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Proyecto de Innovación y Mejora de la Calidad Docente

Convocatoria 2015

Proyecto nº 241

VALIDACIÓN DE LA UTILIDAD Y DIFUSIÓN DE RESULTADOS SOBRE VIDEOJUEGOS EDUCATIVOS EN CIRUGÍA

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Objetivos propuestos en la presentación del proyecto

1. Publicar los resultados finales sobre la evaluación de utilidad de ambos videojuegos

2. Utilizar los materiales elaborados para la docencia de nuestros alumnos.

3. Poner nuestros materiales a disposición del profesorado de la UCM.

4. Difundir nuestros métodos y materiales docentes, así como los resultados de nuestras evaluaciones, entre el profesorado de otros centros docentes Españoles y Europeos.

Objetivos alcanzados

1. Los resultados finales sobre la evaluación de utilidad del videojuego “Toma de contacto con el bloque quirúrgico” fueron evaluados para su posible publicación en la revista PLOSONE (PONE-D-14-22613; *Using a videogame to facilitate students' first visit to the operating room. A randomized controlled trial*) véase anexo. Tras satisfacer múltiples requerimientos por parte de la editorial, el manuscrito alcanzó finalmente la situación *Under Review* en diciembre de 2014, para ser finalmente rechazado. El manuscrito está siendo reeditado con vistas a ser remitido para su posible publicación en *Medical Education* donde ya fueron publicados los resultados preliminares de nuestros estudios.

2. La evaluación del juego educativo “Implementación y correcta utilización del listado de verificación quirúrgica” fue completada con más de 100 profesionales sanitarios de distintos hospitales de nuestra comunidad. Los resultados preliminares de nuestro trabajo fueron rechazados para su posible publicación en la revista MEDICAL EDUCATION (MED-2014-0491; *Videogame to increase WHO Surgical Safety Checklist effectiveness*). Estamos a la espera de remitir el manuscrito del apartado anterior para remitir un nuevo manuscrito, ya iniciado, con los resultados finales sobre la evaluación de nuestro último videojuego a: i) PLOS MEDICINE, ii) PLOSONE, iii) MEDICAL EDUCATION, o iv) otras revistas.

3. Los materiales elaborados están siendo utilizados para la docencia de nuestros alumnos.

4. La última versión del videojuego “Toma de contacto con el bloque quirúrgico” está a disposición del profesorado de la UCM a través del enlace que se muestra a continuación. La última versión del videojuego “Implementación y correcta utilización del listado de verificación quirúrgica” estará disponible con la publicación de los resultados de su estudio de validación (v. punto 2)

   http://e-adventure.appspot.com/redirect/juego-eadventure-mi-primera-experiencia-en-quirofano

5. La última versión del videojuego “Toma de contacto con el bloque quirúrgico”, así como los resultados preliminares de nuestras primeras evaluaciones, está disponible a través del enlace anterior, incluido en Med Educ. 2013 May; 47(5): 519-20. doi: 10.1111/medu.12167

6. Hemos puesto nuestros materiales a disposición de la Consejería de Sanidad de la Comunidad de Madrid y de otras administraciones. Hemos difundido nuestros métodos y materiales docentes, así como los resultado de nuestras evaluaciones, en distintos foros.

Metodología empleada en el proyecto

ELABORACIÓN DE VIDEOJUEGOS

El equipo elabora los guiones y sus correspondientes diagramas de flujo (v. PIMCD 2014/161 y anteriores), luego lleva a cabo: i) la captura, ii) la edición y tratamiento de imágenes, y iii) la incorporación a documento multimedia. A partir de las imágenes se elabora el juego educativo. Con personal de quirófano del Hospital Clínico San Carlos (HCSC), se realizan las capturas de video e imágenes. Posteriormente se filman escenas para la elaboración de las sucesivas versiones de los videojuegos y éstas son editadas.

