A serious game for learning statistics: The Playground Game

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Abstract: The Playground Game was developed for teaching research methods and statistics to nursing and social sciences students in higher education and vocational training. It offers an inquiry-based learning scenario that focuses on a practical problem case: players have to make substantiated judgements about a study that was carried out to decide upon the most suitable location for laying out a children's playground in a fictitious town. This case history explains the design of the game and how the authoring tools of the EMERGO game platform were used to avoid the need for software programming. Also it presents the outcomes of an evaluation with 112 individuals that played the Playground Game.

Keywords: Serious gaming, statistics, methods, evaluation, audio cueing, incentives

Introduction

This case history describes the Playground game, which is a web-based game for teaching research methods and statistics to nursing and social sciences students. By offering a realistic problem case it aims to bridge the gap between theory and practice of statistical methods. The player´s task in the Playground Game is to assist the authorities of a small fictitious town at deciding about the most suitable location for laying out a children's playground. Given the purpose of the playground, which is to combat child obesity, the player has to collect and evaluate the arguments for situating the playground either in the "East" district of the fictitious town or in "West" district. This is not a straightforward decision, because the population of children at risk to obesity is not uniformly distributed over the different town districts, and multiple other influencing factors have to be taken into account. For each of the two districts a variety of data related to obesity have been collected in a research report that is available from the start of the game. The report, however, contains severe flaws, which are either manifest or obscured. The player has direct access to two key characters in the game, which are the consultant and the expert. The former is the originator of the report. The latter is fiercely disputing the claims made in the report. In the game the player has the opportunity to intensively interrogate these characters. Answers are represented in videos. Both characters have strong but conflicting opinions about the quality of the data, the methods used and the conclusions that should be drawn. The player has to critically examine and judge the arguments, while taking into account that both the consultant and the expert may occasionally talk nonsense. This situation essentially characterises what statistics skills are all about: being able to identify and remove plausible but erroneous arguments.

In addition to this main objective of supporting inquiry-based learning of statistics, the second objective of the Playground Game is to explore and demonstrate efficient game creation. Generally, the high upfront investments needed for developing quality games are a severe barrier for the market uptake of serious games (Stewart et al., 2013). To avoid any efforts in software development

required for game creation, we have realised the Playground Game by using dedicated game authoring tools that are embedded in the EMERGO educational gaming platform. The EMERGO platform is an open source gaming platform developed by the Open University of the Netherlands (www.emergo.cc). It runs on the Java EE platform and uses the Spring application framework, the ZK framework, Ajax, MySQL database and XML-tagging for all game content and progress. The platform offers a variety of functional components (e.g. for defining locations, scores, interviews, pop-up messages and many more) that include tools for content authoring and defining structural relationships between content elements. Game dynamics are defined with a rule editor that allows for defining content-based event triggers, to be expressed as condition-action dyads. In principle, the rule editor allows game development without the need for programming. Eventually, teachers and other people lacking computer programming skills would be able to create their own games.

In this paper we will describe the Playground Game and briefly explain the authoring procedure. Also we will report both qualitative and quantitative outcomes of the evaluation that we have carried out with 112 participants from Leuven University.

