JDoc: A Serious Game for Medical Learning

Aidan Sliney (*ajs2@student.cs.ucc.ie*) and David Murphy (*d.murphy@cs.ucc.ie*)
IMCLab, Dept of Computer Science, University College Cork, Ireland

Abstract

This paper presents initial research on a home based junior doctor medical simulator (JDoc) to improve the efficiency of junior doctor training within the restrictions imposed by the European Working Time Directive (EWTD). Our goal is to make theoretical medical knowledge more accessible. We developed a high fidelity test framework JDoc. Our objective is to understand the potential for medical simulation in junior doctor training. The paper outlines the design process and the construction of the simulator as well as a small scale post-test usability study amongst junior doctors from which we can assess the benefits of JDoc.

Introduction and Motivation for Research

Research into and developments of medical simulators have seen significant enhancements in recent times. The use of Human–Computer Interaction (HCI) through such methods as affective computing to portray a mid-to-high level of fidelity is essential. The feeling of using a simulator or simply playing a game needs to be kept at a minimum in order to ensure that the users' experience of the interaction is as realistic as possible. Even if this is accomplished, the construction of a relevant mental model from a complex situation relies on the capacity of the learners to extract appropriate information from that situation [1]. To aid this, learning content must be developed in such a manner that meaningful and sustainable learning effects with the learner can be created [2]. Conventional training methods comprised of texts and images provide restricted possibilities to describe a difficult context, whereas three dimensional views of complex situations can sometimes increase understanding giving simulated training an added advantage [3]. According to Thompson and Riding, animation facilitates learning when it presents fine-grained actions that static graphics do not present [4]. Usability also plays a key role in the fidelity of any medical simulation. Good usability practices leave the user to concentrate on the next action to take rather than how to take them. The possibility of immersion, which provides end users with the experience of being surrounded by the environment, has several opportunities for further research in psychology including object manipulation [5].

Accepted Paper, 1st International Conference on Advances in Computer-Human Interaction. Date of Conference:10-15 February 2008. DOI: 10.1109/ACHI.2008.50
Publisher: IEEE. Print ISBN:978-0-7695-3086-4 URL: https://ieeexplore.ieee.org/document/4455971

What is the purpose of the Junior Doctor Simulator (JDOC)?

The purpose of the JDoc is to familiarise junior doctors with the day-to-day stress of a hectic hospital. By simulating patients and creating scenarios using basic parameters provided by senior doctors, JDoc supplies junior doctors with valuable (virtual) experience, which otherwise would be unobtainable. It both immerses the player in the believable world of a busy hospital at night and educates them as to the diagnostic procedures and medical criteria required while working on-call in a hospital ward. As the need for doctors continuously increases, the ratio of junior doctors to senior doctors also increases. The junior doctor simulator addresses some of the associated problems. Instead of every senior doctor having to continuously teach while working with a trail of junior doctors, they will input interesting cases into JDoc. Using this method the senior doctor can concentrate more on his or her patients without compromising the quality of learning of the junior doctor. The simulator goal is expressed in terms of the effect that it will have on the player. JDoc establishes what the player will learn through prior research with many experienced doctors who have first-hand experience and knowledge of the relevant areas for junior doctor education. Medical simulation has a key role to play in training all medical fields [6]. Medical simulation training programs have resulted in improved performance, shorter response time, and less deviation from practice standards than non-simulator training. Medical simulators increase trainee confidence, competence, and improve patient safety. Medical simulation training can also yield cost and process efficiencies. The introduction of the European Working Time Directive (EWTD) has placed serious constraints upon medical education and has proven to be a major challenge for conventional training methods. Finding time for training has become an issue. The British Medical Journal [8] notes that “before the European Working Time Directive a trainee could expect to work over 30,000 hours between becoming a Senior House Officer and getting a consultant post. The Royal College of Surgeons calculates that this will now fall to 8000 hours. “The issue medical staff are facing is that on-site training fits into the EWTD’s classification of work, and is therefore included in the allotted hours. One potential solution is to further incorporate medical simulators and serious games in to the medical curriculum.