VALIDACIÓN DEL VIDEOJUEGO POR EXPERTOS

Cuando se dispone de una versión razonable, se somete a la consideración de expertos (fundamentalmente cirujanos, anestesiólogos y enfermeros), a quienes se solicita que respondan a un cuestionario (v. PIMCD 2014/161 y anteriores) para mejorar las sucesivas versiones. Los videojuegos se mantienen en continuo proceso de mejora.

ESTUDIO COMPARATIVO DE VALIDACIÓN CON ALUMNOS

Se llevó a cabo un estudio de validación del videojuego “Toma de contacto con el bloque quirúrgico” con alumnos de 2º de Enfermería y de 3º de Medicina que acudían por primera vez a quirófano. Los alumnos fueron distribuidos en dos grupos antes de su primera experiencia en quirófano. A unos (n=70), se les proporcionó el videojuego, mientras que los otros (control; n=62) no tuvieron acceso. Todos, al día siguiente de su práctica en quirófano, rellenaron un mismo cuestionario (v. PIMCD 2014/161 y anteriores).

Los datos obtenidos, fueron agrupados para evaluar cuatro percepciones distintas por los alumnos: i) miedo a cometer errores, ii) conocimiento sobre “cómo actuar”, iii) errores cometidos y iv) actitud/comportamiento hacia los pacientes. Los resultados demostraron que la exposición a nuestro videojuego, antes de la primera visita a quirófano, tuvo un efecto significativamente positivo en las cuatro dimensiones analizadas.

ESTUDIO COMPARATIVO DE VALIDACIÓN CON PROFESIONALES SANITARIOS

Tras un estudio piloto con el videojuego “Listado de Verificación Quirúrgica” con profesionales sanitarios (enfermeros, anestesiólogos y cirujanos) del HCSC, se llevó a cabo la validación a gran escala en distintos hospitales. En sesiones de 90 minutos, tras rellenar un cuestionario (v. PIMCD 2014/161 y anteriores), los profesionales de los distintos estamentos utilizaron libremente el videojuego durante aproximadamente 45 minutos. Finalmente, rellenaron otro cuestionario (v. PIMCD 2014/161 y anteriores).

Recursos humanos

MIEMBROS DEL GRUPO

- Manuel Giner Nogueras, Javier Arias Díaz, Juan José Vázquez Estévez y Pedro Ruiz López, profesores de Medicina y cirujanos de plantilla de hospitales del Servicio Madrileño de Salud vinculados, planifican el diseño de los videojuegos y elaboran la relación de elementos que los integran. Una vez elaborada cada una de las sucesivas versiones, se revisa críticamente y se somete a la consideración de sus colegas y otros profesionales sanitarios, proponiendo las modificaciones pertinentes. Además, elaboran el diseño de estudios de evaluación y participan en la publicación de resultados.
- Baltasar Fernández Manjón y colaboradores, profesor de la Facultad de Informática de la UCM, y creador de la plataforma e-Adventure de videojuegos educativos, verifican el diseño propuesto por los cirujanos y elaboran las sucesivas versiones del mismo; primero con recursos gráficos (animación) y posteriormente con imágenes reales (fotografía y vídeo). Además, participan en el diseño de los estudios de evaluación y en la publicación de resultados.
- Antonio Blesa Malpica y Fernando del Rio Gallegos son médicos intensivistas ejerciendo activamente su especialidad en el Hospital Clínico San Carlos y profesores con dedicación a tiempo parcial en la UCM. María Caniuca, es alumna de la Facultad de Filología de nuestra universidad. Todos ellos se han incorporado más recientemente al equipo de trabajo, colaborando en las tareas anteriores.

OTRAS PERSONAS DISTINTAS DE LOS MIEMBROS DEL GRUPO

- Evaluadores expertos: 66
- Alumnos de 2º curso de Enfermería y de 3er curso de Medicina de la UCM: 132
- Profesionales sanitarios (enfermeros, anestesiólogos y cirujanos) del HCSC: 100
- Personal de quirófano del HCSC que colaboraron en la toma de recursos gráficos.
- Varias personas que nos ayudaron en la edición, y traducción de textos en distintos momentos.