The teaching problem

Statistics and research methods are gaining relevance in many professions, e.g. in health, business and education, since professional work is increasingly informed by social sciences studies. An increasing number of students in psychology, medicine, nursing, pedagogy and many other disciplines are required to be capable of critically analysing and assessing the validity and applicability scientific studies and the associated research outcomes. They need to learn how to define and operationalise variables, how to select an appropriate design to examine links between variables, how to decide about suitable methods of data collection and data processing and how to make inferences from the outcomes. For many students, however, research methods and statistics are notorious obstacles, because of the complex material involving abstract concepts, a diversity of pre-conditions, practical constraints, mathematical formulas and complex software tools. Various studies report anxiety among students and negative attitudes toward statistics (Beurze et al. 2013; Griffiths et al. 2012). A major problem in methods and statistics teaching is the gap between the formal methods and procedures, which all seem to work fine under well-defined constraints, and their application in practical problem cases, which generally display a larger number of variables, a higher degree of complexity and unclear boundaries. We chose to develop the Playground Game, because exactly games are supposed to be useful for bridging the gap between theory and practice (Westera et al., 2008). Various games for this purpose have been made available in the past, be it that most of these games present small, quiz-like exercises about statistical concepts, such as mean, standard deviation, and correlations. They thereby adopt an instrumental perspective, while they focus on the technical execution of elementary processing steps (e.g. www.statgames.ucr.edu/games.htm, www.onlinemathlearning.com/statistics-games.html). Scarce educational games about doing research include the context of operation, but thereby these tend to be highly specialised, e.g. addressing Master of Science level students (Westera et al., 2008). The Power of Research is a widely announced browser game, supported by the European Commission, that would allow players to adopt the role of scientists working in a realistic (but virtual) research environment. However, the game failed to attract a large group of players, possibly because of its complex contents and the high demands these make to the players. For wider audiences, various games are available that allow players to participate in and contribute to real scientific research via a crowdsourcing model, for example the EteRNA project (http://eterna.cmu.edu/web/), which

involves players for reconstructing RNA molecules, Foldit (http://fold.it), which requires players to link, bend and fold amino acids, and EyeWire (http://eyewire.org/), which lets players construct the 3D wiring of nervous cells in the retina. Although participation in such games may be informative, the players´ contributions tends to involve small repetitive tasks rather than the overall research design.

The Playground Game design

The Playground Game is in Dutch; a demo version of the game is available at http://goo.gl/mwH9YL. As a starting point we have identified the following requirements for the game: 1) a simple problem case for contextual learning, 2) the need for active inquiry, 3) experiencing and learning about common pitfalls, and 4) feasible, efficient creation. For reasons of simplicity the player's task was decided to involve the analysis rather than the synthesis of a research design: assessing the quality of a research method and the validity of its outcomes. Figure 1 displays the overall structure of the Playground Game.

