Serious games in surgical education
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Mapping the demand for Serious Games in Postgraduate Medical Education using the entrustable professional activities framework

Maurits Graafland, Olle Ten Cate, Jan-Pieter van Seventer, Jan Maarten C. Schraagen, Marlies P. Schijven

Submitted


**ABSTRACT**

**Background:** Serious games are potentially powerful tools for residency training and increasingly attract attention from medical educators. At present, serious games have little evidence-based relation with competency-based medical education, which impedes their incorporation into residency training programs. The aim of this study was to identify highly valued entrustable professional activities (EPAs) to support designers in the development of new, serious games built on a valid needs-assessment.

**Methods:** All 149 licensed medical specialists from 7 specialties in one academic hospital participated in a 2-round Delphi survey, aimed at identifying the most valuable EPAs in their respective curricula. Specialists were asked to name the most highly valued EPA in their area. In the second round, their responses were ranked according to overall priority.


**Conclusions:** Some high-priority EPAs are already targeted by technology-based training solutions, whereas others are not. These results disclose new opportunities in technology-enhanced training, in which serious or applied gaming promise to be a powerful teaching modality.
INTRODUCTION

Motivation is an important drive for learning. Serious games, or applied games, are virtual learning environments designed to activate, entertain and educate the player at the same time. Serious games trigger players’ intrinsic motivation to engage with the learning content, through competitive elements, playful interaction and direct feedback mechanisms. They are therefore recognized as potentially powerful tools in higher education.1–3 Whereas ‘simulations’ attempt to fully resemble the real action or training scenario, ‘serious games’ use narratives and challenges to draw the player into the scenario or action, making learning occur playfully and effortlessly.4,5 This leads to an active and repetitive form of learning.6 A safe, game-based environment could therefore be an ideal format for problem-based adult learning, provided content is relevant and valid.4,7,8

Although serious games have been developed for the medical field, their value for medical educational programs remains questionable. A recent systematic review showed that of 30 serious games aimed at training medical professionals, none had teaching goals or assessment strategies that match the existing medical curricula for residents.2 This mismatch is not so surprising, as the educators have never expressed a clear demand for medical games nor has this been disclosed to designers.

The aim of this study was to map priorities in medical educational curricula in order to support game designers in developing targeted medical serious games. The primary research question focused on selecting the prime clinical activities to be mastered by residents before participating in clinical rotations – as perceived by the medical profession.

METHODS

Study design

A single-centre proof-of-concept study was performed among seven major specialties in an academic hospital in the Netherlands. A two-round Delphi9 survey was conducted between July 1st, 2011 and January 31st, 2012 among all licensed medical specialists from the participating specialties: Anaesthesiology, Emergency Medicine, Gastroenterology, General Surgery, Gynaecology, Psychiatry and Radiology. The education of medical specialists in the Netherlands is based upon the CanMEDS competencies10. All respondents received an electronic questionnaire (SurveyMonkey.com, LLC, Palo Alto, CA). The participants could enter the questionnaire through the email only once. All identifiers from the data were removed before interpretation and analysis. Approval by the Institutional Ethics Committee was sought and not required for this study.
**Delphi survey**

The participants were asked to identify one entrustable professional activity (EPA) that they considered top-priority to their specialty’s residency training and to be mastered by residents before participating in clinical rotations. This could be based on safety, complexity of the activity, or other reasons. Entrustable professional activities (EPAs) are clinical activities that may only be entrusted upon a sufficiently competent professional.\(^{11}\) EPAs are meant to connect competency frameworks to the workplace.\(^{12}\) This distinguishes EPAs as practical activities from general competencies (such as the CanMEDS\(^{10}\) or ACGME\(^{13}\) competencies).

The EPAs were pooled according to specialty. Three independent reviewers (MG, MS and JMS) excluded activities that did not meet the definition of EPA given to the participants (“key activity in clinical practice that may only be entrusted to a competent professional”).

The first Delphi round addressed demographic characteristics and the participant’s experience with games. In the second Delphi round, each participant was asked to rank specialty-specific EPAs according to their value to residents’ training (“Which EPA is most valuable to the resident to ensure good and safe conduct in the patient care practice?”). In order for a Delphi survey to be robust enough, literature reports a minimum acceptable response rate of 70% per round\(^6\). Therefore, the minimum required response rates per round per specialty were 70%.

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Anaesthesiology</th>
<th>General surgery</th>
<th>Gynaecology</th>
<th>Emergency medicine</th>
<th>Radiology</th>
<th>Psychiatry</th>
<th>Gastroenterology</th>
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<tr>
<td>Invited</td>
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<td>20</td>
<td>21</td>
<td>7</td>
<td>24</td>
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<td>16</td>
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<td>20</td>
<td>15</td>
<td>5</td>
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<tr>
<td>Respondents R2</td>
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<tr>
<td>Gender F (%)</td>
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<td>67</td>
<td>20</td>
<td>41</td>
<td>33</td>
<td>36</td>
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<tr>
<td>Experience with videogames Active (%)</td>
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<td>35</td>
<td>20</td>
<td>60</td>
<td>35</td>
<td>42</td>
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<tr>
<td>Experience with videogames Past (%)</td>
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<tr>
<td>Experience with videogames None (%)</td>
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<td>25</td>
<td>47</td>
<td>40</td>
<td>36</td>
<td>38</td>
<td>36</td>
</tr>
</tbody>
</table>