Desarrollo de las actividades

Se llevaron a cabo varias reuniones de los miembros participantes en el Proyecto. Posteriormente, se llevo a cabo la elaboración detallada del Proyecto (texto, elementos, esquema, captura y edición de imágenes) dando lugar a las sucesivas versiones de los juegos. Actualmente seguimos trabajando en la elaboración y edición de sucesivas versiones del videojuego. Los estudios de evaluación se desarrollaron como se describe en el apartado “metodología”.

Se llevaron a cabo los sucesivos estudios de validación de la forma descrita en el apartado “metodología empleada”. Los resultados de los distintos estudios han sido propuestos para su publicación de la forma indicada en “objetivos alcanzados”.

Anexo (manuscrito y documentos acompañantes, remitidos a Plos One para su posible publicación)

PLOS ONE

Using a videogame to facilitate students' first visit to the operating room. A randomized controlled trial

--Manuscript Draft--

Manuscript Number:
Article Type: Research Articles
Full Title: Using a videogame to facilitate students' first visit to the operating room. A randomized controlled trial
Short Title: Videogame to facilitate students' first visit to the OR
Corresponding Author: Manuel Giner
Complutense University of Madrid
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Keywords: Videogames, serious games, simulation, medical education, nursing education, surgery, operating room, operating theatre, novices, stress
Abstract: First experiences in the operating room (OR) with patients are always stressful and intimidating for students. We hypothesized that a game-like simulation could efficiently improve perceptions and performance of novices.
METHODS AND FINDINGS
A videogame was developed, combining pictures and short videos, by which students are interactively instructed in how to act in the OR. Moreover, the game includes detailed descriptive information. After playing, students are given feedback on their performance.
A randomized controlled trial was conducted with 132 medical and nursing students with no previous experience in the OR. 62 (47.0%) were allocated to a control group (CG) and 70 (53.0%) to a study group (SG). Subjects in SG played the game on the day prior to their first experience in the OR; CG had no access to the application. On the day after their OR experience, all students filled in a questionnaire in a 7-point Likert format collecting subjective data about their experience in the OR.
Four constructs related to students' feelings, emotions and attitudes were measured through self-reported subjective scales, i.e. C1: fear to make mistakes, C2: perceived knowledge on how to behave, C3: perceived errors committed, and C4: attitude/behavior towards patients and staff. The main research question was formulated as follows: do students show differences in constructs C1-C4 by exposure to the game?
SG reported statistically significant higher scores on the four aspects measured than CG ($p<0.05$; Mann-Whitney U tests; Cohen's d standardized effect size d1=0.30; d2=1.05; d3=0.39; d4=0.49).
CONCLUSIONS
Results show clear evidence that the exposure to the game-like simulation had a significant positive effect on all the constructs. After their first visit to the OR, students in SG showed less fear (C1) and also perceived to have committed fewer errors (C3), while they showed higher perceived knowledge (C2) and a more collaborative attitude (C4).
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Ethics Statement

All research involving human participants must have been approved by the authors' institutional review board or equivalent committee(s) and that board must be named by the authors in the manuscript. For research involving human participants, informed consent must have been obtained (or the reason for lack of consent explained, e.g. the data were analyzed anonymously) and all clinical investigation must have been conducted according to the principles expressed in the Declaration of Helsinki. Authors should submit a statement from their ethics committee or institutional review board indicating the approval of the research. We also encourage authors to submit a sample of a patient consent form and may require submission of completed forms on particular occasions.

All animal work must have been conducted according to relevant national and international guidelines. In accordance with the recommendations of the Weatherall report, "The use of nonhuman primates in research" we specifically require authors to include details of animal welfare and steps taken to ameliorate suffering in all work involving non-human primates. The relevant guidelines followed and the committee that approved the study should be identified in the ethics statement.

Please enter your ethics statement below and place the same text at the beginning of the Methods section of your manuscript (with the subheading Ethics Statement). Enter "N/A" if you do not require an ethics statement.