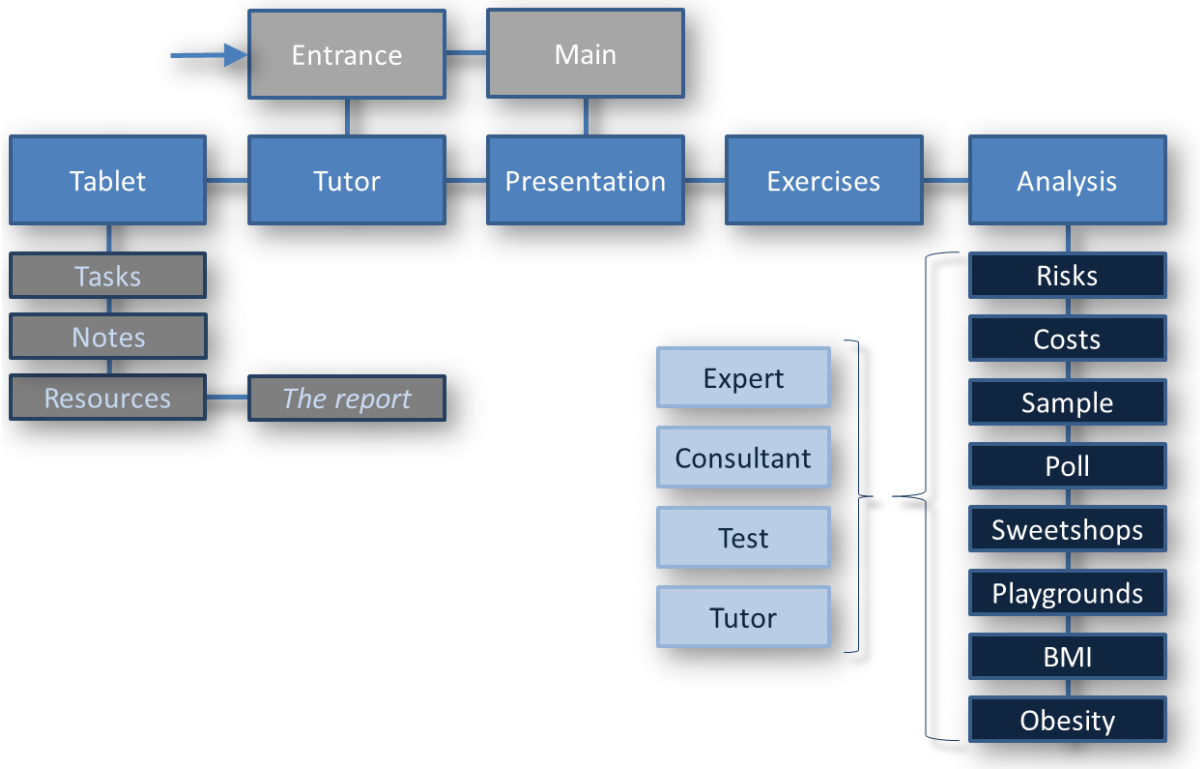

Figure 1. Floor plan of the Playground Game

The game starts at the entrance, which briefly presents the task assignment. Next, the player is transferred to the tutor, who is a built-in character (captured in pre-recorded videos) explaining the problem case. After this introduction the player is transferred to the main location, which provides access to five underlying activities or locations: tablet, tutor, presentation, exercises and analysis. The tablet reflects a ubiquitous device that gives access to a tasks progress report, the player's recorded notes and a variety of resources among which the playground report that was written by the consultant. The tutor remains approachable during the game and may provide tailored feedback on performance. The presentation displays a recording of a press conference with the consultant presenting and explaining her final report. The exercises comprise a series of mini-games dealing with basic aspects of the research cycle, e.g. formulating hypotheses, defining relevant variables,

selecting appropriate methods for data analysis, identifying ethical issues and interpreting the outcomes. The mini-games are add-ons that are fully separate from the playground case. The analysis part is where the actual work is done. It zooms in onto eight different issues of the report that need to be dealt with (in arbitrary order). The issues include the risks of obesity in different districts, costs against benefits, the sample taken in the study, the questionnaire used, the effect of existing sweetshops in the districts, existing playgrounds in the districts, the body-mass indexes observed in different districts and the actual abundances of obesity in the districts. Each of these issues are analysed along the following four activities: an interactive interview with the expert who reveals his criticisms, an interactive interview with the consultant defending her case, a test where the player has to decide about the conclusions, and a feedback presented by the tutor. Performance on these tests is expressed as a cumulative score. Figure 2 displays the consultant giving her presentation. The tablet with utilities is at the bottom left.

