:

> **Hulshof, C. D., Eysink, T.H.S., & de Jong, T. (2006). The ZAP Project: Designing interactive computer tools for learning psychology. Innovations in Education & Teaching International, 43, 337–351.**
>
> **[the corresponding ZAP website (Dutch only) :** http://zap.gw.utwente.nl/__ZAP-project/__project.html**]**
>
> **Hulshof, C. D., Eysink, T. H. S., Loyens, S., & de Jong, T. (2005). ZAPs: Using interactive programs for learning psychology. *Interactive Learning Environments, 13*, 39-53.**

Approach 3 is of particular interest. It does not offer an integrated approach. Instead, it focuses on small, independent units 'mini-games', so-called ZAPS. The ZAP project (Very Active Psychology) distinguishes three types of 'mini-games' to explore phenomena in Psychology in an active and interactive way, i.e. Exploration-ZAPs, Experience-ZAPs and Experiment-ZAPs (Joyca Lacroix, Sofie Loyens, Casper Hulshof (2002) D2.1 Domein Analyse. Online: http://zap.psy.utwente.nl/documents/ZAP_D2-1-domeinanalyse.pdf). They use a check list of questions to derive if a phenomena is suitable to be 'Zapped'.

For CHERMUG we (probably) will opt for a combination of approach 1 and 3. It will enable us in an integrated way to focus on the research process as a whole and concentrate on key issues. Approach 1 can be implemented as an EMERGO alike role-playing game. Additionally, following approach 3, a set of small games can focus on key (suitable for games) issues identified and offers flexibility in how to embed the results more easily in a lesson or curriculum. In our case this would imply that we have to select, analyse, design and develop a set of game based methods and stats essentials, GEMS, and (probably) integrate them in a way similar to approach 1.

2.5.1 Game based Essentials for Methods & Statistics (GEMS)

The idea behind GEMS for methods & statistics is that small games are relatively easier to build and to embed in a course or a curriculum. The idea of GEMS is not new. Reduced and adapted this gives for GEMS the following, first shortlist of questions (to be adapted):

1. Is it a common task/concept for an introduction in M&S
2. Which type of game?
3. Will the student produce data that can be used? (E.g. as part of this game, for the overall game or for the CHERMUG evaluation; Describe the data.)
4. What is the expected added value to use a game as compared to other approaches or the game interaction, how will it help to improve the understanding or to make the task/concept more attractive to study?
5. The game size/complexity: is it possible to create a 15-30 minutes game?
6. Are there any specific issues to consider in the game design e.g. support required, complexity to focus upon, underlying model, misconceptions, etc…
7. Is an initial briefing and/or debriefing required. If yes, describe
8. Available materials? E.g. text, movies, images, persons to interview, etc. to use or to point to…?
9. Any domain / M&S specific prerequisites for this game? If yes, describe.
10. Is it related to real world phenomena?

The shortlist should help to select suitable GEMS and give the first input for the detailed design.