Students' participation was entirely voluntary and was performed with the informed consent of the participants. Students were orally informed about the nature of the study in which a new instructional method was investigated to the benefit of the students prior to its routine deployment. The intervention of the study (game playing and filling in a questionnaire) was not part of any examination, so that a participation or nonparticipation would have no consequences on their grades.

The ethics committee at our Medical School reviewed the project and concluded that a full formal ethics committee statement was not required, due to the educational nature of the study. Data analysis was anonymous. With the participation in the study, the students' agreed on the anonymously analysis of their data. Students who would not like to participate could chose to deny participation without further consequences. Anonymous participation is document of the oral agreement of the students. This type of orally agreement employed in our study was discussed with the ethics committee which agreed on it. Due to practical reasons, a formal written consent prior to the study was not feasible.

Cover Letter

Dear Editor,

By recommendation of the Editor of PLOS MEDICINE, we submit the manuscript entitled "Using a videogame to facilitate students' first visit to the operating room. A randomized controlled trial", to be considered for its possible publication in PLOS ONE. A presubmission inquiry was sent to PLOS MEDICINE (PMEDICINE-D-14-00137). This is a new manuscript and it is not being considered elsewhere. A previous report of our related work was published at the Really Good Stuff section in MEDICAL EDUCATION (2013; 47: 513–535).

The manuscript, including a link to freely access our videogame (http://eadventure.appspot.com/redirect/operating-theater-game-es), reports the results of our controlled study to assess the utility of a serious game, to overcome the difficulties experienced by students at their first visit to the operating room with real patients.

Students' participation was entirely voluntary and was performed with the informed consent of the participants. The ethics committee at our Medical School reviewed the project and concluded that a full formal ethics committee statement was not required, due to the educational nature of the study.

Thanking you in advance for considering our submission, I look forward to hearing from you.

Sincerely,

Manuel Giner (Prof.)

USING A VIDEOGAME TO FACILITATE STUDENTS' FIRST VISIT TO THE OPERATING ROOM. A RANDOMIZED CONTROLLED TRIAL

(Short title: Videogame to facilitate students' first visit to the OR)

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ABSTRACT

First experiences in the operating room (OR) with patients are always stressful and intimidating for students. We hypothesized that a game-like simulation could efficiently improve perceptions and performance of novices.

Methods and findings

A videogame was developed, combining pictures and short videos, by which students are interactively instructed in how to act in the OR. Moreover, the game includes detailed descriptive information. After playing, students are given feedback on their performance.

A randomized controlled trial was conducted with 132 medical and nursing students with no previous experience in the OR. 62 (47.0%) were allocated to a control group (CG) and 70 (53.0%) to a study group (SG). Subjects in SG played the game on the day prior to their first experience in the OR; CG had no access to the application. On the day after their OR experience, all students filled in a questionnaire in a 7-point Likert format collecting subjective data about their experience in the OR.

Four constructs related to students' feelings, emotions and attitudes were measured through self-reported subjective scales, i.e. C1: fear to make mistakes, C2: perceived knowledge on how to behave, C3: perceived errors committed, and C4: attitude/behavior towards patients and staff. The main research question was formulated as follows: do students show differences in constructs C1-C4 by exposure to the game?

SG reported statistically significant higher scores on the four aspects measured than CG ($p<0.05$; Mann-Whitney U tests; Cohen's d standardized effect size d1=0.30; d2=1.05; d3=0.39; d4=0.49).

Conclusions

Results show clear evidence that the exposure to the game-like simulation had a significant positive effect on all the constructs. After their first visit to the OR, students in SG showed less fear (C1) and also perceived to have committed fewer errors (C3), while they showed higher perceived knowledge (C2) and a more collaborative attitude (C4).

INTRODUCTION

First experiences of nursing and medical students in the operating room (OR) with real

patients are always stressful and intimidating. Novices, without a defined role, feel the high-pressure of such a dynamic environment with many health professionals working at once and, conscious that they may compromise patients safety, tend to remain passive to avoid making mistakes. As a result, novices feel they are unproductive with a possible negative impact on their future career decisions.