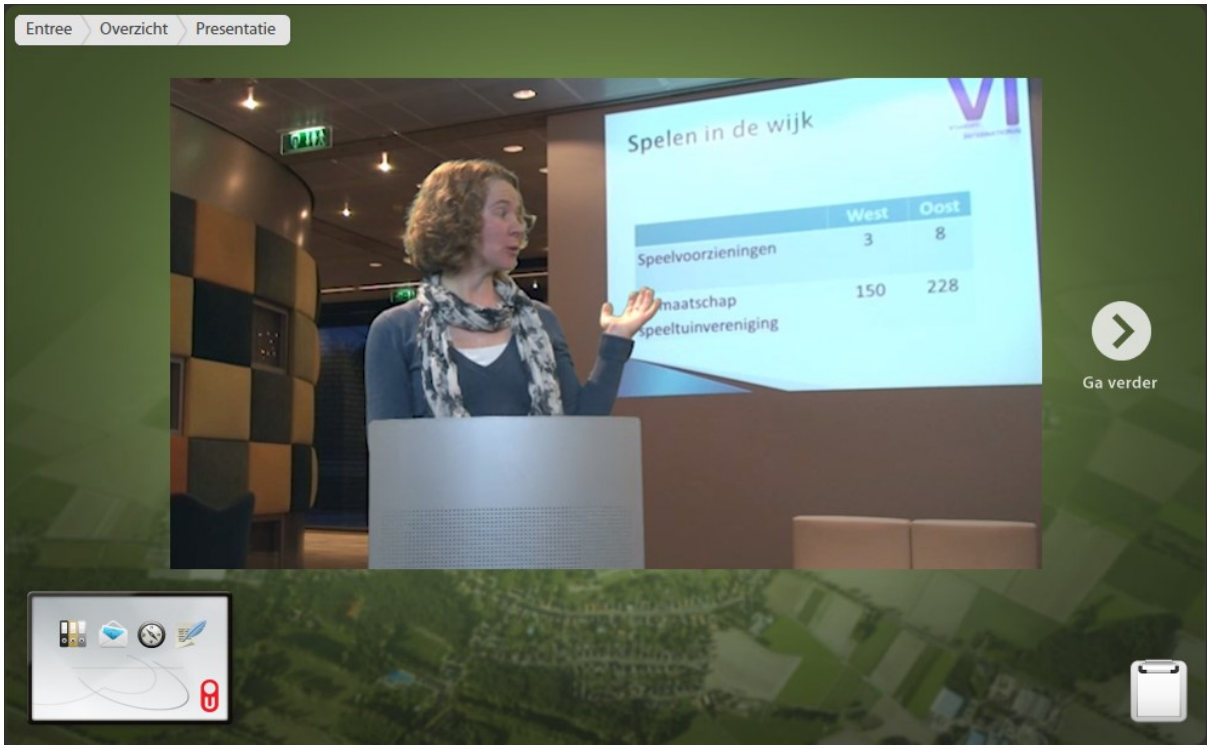

Figure 2. Screenshot of the consultant presenting the outcomes of the report.

In figure 3 one of the analysis parts is shown with the expert disputing the validity of the sample. The interview (as are all interviews) is carried out by selecting questions from the list that is displayed below the video image.

