User requirements of a serious game as training tool for basic psychomotor skills training in minimally invasive surgery: Kheiron Training System

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Abstract

Minimally Invasive Surgery (MIS) requires a particular training of different psychomotor skills. To safely train these skills outside of the operating room, physical simulators, also called box trainers, are usually employed The application of ICT-based technologies, such as serious gaming and e-learning, to MIS training could provide final users (medical students and surgeons) with a novel tool to acquire basic psychomotor skills. This work surveys end users of a future serious game for basic psychomotor skills training in MIS in order to determine technical characteristics to be included in the definition and implementation of the serious game. 14 Spanish medical students and surgical residents participated in the study and they all agree in the usefulness of this type of systems as a training tool. Preferred characteristics include: multiplayer capabilities, the inclusion of achievements/awards and privileges. In as second phase, these results will be complemented to those obtained in a series of co-creation workshops in different European countries in order to design, develop and validate a serious game for basic psychomotor skills training in MIS to be used by the European medical community.

1. Introduction

Minimally Invasive Surgery (MIS) has become a gold standard in many procedures thanks to its multiple benefits for patients (shorter recovery rate or morbidity) and health systems (reduction in the overall cost) [1]. These techniques imply acquiring specific psychomotor skills due to the differences between open and MIS psychomotor skills, which are not in any case interchangeable [2]. The fast and continuous development of MIS request new systems for initial and lifelong learning training.

During its early stages, MIS training can be split in cognitive and psychomotor training [3]. Cognitive training covers the theoretical knowledge related to the MIS procedure and psychomotor training comprises the skills to accomplish it. To allow for safe training outside of the operating room, psychomotor training is initially performed on surgical simulators (physical training boxes or “box-trainers”, virtual reality simulators, etc.) and then on an animal models and cadavers (where available) before performing a procedure on a patient. Cognitive and psychomotor trainings are usually acquired in a combined approach by assisting to in-person courses in specialized training centres [4].

ICT-based technologies have proved a high value for medical education. E-learning platforms have been developed for MIS training with positive acceptance of the final users [5][6]. The gap is found in the fact that these environments are mainly focused on cognitive training rather than in psychomotor skills training.

On the other hand, serious gaming is an innovative ICT approach with great success in different fields of education [7] and with an enormous potential to improve medical training by providing non-formal and informal learning or being part of formal training programmes [8]. Initial studies prove the correlation between performance in commercially available games and laparoscopic performance in box trainers; but serious games specifically designed for MIS training and their utility as learning tool have not been fully exploited yet [9]-[11].

Therefore, the objective of this work is to define, implement and validate a new serious game for MIS psychomotor training. This particular article is focused on a survey with end users to establish a preliminary list of

user requirements to be included in the definition and implementation of the serious game to increase its acceptation and utility.

2. Material and methods

2.1. Participants

14 Spanish end users were recruited for the study. These included 8 medical students and 6 surgical residents. The only pre-requisite to participate in the study was matching any of these two profiles as they are considered the end users of the serious game.

2.2. Questionnaires

An online survey was developed and distributed using Survey Monkey, a commercial survey delivery service. Candidates who had shown willingness to take part in the study were contacted via an e-mail invitation letter. Detailed purpose and goals of the study were included in said invitation letter. A link to access the survey and instructions to complete it were also provided.

The questionnaire was composed of two different sets of questions. The first one included open questions related to the use of serious games for psychomotor skills training, such as:

- Have you ever thought about the possibility to make use of serious games for your further education? Why? Why not?
- What would you expect to learn from a serious game for laparoscopy?
- What factors or characteristics should the serious game include for you to use it?

The second set of questions included closed questions about possible characteristics of the games.

2.3. Data analysis

All identifying information was kept confidential and data were anonymous and statistically analyzed. Percentages were rounded to one decimal. For closed questions, descriptive analysis was performed using the same delivery system Survey Monkey, while statistical analysis was performed using SPSS software (version 18.0 for Windows, SPSS Inc., Chicago, IL) and significance was set to 0.05.

3. Results

Thirteen participants (92.9%) had never played a serious game before. The only user who answered affirmatively had played a game for language learning but not related to surgery.