While in the OR, students have to learn through three domains (1), i.e. i) managing the demands of the working environment, ii) the educational tasks, and iii) the learning and social relations of the OR. Students able to successfully manage these will have an enhanced experience.

Novice's knowledge, skills and attitudes may be improved implementing an OR induction curriculum, as shown by Patel et al. (2), who compared the results of implementing a didactic lecture, an online Second Life operating room, or a simulated operating suite. This study was the first to address primary exposure of novices to the OR. Novices' knowledge, skills and attitudes were assessed using a behavioural observation scale and a self-report scale, as well as a multiple-choice questions test. The introduction of an OR induction curriculum demonstrated a significant improvement in novices' performance, regardless of the methodology used. The use of a simulated operating suite has been demonstrated to be the most expensive of these training interventions. The use of a didactic lecture displayed promising results. However, it would be necessary to repeat the lecture several times to different groups of students being exposed to the OR at varying times. The less expensive alternative was the Second Life operating room, which also demonstrated favorable results. Accordingly, we developed a game-like simulation (freely accessible at http://eadventure.
appspot.com/redirect/operating-theater-game-es) where the real environment is reproduced (3). In the game, students are instructed by practicing on how to act in the surgical area in different situations and extensive feedback is provided at the end. Also, the game includes detailed descriptive information on structure, elements and personnel of the surgical block.

The first game prototype was evaluated by experts using Likert scales to assess game's utility, application and feedback. Comments received were used to continuously improve the successive versions of the videogame. Then, the game was validated with students. For this purpose, a prospective randomized controlled trial (RCT) was conducted. Half of novices played the game the day prior to their first experience in OR; the other half (control group), had no access to the application. All students filled in a questionnaire the day after their first OR experience with a series of items about the different aspects contemplated in the game. Our results show how the exposure to the game-like simulation had a significant positive effect on the first experience of novices to the OR.

METHODS, MATERIALS, PARTICIPANTS AND SETTINGS

Objectives and hypotheses

The goal was to assess the potential of a self-developed game-like simulation to enhance the experience of visiting the OR for the first time. Four subjective constructs related to students' feelings, emotions and attitudes were measured through students self-reported data. These constructs serve as quality indicators of the first OR visit experience:

- C1: Fear to interfere in clinical activity through incorrect interaction with

patients, equipment, environment or staff.
• C2: Perceived knowledge on how they have to behave in the clinical area and how to interact with patients, equipment, environment and staff.
• C3: Perceived errors committed while in the clinical area.
• C4: Attitude/behavior towards patients and staff while in the clinical area.

A separate analysis for each of the constructs was proposed in the aim of answering the main research question: do students show any significant difference in the constructs C1-C4 caused by the exposure to the game-like simulation developed before attending their first visit to the operating theater?

The hypotheses formulated are that the game would decrease negative constructs C1 and C3 (perceived fear to interfere in clinical activity and perceived errors committed) and increase positive constructs C2 and C4 (perceived knowledge and attitude).

Participants

One hundred and thirty two students were recruited and successfully completed the study. Sixty two (47.0%) were allocated to a control group (CG) and 70 (53.0%) to a study group (SG). Ninety six (72.7%) were females and 36 (27.3) were males. They were recruited from 2nd and 3rd year at the Nursing and Medical Schools respectively of the Complutense University of Madrid, with no previous experience in the OR. Pearson's $\chi 2$ test showed there were no statistically significant differences between CG and SG in gender or institution of origin.

Method and Settings

The study was performed completely online. Students provided researchers the scheduled date for their first experience in the OR. Researchers sent detailed instructions to SG students on how to access and play the game to ensure they played the day before their first experience in the OR. The day after the first visit researchers administered all students (SG and CG) the questionnaire used to measure the four constructs of the study.

Materials and instruments

A videogame was developed using pictures and short videos (4). In the game, players adopt the role of a student who visits the OR for the first time. Students learn through a first-person experience (the videogame shows what the player is seeing; Figure 1) how to act in the surgical block in situations such as: getting correctly equipped, interacting with patients and relatives, entering and leaving the OR, maintaining sterility, leaving the theatre if they feel sick, assisting in small tasks (e.g. tying the surgeon's gown, positioning the lamp, handing materials, etc.). Moreover, the game includes detailed information about i) structure and dependences of the surgical block; ii) common OR elements; and iii) scrubbed and non scrubbed surgical personnel. After completing the game, students receive feedback about their performance, being acquainted of any errors committed.