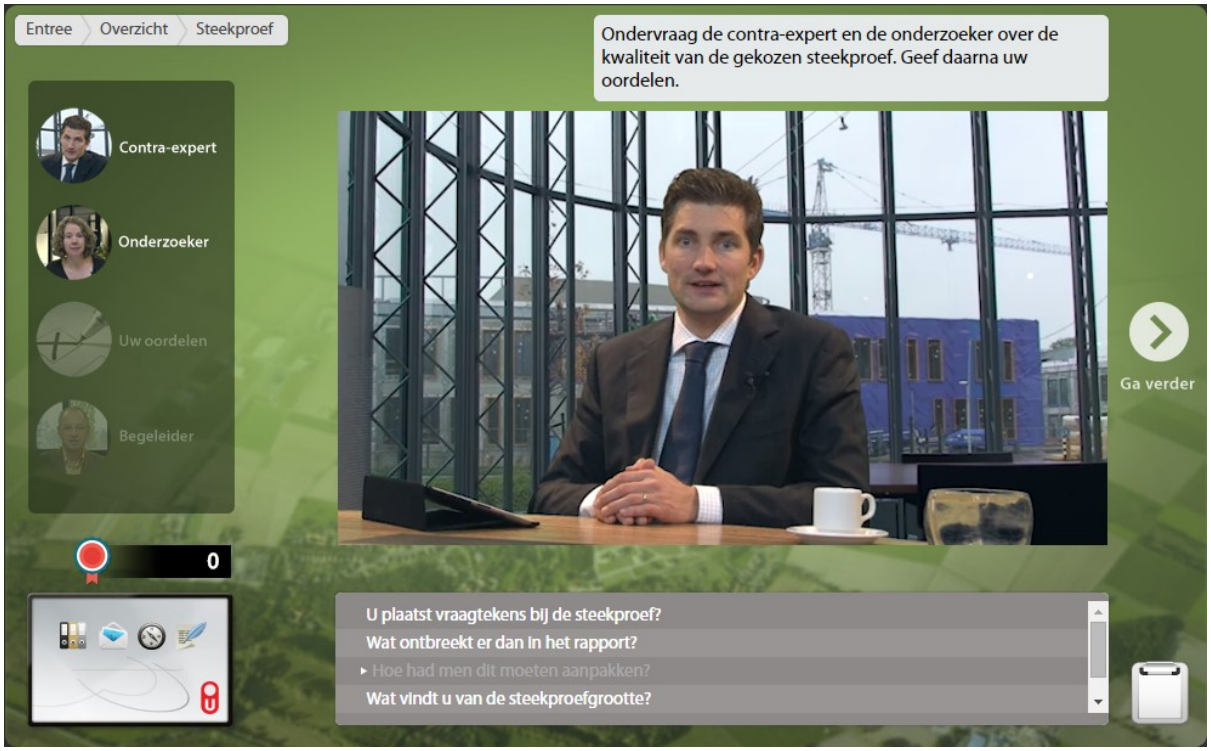

Figure 3. Screenshot of the interview with the expert.

On the left, navigation buttons are visible that provide access to the two interviews, the test (still disabled here) and the tutor feedback (also disabled). Below these navigation buttons, the score is displayed, which is linked to the results of the tests.

Game creation with the EMERGO platform

The Playground Game was created with the EMERGO game platform, which is a component-based system, particularly designed for efficient game creation: no software development is needed since it uses an extended set of functional components that allows for defining and authoring the game contents (cf. figure 4).

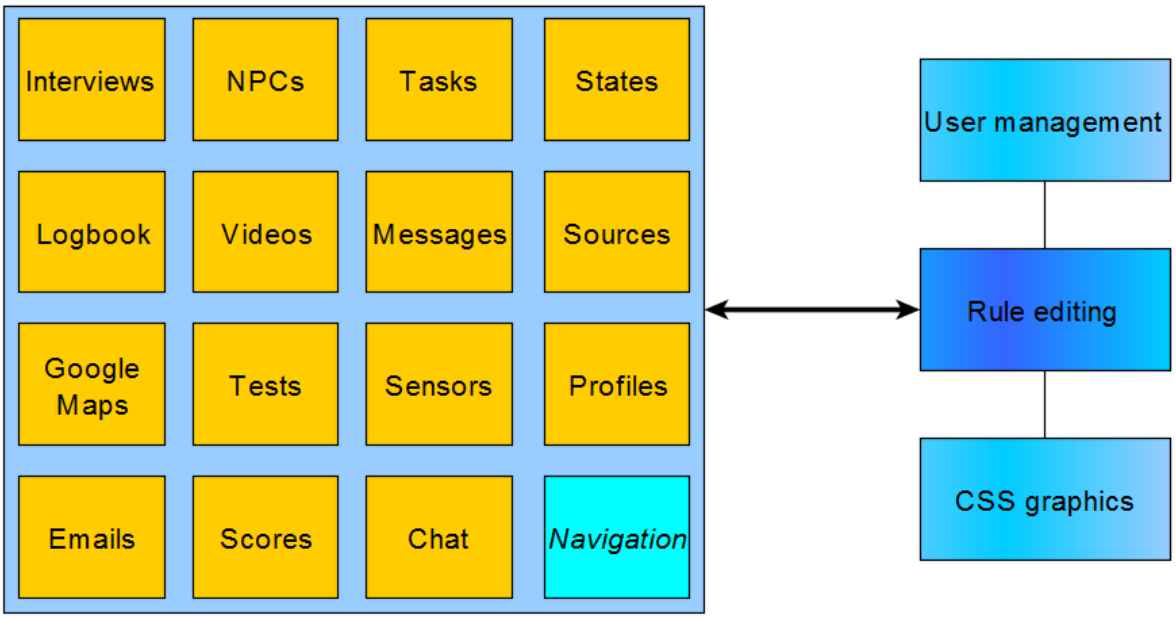

Figure 4. Components of the EMERGO gaming platform (non-exhaustive)