The main reason most mentioned for not considering serious games for surgical training was the lack of awareness and availability of this type of systems (4 users, 28.6%). Ten users (71.4%) would like to have them available to acquire and improve their surgical skills. The reasons given for this were: because practice must be done elsewhere but in patients (1 user, 7.1%); because serious games would very useful for training and acquisition of skills in the initial stages (7 users, 50.0%); because they can complement theoretical lectures (1 user, 7.1%) and because the learning curve could be shortened with them (1 user, 7.1%).

The features that would encourage the final user to play the serious game are provided in Table 1, while expected skills to be learned with the serious game are included in Table 2. Percentages of final users who would like the proposed characteristics in the closed questions are shown in Figure 1. Most preferred characteristics are: multiplayer capabilities, the inclusion of achievements/awards, and privileges (92.9%). The only characteristic that was highly rejected is having a limited number of lives to play (35.7%).

Feature	N	%
Realism in images and movements of the tools	7	50.0%
Easy to use and interactive	7	50.0%
Different levels of difficulty along the game	5	35.7%
Clear and basic information and no background knowledge required	4	28.6%
Complete in terms of contents (theoretical and hands-on practice) covering al requested skills to perform the surgical procedure	3	21.4%
Cheap	3	21.4%
Accessible	2	14.3%
Tactile feedback	1	7.1%
Include surgical complications	1	7.1%

Table 1. *Number of users (and percentage) who mentioned each feature. Percentages do not add 100% because more than one feature was stated by some users.*

Skill	N	%
Calculate movements	11	78.6%
Use of the surgical tools	5	35.7%
Orientation in the surgical field	3	21.4%
Get used to work with a 2D vision of a 3D field	2	14.3%
Accuracy	1	7.1%
Self-confidence	1	7.1%
Surgical techniques	1	7.1%
Surgical complications	1	7.1%

Table 2. *Number of users (and percentage) who mentioned each skill. Percentages do not add 100% because more than one skill was stated by some users.*

Users were also asked about other possibilities for the implementation of the serious game (Table 3). They all prefer a positive scoring system, where they acquire points each time that a task is properly completed rather than having an initial score and subtract points when

mistakes are made. On the other hand, there is a more divided opinion related to whether tasks should be available from the beginning (9 users, 64.3%) instead of unlocking them when progressing along the game (5 users, 35.7%). Finally, both unlocking new tasks and unlocking new levels of the same task after properly completing one were similarly preferred (4 vs. 3 users and 7 users who liked both options).

Significant differences were not found between opinions of medical students and surgical residents in any of the closed questions (p>0.4 in all cases).