Data collection and statistical analysis

To measure the defined subjective constructs, a questionnaire was designed and administered to the students the day after their first practice at the operating theater (see Appendix 1 and 2). The questionnaire had 15 items in a 7-point Likert format meaning 1 complete disagreement and 7 complete agreement with the given statement.

Items were summed to build a different scale for each subject construct. Table 1 describes the four resulting scales. One of the 15 items was discarded during analysis

for ambiguous wording. Reliability of each scale was assessed through Cronbach's alpha tests also reported in Table 1. Items were formulated using positive wording if they were oriented to measure positive constructs C2 or C4 (e.g. "My attitude has been active and collaborative while in the operating theater") and negative wording if oriented to measure negative constructs C1 or C3 (e.g. "I haven't made any mistakes when I came into the operating theater"), resulting in the four scales having a positive orientation (i.e. the higher the values the better).

Data collected were analyzed using statistical software package IBM SPSS 19. Missing values were excluded from the analysis, resulting in lower valid N than the number of participants.

Ethical approval

Students' participation was entirely voluntary and was performed with the informed consent of the participants. Students were orally informed about the nature of the study in which a new instructional method was investigated to the benefit of the students prior to its routine deployment. The intervention of the study (game playing and filling in a questionnaire) was not part of any examination, so that a participation or non-participation would have no consequences on their grades.

The ethics committee at our Medical School reviewed the project and concluded that a full formal ethics committee statement was not required, due to the educational nature of the study. Data analysis was anonymous. With the participation in the study, the students' agreed on the anonymously analysis of their data. Students who would not like to participate could chose to deny participation without further consequences. Anonymous participation is document of the oral agreement of the students. This type of orally agreement employed in our study was discussed with the ethics committee which agreed on it. Due to practical reasons, a formal written consent prior to the study was not feasible.

RESULTS

As Table 1 and Figure 2 show, students in SG reported higher mean and median scores on the four aspects measured as compared to students in CG. Standard deviation (SD) is also lower in SG, suggesting lower dispersion of the data. As assessed by a Kolmogorov-Smirnov test of normality, none of the scales could be considered close to the normal distribution ($p<0.05$, see Table 1), impeding the use of parametric tests to determine statistical significance of the mean differences observed between groups. Mann-Whitney U tests for independent samples were run instead, showing that median differences between groups were statistically significant ($p<0.05$) for scales S2-S4, but not for S1 ($p=0.123>0.05$).

Twenty lower outliers (extreme values at least 1.5 times the SD below the mean of the intervention group) were found through inspection of boxplots for S1-S4 (see Figure 2). No upper outliers were found. Most of the outliers are concentrated in SG (N=16). While most of these are only outliers for one of the scales (N=13), others are in two scales (N=4), three scales (N=2) and even the four of them (N=1). Inspection of outliers showed they were not caused by errors in data entry or to unusual demographics, compared to the study sample, suggesting that the game was not effective for a particular group of students whose characteristics remain unknown. In contrast, the game was very effective for the majority of the students.

The presence of outliers mostly concentrated in SG motivated a second analysis for S1 removing the 10 outliers previously identified. Mean and standard differences

between SG (20.61±3.83) and CG (18.09±5.39) increased and a Kolmogorov-Smirnov test showed more proximity to the normal distribution for both groups (Z=1.153, p=0.140; CG: Z=0.979, p=0.293; SG: Z=0.600, p=0.865). These results allowed running an unpaired (independent samples) t-test showing a significant difference between groups (t=2.732; p=0.007<0.05). A second Mann-Whitney U-test also showed median significant differences (U=1,690.500; z=2.211; p=0.027<0.05) when outliers were not considered.