The components include utilities for adding interviews, pop-up messages, multiple-choice tests, scores, chat, source materials, and many more to the game. Each component allows for entering specific contents, e.g. texts, graphics, videos, sounds. The rule editor allows for linking these contents in event triggers, which are logical conditions that produce state changes upon firing, for instance “if the player is in location A, then play sound B and show message C”. The resulting set of rules governs how the game behaves. A special object is the navigation component that allows for defining the floor plan of the game. This is done by building a data tree of locations and their attributes. Figure 5 shows an example of the location data tree.

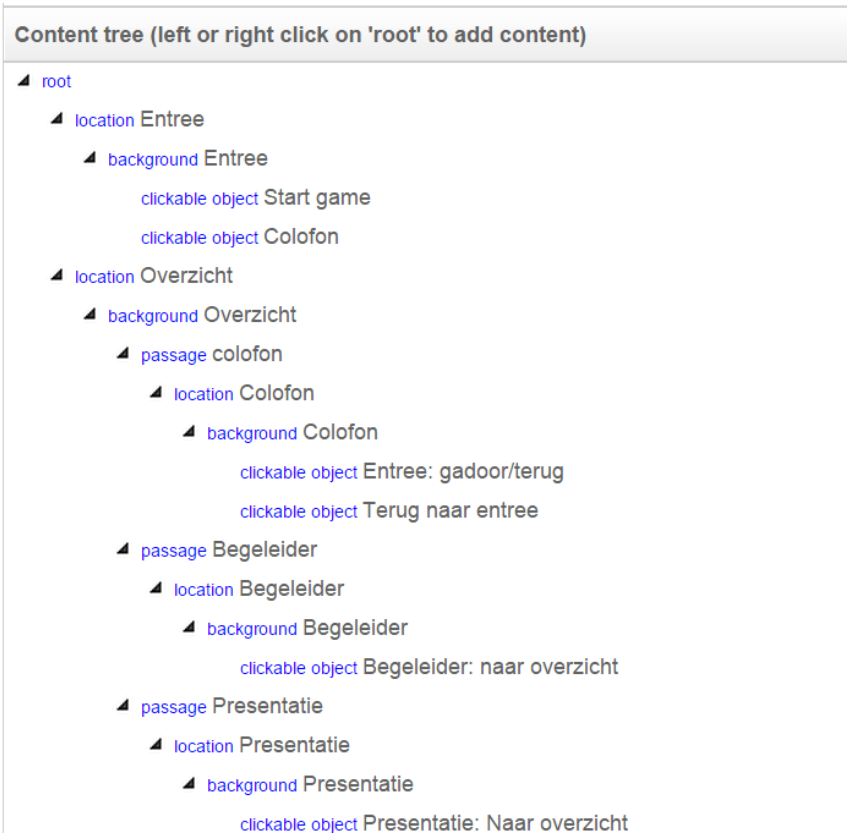

Figure 5. Excerpt from the authoring part of the game’s floor plan

The location data tree includes “locations”, “backgrounds”, which are graphics to be shown as background pictures, “clickable objects”, which are buttons, and “passages”, which are buttons leading to a subordinate location. Detailed attributes define the appearance of the objects and their position on the screen. The look and feel of a location can be easily adjusted by uploading another background graphic, or replacing the graphics of clickable objects and passages. The creation of the Playground Game took about 15-20 person days, half of the time required for content creation, viz. text writing, graphics design, video recording and video editing, and the rest of the time for game design, data entry, rule specification and testing. Video recording, which may easily be laborious and time-consuming, was greatly simplified by using green screen keying in our studio (no lighting and sound issues), and involving colleagues for playing the roles of tutor, expert, and consultant (no casting and no bills) and using autocue (no rehearsals needed).