The first and most important type of medical simulator is the single purpose simulator that is typically based in a hospital or medical training facility. An example would be a computer connected to relevant anatomy or a mannequin that responds to an action like the injecting of drugs. The Human Computer Interaction (HCI) and the usability practices of these simulators are minimal, with the use of mannequin’s etc. accounting for most of the user’s actions. The second type of Medical simulator, the personal simulators, are the simulators that benefit from not been categorised by the EWTD as work. It is these types of simulators that require solid technological implementations through usability engineering and concise HCI methods to bring them to the level of satisfactory realism. These simulators suffer from the disadvantages of not being able to operate in association with specialist instrumentation. It is not feasible to expect each doctor in training to own a standalone machine for each type of training module. This is one of the main goals of the current work.

JDoc

JDoc is an interactive, computer-based 1st and 3rd person junior doctor simulator prototype. It is designed to train and teach junior doctors interpersonal skills, communication skills, medical information, decision making skills etc. It is a simple, cheap and easy-to-use development model, where people are assisted by information technology [9]. It can be installed on any home computer that meets the minimal required specification (e.g. any PC less than 3yrs old). The users' actions are continuously logged for reviews and revised by either the user or by a senior doctor dependant on which situation is preferred. Interactive prototypes of specific fidelity enable a better understanding of end-users and their tasks, lead to a better collaboration and make it possible to produce better software faster [10]. Realistic prototypes help resolve detailed design decisions in layout, visual presentation, and component selection, as well as finding points in interaction design and interface behaviour [11].

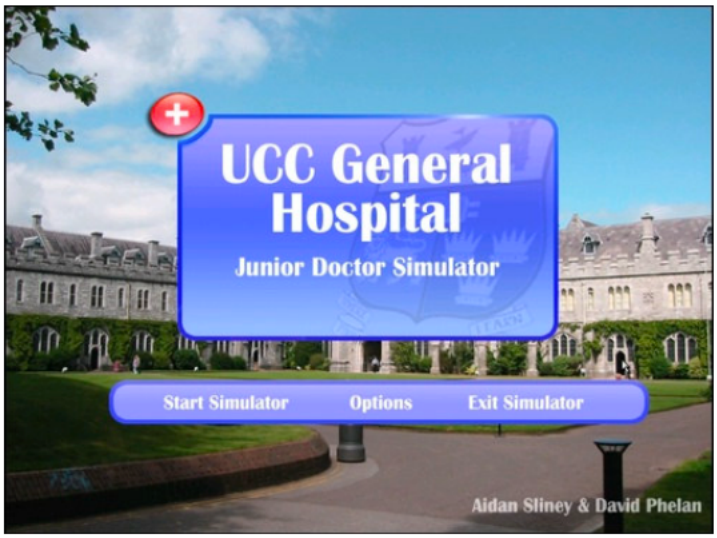

Figure 1: JDoc intro screen; from here they can begin the simulator, change the video/ audio setting or exit the simulator.

Once the user has installed JDoc onto their personnel computer they can run it anytime by double-clicking on the desktop shortcut. As the simulator boots up, the various entities (Bots, tables, beds, buildings, etc.) are loaded up. These entities are given predefined mass and position. Each static (for example a chair model) object has their given co-ordinates and rotation. All triggers and audio emitters are programmed to react to specific events. Each "bot" (Non-Player Character) and the one player character are then spawned to their specified location. They either have static orders or dynamic orders called upon from a tripped trigger.

When the simulator is fully loaded, the user has to attempt to go from waiting on call to assessing the patient (Fig. 2.). When the user has finished using the simulator, all actions can be reviewed either by themselves or their supervisor in an individual txt file. Once a junior doctor logs onto JDoc they take control of a doctor model (an on call junior doctor). JDoc creates a file under the doctor's name in which all their actions will

be documented. The user must make their way to the hospital and then find and assess the patient. To accomplish this they must talk to other doctors and nurses (Non-Player Characters (NPCs)) ask questions and follow the correct protocol in assessing the patient. Each assessment and every reaction from the in-game doctors and nurses, and factors like ECGs, blood test results and patient history can differ as the senior doctors create a new scenario.