**Table 1. Demographic characteristics per specialty**

*Counts depict n unless stated otherwise; Abbreviations: R1 = Round, R2 = Round 2*

**Statistical analysis**

Data were collected and analysed using the Statistical Package for the Social Sciences version 16.0 (SPSS, Chicago, II, USA) and R version 2.13.1 (R, The R Foundation for Statistical Computing, Vienna, Austria). Confidence intervals of the ranks derived from the
second Delphi stage were calculated using the Monte Carlo re-sampling ("bootstrapping") method, as ranking distributions are complex to represent mathematically\textsuperscript{14}. Re-sampling was performed 5000 times to minimize re-sampling error.

**RESULTS**

**Participants**

The first round questionnaire was sent to 149 medical specialists of 7 specialties. The number of specialists per specialty varied between 46 (Anaesthesiology) and 7 (Emergency Medicine). An overview of the modified Delphi survey with response counts is given (Table 1). The first round of the survey had a response rate of 76\%, with a variation of 69–100\% between specialties. A total of 36 responses did not suffice to the definition of an EPA used in the study (Table 2).\textsuperscript{15} Three examples are: “Multi-tasking” (considered a general competency relevant to many EPAs), “laparoscopy” and “stressful situations” (both were considered too unspecific and contain more than one individual EPA). A total of 7 responses contained more than one EPA, whereas 16 EPAs were stated more than once.

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Anaesthesiology</th>
<th>General surgery</th>
<th>Gynaecology</th>
<th>Emergency medicine</th>
<th>Radiology</th>
<th>Psychiatry</th>
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<td>Responses R1</td>
<td>34</td>
<td>20</td>
<td>15</td>
<td>5</td>
<td>17</td>
<td>12</td>
<td>11</td>
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<td>6</td>
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<td>6</td>
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<td>2 (4)</td>
<td>0</td>
<td>0</td>
<td>2 (4)</td>
<td>1 (2)</td>
<td></td>
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<tr>
<td>Merged (to n)</td>
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<td>5 (2)</td>
<td>5 (2)</td>
<td>2 (1)</td>
<td>2 (1)</td>
<td>6 (2)</td>
<td>5 (2)</td>
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<tr>
<td>Total EPAs (n)</td>
<td>17</td>
<td>13</td>
<td>8</td>
<td>3</td>
<td>10</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>

**Table 2.** Flow of responses in the analysis.  
*Abbreviations: EPA = Entrustable Professional Activity, R1 = Round 1*

**Delphi survey**

A total of 66 EPAs were indicated to have high priority to residency training within the seven specialties (Appendix). The EPAs ‘management of trauma patients’, ‘cardiopulmonary resuscitation’ and ‘ultrasound-guided puncture’ were indicated by multiple specialties (surgery, anaesthesiology, radiology, anaesthesiology, emergency medicine; anaesthesiology, radiology, respectively). The EPA ‘diagnostic ultrasound’ was indicated by both radiology and gynaecology, although it indicates two different clinical activities for each specialty (general versus transvaginally, respectively).
Figure 1 shows the results of the second Delphi round per participating specialty. Forty-five EPAs were ranked according to the perceived importance to residency training per specialty. General Surgeons indicated ‘management of trauma patients’ (mean median rank 11.0, 95% CI 9.0 to 12.0), ‘placement of chest tube’ and ‘laparoscopic cholecystectomy’ (both mean median rank 10.0, 95% CI 9.0 to 11.0) as most valuable out of 13 EPAs. Anaesthesiologists indicated ‘assessment of vital signs during surgery’ (mean median 17.0, 95% CI 15.0 to 17.0), ‘airway management’ (mean median 15.0, 95% CI 10.0 to 16.5) and ‘induction of general anaesthesia’ (mean median 14.5, 95% CI 11.0 to 15.0) as most valuable out of 17 EPAs. Psychiatrists indicated ‘assessment of suicidality’ (mean median 8.0, 95% CI 8.0 to 8.0) and ‘psychiatric assessment’ (mean median 7.0, 95% CI 7.0 to 8.0) as most valuable out of eight EPAs. Gastroenterologists ranked ‘gastroscopy’ (mean median 4.0, 95% CI 1.0 to 5.0) and ‘colonoscopy’ (mean median 4.0, 95% CI 1.0 to 5.0) the highest out of five EPAs. Emergency physicians indicated ‘management of
emergency patients (general) according to the ABCDE-principle’ (mean median rank 3.0) unanimously as the most important EPA in their residency training program.

The results from the specialties Gynaecology and Radiology were excluded from the analysis due to low response rates.