Looking at the individual items of each scale, scores in SG are also higher than in CG and with lower dispersion (Table 2).

High scores of perceived usability (N valid=68; Mean=11.94±2.59 out of 14; Median=13 out of 14) and perceived usefulness (N valid=67; Mean=52.37±7.62 out of 63; Median=54 out of 63) of the game reported in Figure 3 also suggest that the game was well received by students who had the opportunity to use it (SG).

DISCUSSION

Results show clear evidence that the exposure to the game-like simulation had a significant effect on all the constructs C1-C4 proposed for analysis. After their first visit to the OR, students in SG showed less fear to make mistakes (C1) that could interfere in the normal development of clinical activity and also perceived to have committed less errors (C3), while they showed higher perceived knowledge on how they had to behave and what they could and could not do while in the surgical block (C2) and showed a more collaborative attitude with patients and staff (C4).

The high number of lower outliers identified (22.8% of the cases in SG) deserves its own piece of discussion. This is especially notorious on C1 (perceived fear to interfere in clinical activity), where the differences observed between CG and SG were not statistically significant if outliers were included in the analysis. It suggests that the game was not so effective for a number of students and, although a minority, further analysis should be conducted to get a better understanding of under what circumstances the effectiveness of the game is lessened.

The results also clearly show that the game had not the same effect for all the constructs. To compare effect sizes, we calculated Cohen's d, an adimensional statistic that divides the difference between group means by the pooled standard deviation, resulting in d1=0.30; d2=1.05; d3=0.39; d4=0.49. Constructs C1, C3 and C4 show consistent “medium” effect sizes as defined by Cohen (4), while C2 (perceived knowledge on how to behave in the surgical block) has a large effect size. This finding can also be observed in Figure 2, where the distribution of S2 is significantly leftskewed (higher values predominate) compared to EG and also to other scales.

As in Patel’s experience, our videogame showed to be an effective OR induction curriculum to prevent stress and intimidation of novices. There are advantages to the implementation of a simulation or Second Life operating room. Primarily, it is accessible from users’ desktops and would not require users or educators to be physically present for the training, and it also may be accessed at any time, so training would be repeatable.

Learning preferences have been strongly shaped by new media technologies. A crosssectional

survey was conducted in two American universities to elucidate medical student experiences and attitudes about using new media technologies in medical education (5). Students, including many who do not play video games, held highly

favorable views about the use of video games and related technology in medical education. The sparse but encouraging data on learning outcomes for video games in science, technology, engineering, and math disciplines, as well as the infrastructural obstacles to wider adoption of this new medium, was early reviewed (6).
Virtual worlds like Second Life and digital games and simulations in medical education have been explored in the past, partly motivated by students' interest in these technologies with mixed results (5, 7-8). Game-like simulations have been used in previous medical education research to allow students and trainees rehearse procedures that are tightly linked to a specific environment in a realistic but safe way, showing improved performance when conducting the procedure in the work place (9). In addition, Cook. et al, showed through a systematic literature review that technology-enhanced simulation in health professions education is consistently associated with large effects for outcomes of knowledge, skills, and behaviors and moderate effects for patient-related outcomes (10).
While systematic use of videogames has shown to decrease the time needed to acquire surgical skills (11-12), the effect of educational games on medical students' satisfaction, knowledge, skills, attitude, and behavior has been questioned. This issue was studied in a systematic review (13). Findings in the only three eligible RCT suggested but did not confirm a positive effect of the games on medical students' knowledge. More recently, other review conducted by the same group to assess the effect of educational games on health professionals' performance, knowledge, skills, attitude and satisfaction, as well as on patients' outcomes, neither confirm nor refute the utility of games as a teaching strategy for health professionals (14). In another review of serious games for medical education and surgical skills training, none of the games had completed a full validation process for the purpose of use (15). All these data highlight the need for game designers and educators to cooperate in designing and validating serious games for specific educational problems. Only then, a serious game should be integrated as a teaching tool (16-17).
Our game is consistent with the three domains, identified by Lyon (1), through which students must learn while in the OR. Also, students receive feedback about their performance. These design features are consistent with simulation best practices identified by McGaghie et al, (18). After our experience, we believe in the effectiveness of educational games in medical education for particular purposes, as assessed in terms of students' satisfaction, knowledge, skills, attitude, and behavior (14).