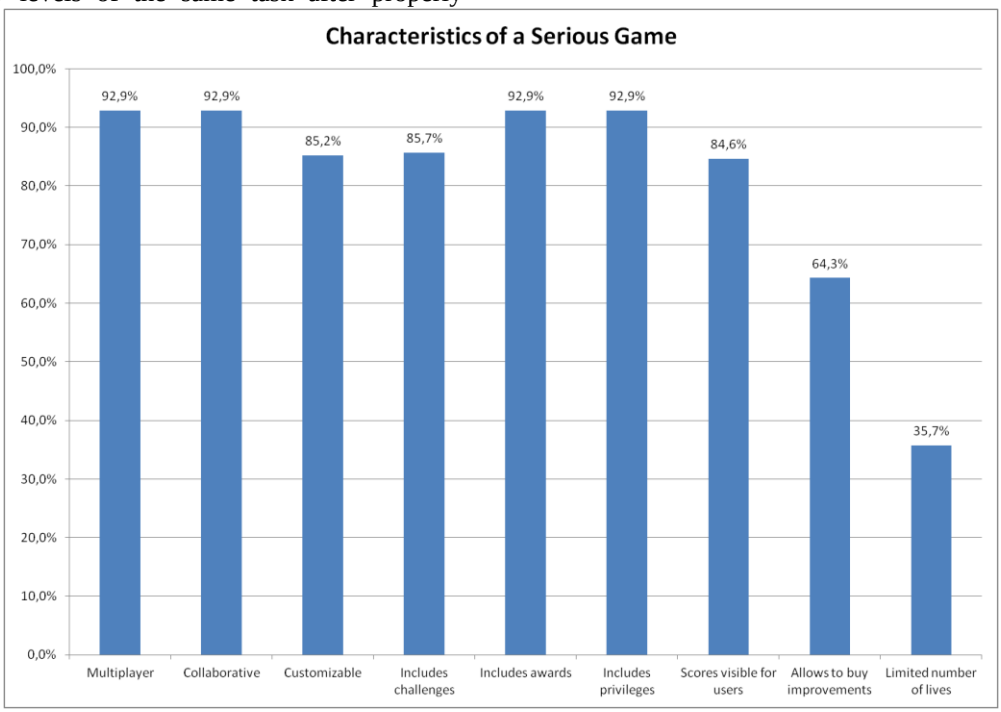

Figure 1. *Percentage of users who positively rated the inclusion of each characteristic in the serious game for surgical psychomotor skills training.*

Characteristic	Options	N	%
Scoring system	A positive scoring system (earning points in correct actions)	14	100%
	A negative scoring system (losing points in incorrect actions)	0	0%
Unlocking tasks	Progress in the game unlocks new tasks	9	64,3%
	All tasks are available from the beginning of the game	5	35,7%
Availability of tasks	Finishing a task unlocks new tasks	4	28,6%
	Finishing a task unlocks new levels of the same task	3	21,4%
	Both	7	50,0%

Table 3. *Number of users (and percentage) who prefer each of the proposed options.*

4. Conclusions

Psychomotor skills training is a key part of any formative curricula for MIS due to the characteristics of these procedures. The use of box-trainers in the initial stage of training is widely used, but their combination together with e-leaning systems is still missing. On the other hand, serious gaming is an innovative ICT approach with great success in different fields of education and it has an enormous potential to improve medical training [9]-[11] that have not been fully exploded yet and no commercial serious game specifically designed for MIS training is currently available.

Therefore this work aims to determine which characteristics are more suitable to be included in the development of the serious game. Medical students and surgical residents are the target users of this training tool. Since they all belong to the Y generation (born between 1980 and 2000), they are all used to ICT-technologies and are willing to use any ICT device in any field of their lives, more specially for their professional training [12]. This is confirmed by the fact that none of them was reluctant to use the serious game for basic psychomotor skills. Bearing in mind that the users to come will belong to the Z generation (born from 2000 until nowadays), who will be used to technology (smartphones, tablets, etc.) from their early days, the inclusion of ICT-based systems, such as e-learning and serious games, in the surgical curricula seems the natural evolution of the current trends.

Medical students and surgical residents would like to acquire and train basic psychomotor skills using a serious game with a high degree of realism, both in the images displayed and the movements requested to complete the tasks. This way, they would be able to better calculate movements in the 3D surgical field and learn how to use the surgical tools. Therefore, it is important to mimic as much as possible the actual surgical setting, using actual surgical instruments as controllers of the serious game, rather than a mouse for PC or controllers for commercial video consoles.

Characteristics such as collaborative multiplayer, including challenges or making scores visible to all users encourage medical students and residents to play. Competitiveness is a key factor that would increase participation with the final aim of obtaining better results, and therefore, better performance than the rest of users.

The serious game must also present a sufficient variety of tasks and difficulty levels to cover all psychomotor skills intended to be taught through the game. An intermediate approach between all tasks available and unlocking tasks while progressing along the game must be defined, in order to meet users' expectations. The serious game should not restrict the user to play (limited number of lives or all tasks being blocked at the same time) as this is seen as a discouraging factor.

With the development of a serious game with these characteristics combined with e-learning, medical students and surgeons will be provided with an ICT-enhanced training system that will cut across traditional in-site training systems including open and distance learning and open educational resources.

5. Future work

These results are the initial research for the design and development of the Kheiron Training System (KTS).

The next step in the definition of the user needs and technical requirements of the of KTS serious game is the organization and development of a co-creation workshops in different European countries (Spain, Germany, Hungary and Romania), where end users will get together with technical experts in order to determine current training needs and further define the technical requirements of the KTS serious game.

Similarities and differences between countries will be analysed and taken into account into the definition of the KTS serious game architecture, including the learning objectives and specifications, with the aim to tailor the KTS serious game to national specific needs, if deemed necessary. Finally, the KTS will be implemented and validated by a broad number of final users, who will determine its utility and functionality, and will provide the actual and valuable feedback of the development.

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