Evaluation

The evaluation of the Playground Game was arranged by recruiting psychology students from the bachelor programme of Leuven University; participation was rewarded with credit points for the curriculum. A pre-questionnaire was used to collect background information about the participants and to establish their prior knowledge level. An aggregated metric for prior knowledge level was based on 1) an overall self-assessment score, 2) a set of questions about familiarity with statistical concepts, 3) a 5-items test about methodological issues. The metric was expressed as a figure between zero (no knowledge) and one (full knowledge). A post-questionnaire was used to derive a similar aggregated metric of the knowledge level for being able to establish learning gains. Also the post-questionnaire collected qualitative feedback from the participants. Out of 125 subscriptions, 117 participants completed the games and the two questionnaires. With respect to the distribution of prior knowledge we've detected and removed five outliers. The resulting sample contained 112 participants.

Outcomes

Significant learning gains represented by the differences between the final knowledge score in the post-questionnaire and the prior knowledge score derived from the pre-questionnaire. After playing the game, the test score mean has increased from 0.515 (SD=0.086) to 0.571 (SD=0.099) representing an overall relative gain of 10.9 %. A paired t-test analysis qualifies the overall increase as highly significant: $t(111)=-5.670$, $p<0.01$, $r=0.383$.

In the post-questionnaire the participants were invited to express their comments on the Playground Game (Table 1). All judgements involve quality scores that are aligned as percentages (0-100%).

Table 1. Quality scores about the Playground game.

Topic	Judgement (%)	Standard deviation
Clarity about what to do	49	28
Structure of the game	50	28
The role of the videos	69	21
The quality of the videos	63	22
Quality of tutor feedback	68	22
Operating the game	51	23
Fun	63	24
Concreteness	66	20
Instructiveness	59	26

The quality and role of the videos are positively evaluated as is the quality of tutor feedback. Students indicate that playing the game is instructive and makes statistics concrete. These findings are confirmed by the participants´ answers to open questions on the Playground game´s strengths and weaknesses. Up to 40% of the students referred positively to the videos used in the game (e.g. "you are completely absorbed in the game and part of the story"). Another 20% referred to the degree of realism and concreteness that the game offers; 13% commended the feedback given by the video tutor; 10 % referred to the game as highly motivating by its playful approach to learning. Three students explain that the game amplifies a critical attitude toward proclaimed pros and cons in research. Clarity, structure and operation of the game receive moderate (neutral) judgements.

Quite some students (30%) were a bit puzzled at the start and would have preferred more instruction; 17% of the students had some technical issues (e.g. browser issues, or slow internet connection, which affected performance of the videos). Few students didn't like the approach, or found that the approach was too practical and that it should include more theory. One quarter of the students didn't mention any weaknesses.

Conclusions

Based on a substantial group of participants we conclude that the Playground Game substantially and significantly procures learning gains. Players appreciate the integration of statistical learning contents in a game environment, which bridges the gap between theory and practice. Many participants have qualified the Playground Game as highly motivating by its playful approach to learning, which successfully made statistical problems tangible and accessible and at the same time enforced an active role for the players during interrogations and decision making. Even though the videos were just provisional recordings with colleagues who kindly adopted the roles of the Playground Game's actors, the students appreciated the videos' involving qualities. It suggests that high-quality recordings with professional actors need not be a necessity for achieving learning gains. This supports the premise of the EMERGO platform that teachers and students should be accommodated to create their own games. Also, the instructions and feedback provided by the video tutor were considered positively. Quite some participants, however, commented on the openness of the game and would require more specific instructions and theory. This means that a learning-by-doing approach and the associated freedom of movement, which are often advocated with respect to games and simulations (Schank, Berman and Macpherson, 1999; Aldrich, 2005) should go with clear instructions and support in order to prevent disorientation among players (Westera, 2014). Overall we conclude that the Playground Game is well appreciated by the students, in particular for its realistic and playful approach to making statistical methods concrete and tangible.

Acknowledgements

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