**DISCUSSION**

**Primary findings**
Development of novel teaching methods for medical professionals should correspond to the needs of professional educators and to the target group. This the first study assessing prioritized teaching objectives for serious games in residency teaching curricula, using EPAs as a conceptual framework. Consensus was reached on the value of eleven EPAs for gaming in the residency teaching curricula within five different specialties. The survey indicated three EPAs to be important in different residency teaching curricula: ‘management of trauma patients’, ‘cardiopulmonary resuscitation’ and ‘US guided puncture’.

**Innovations in medical education**
Currently, a surge of game-based developments in medical education can be witnessed, ranging between playful ‘gamey’ designs for e-learning to traditionally ‘realistic’ virtual reality simulations. These projects have been initiated by single institutions\(^1\), the military\(^2\), and commercial parties.\(^3\) However, their value for medical educational programs remains questionable.\(^4\) Anchoring serious games firmly in postgraduate medical curricula is important to prevent proliferation of technologies that do not comply to (inter-) national medical educational standards. There is a delicate balance to be guarded in good co-creation of games. Medical educators should safeguard contents whilst not ‘sitting on the chair’ of the game designers –in order to avoid ending up with mere simulations that are not attractive enough to play in the end.\(^5\)

As the industry has little understanding of medical education, direction from medical educators is needed. This starts with an outline of the demand from the field. Medical educators should indicate high-priority teaching subjects for game designers, outlining the importance of what is to be taught.

This study provides an overview of highly valued EPAs within the specialties Anaesthesiology, Emergency Medicine, General Surgery, Gastro-enterology and Psychiatry. The entrustable professional activity framework relates practical activities to CanMEDS or ACGME competency frameworks in this context.\(^6\)
The EPAs prioritized in this study are not just applicable to serious games. Many EPAs have been targeted by the full range of simulator types, from part-task trainers to mannequin-based simulation and virtual reality. It must be clearly stated that distinguishing between serious games, game-based simulations and simulators is considered a grey area, with considerable overlap. For example, the web-based virtual reality simulation abcdeSIM provides a case-based course in acute care through simulated scenarios. On the contrary, its use of player competition through leader boards is a gaming technique, known to improve adherence to training. When developing new games and simulations, educators should determine how a user-centred mix of techniques could deliver optimal learning outcome in each case specifically. The importance of user involvement in the design process therefore cannot be stressed enough.

The impact of available serious games on learners’ performance is promising, although the evidence is far from comprehensive yet. A systematic review on the validity of serious games designed for education in medicine describes 30 serious games used to educate or train medical professionals. Two serious games show concurrent validity in experimental studies compared to conventional training methods. A second systematic review explores the effectiveness of serious games and videogames for all medical and non-medical purposes. Out of eleven experimental studies with a pre-test/post-test design, three games show a positive learning effect, seven find no effect and one finds a mixed effect.

**Entrustable professional activities in competency-based residency training**

Entrustable professional activities in residency training curricula relate residents’ general competencies (e.g. CanMEDS competencies) to their performance in everyday practice. A resident can be judged upon his or her performance by the level of entrustment (i.e. the level of supervision that is required for this learner), which may include independency during the execution of the EPA. In this context, valid serious games and simulations may enhance the residents’ level of entrustment without risking harming patients. Only if a resident is judged objectively according to standards similar to the residency-teaching curriculum, can he or she be granted a higher level of entrustment for an EPA.

This study is the first to draw a relation between the EPA framework and serious games. Previous studies have assessed EPAs to guide postgraduate curriculum development. Boyce et al. assessed which EPAs were seen as high-priority in the first year of postgraduate Psychiatry training in Australia. Conducting a risk assessment for suicide and aggressiveness received an equally high endorsement in this study (82% endorsement (n = 488 / 2736). Conducting psychiatric assessments was not described as EPA as such, whereas other general EPAs were considered (e.g. acute assessment and management of psychiatric emergencies). Mulder et al., Shaugnessy et al. and Hauer et al.
assessed EPAs for curriculum development in Physicians Assistants, Family Medicine and Internal Medicine training curricula. The definition of EPAs used in this study was less strict than recommended when building a curriculum.\textsuperscript{29} For instance, competency levels are defined per residency year.

**Limitations**

This study reports a single-centre proof-of-concept study and results apply to Dutch medical teaching curricula. Every participating specialty employed medical specialists educated in different hospitals throughout the country. To confirm these results, further studies should determine EPAs with high priorities from non-academic hospital perspectives.

Medical educators are largely unfamiliar with games and related concepts. A direct inquiry for the demand for new developments among educators is therefore meaningless and would contain selection bias, as only respondents familiar to the concepts would be included. Prioritizing EPAs in educational curricula does provide more objective information on where new developments are considered valuable.

The Delphi methodology is a recognized method to obtain consensus from respondents within one area of expertise.\textsuperscript{30} As low response rates are a major cause for bias in Delphi surveys, strict minimum response rates were maintained in our analysis. Two specialties (Gynaecology and Radiology) were therefore excluded from the second round.

**Conclusion**

This study defines EPAs in five medical and surgical specialties, regarded as top-priority by their educators. Designers should develop technology-enhanced training solutions with high regard to validity of the educational content, starting with selecting top-priority subjects. Serious games provide a promising new direction in graduate medical education for the active learner.

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