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FIGURE LEGENDS

Figure 1. Four screenshots of the game-like simulation developed. Top left: the user gets dressed and receives feedback. Top right: player experiences casual interaction with patients. Bottom left: player interacts with personnel in the OR. Bottom right: player exercises decision-making on a situation that arises.

Figure 2. Boxplot for S1, S2, S3 and S4 (left to right, up to down). For each group the box shows the Inter Quartile Range (50% of the distribution) and the median (horizontal line inside). Whiskers show the min and max value observed on a scale from 4 to 28 or 3 to 21 depending on the scale. The figure shows how EG scored higher than CG in all four constructs. It shows also that the improvement for S2 is higher than for the other three constructs.

Figure 3. Boxplots for the perceived usability and usefulness of the game reported by students in EG, showing high student acceptance of the game.

TABLE 1

Summary of scales used to estimate the four constructs considered in the study

S1 Fear to make mistakes 4 0.844 [4-28] *Negative*
(Higher values show less
perceived fear)
S2 Perceived knowledge 3 0.828 [3-21] *Positive*
(Higher values show more
perceived knowledge)
S3 Perceived errors
committed
4 0.776 [4-28] *Negative*
(Higher values show less
subjective error rate)
S4 Adequate attitude 3 0.709 [3-21] *Positive*
(Higher values show better
attitude)

TABLE 2

Summary of results obtained for scales S1-S4. (*) Highlights S1, where median differences between groups were not statistically significant. Independent-samples t-test run without outliers showed statistical significance.

CG EG CG EG CG EG CG EG CG EG U z **p**

S1 **17.43±5.96 19.14±5.39** 19 20 5 6 28 28 56 58 p=0.005 p=0.013 1,895.500 1.543 **0.123***

S2 **15.93±4.32 19.56±2.43** 17 20 4 10 21 21 59 61 p=0.010 p<0.000 2,807.500 5.403 **<0.000**

S3 **23.54±4.41 25.19±4.13** 25 26 11 8 28 28 54 57 p<0.000 p<0.000 1,938.500 2.386 **0.017**

S4 **15.72±4.22 17.60±3.44** 16.50 18 8 5 21 21 54 57 p=0.055 p=0.001 1,937.000 2.364 **0.018**

TABLE 3

Individual results for each of the items of the scales

CG 61 1 7 3.7 1.764
EG 68 1 7 **4.47 1.706**

CG 57 1 7 4.89 1.77
EG 61 1 7 **5.03 1.549**

CG 60 1 7 4.48 1.742
EG 66 1 7 **5.12 1.732**

CG 62 1 7 4.1 1.956
EG 64 1 7 **4.5 1.604**

CG 62 1 7 5.23 1.634
EG 69 4 7 **6.68 0.696**

CG 59 1 7 5.29 1.733
EG 64 2 7 **6.59 1.05**

CG 62 1 7 5.42 1.742
EG 68 2 7 **6.32 1.071**

CG 62 1 7 5.45 1.715
EG 68 1 7 **6.38 1.234**

CG 54 2 7 6.24 1.345
EG 61 1 7 **6.39 1.037**

CG 60 2 7 5.83 **1.368***
EG 66 1 7 **6.23** 1.507*

CG 61 1 7 6.03 1.494
EG 67 1 7 **6.31 1.104**

CG 60 1 7 5.67 1.763
EG 66 1 7 **5.89 1.337**

CG 55 1 7 5.07 1.741
EG 60 1 7 **5.65 1.56**

CG 60 1 7 4.92 1.907
EG 66 1 7 **5.97 1.488**

CG 51
EG 50

Figure 1

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Figure 2

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Figure 3
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Appendix 1. Questionnaire
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Appendix 2. Relationship between questions and items
Click here to download Supporting Information: Appendix 2 - Relationship between questions and items.docx