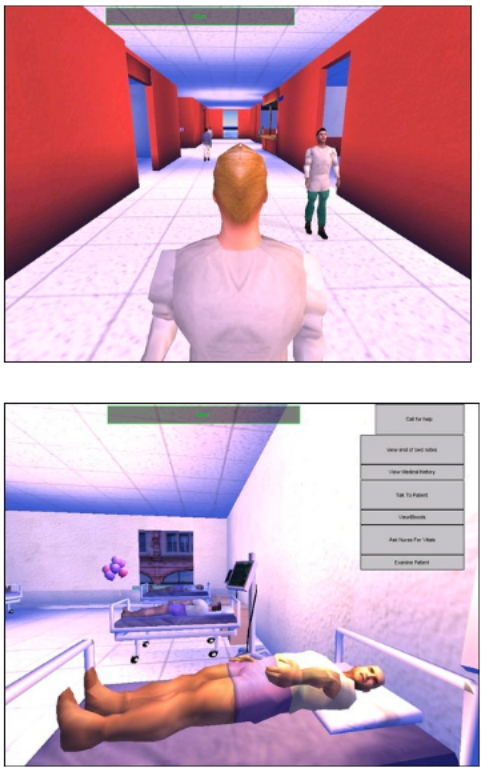

Figure 2: A selection of in game shots from JDoc.

The Output

For each user of JDoc an individual Xml file is created. The file named after the users' log-in name records every movement and decision the user makes. Dependant on how JDoc is set up by the senior doctor this Xml file can either contain the correct procedure for each step so the junior doctor can compare his/her own mistakes or it can be setup so only the senior doctor can assess each users' decision making skills and how well each user diagnosed the patient.

How was JDoc built?

For the purposes of developing the JDoc prototype, the popular game engine, Torque Game Engine (TGE) from GarageGames was used. 3DS Max 8 was used for modeling. The game engine itself is coded in C++. These factors will remain hidden from end users' of JDoc. Any new scenarios created by senior doctors shall be done through a simple Content Management System. Within this CMS will be a series of simple questions with either tick boxes or text boxes that will edit the underlying code and will ultimately create new unique scenarios.

It is with the use of this Content Management System (CMS) that JDoc becomes infinite. Once the senior doctor has completed building his scenario he can save it and make it assessable to other senior doctors or ever other hospitals. The likelihood of scenario sharing would increase significantly with the addition of a simple database website accessible to all users' of JDoc.

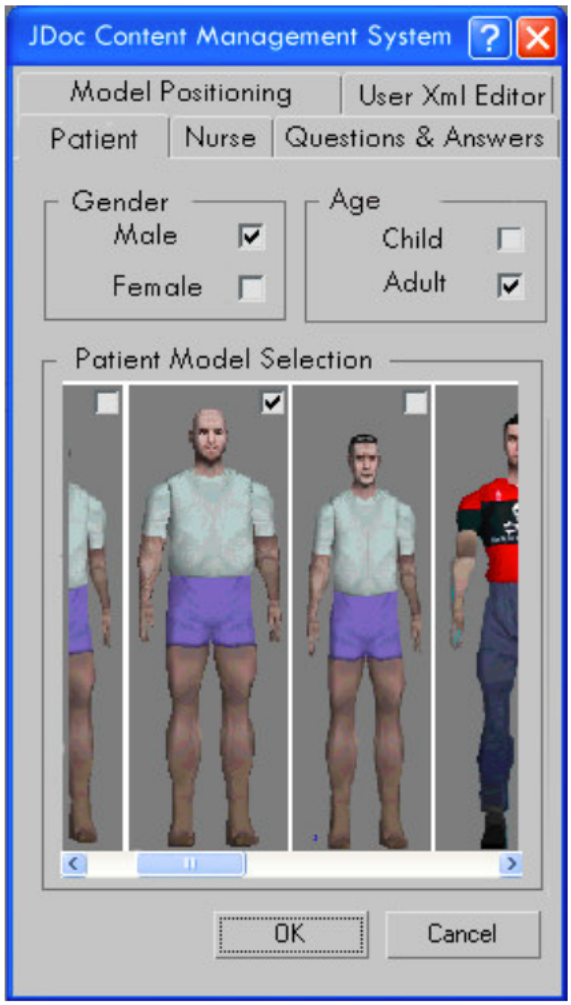

Figure 3: Using the JDoc CMS the senior Doctor is able to create new scenarios.

Usability aspects of JDoc

JDoc input devices are constrained to tactile (keyboard or mouse) and the output devices are constrained to visual (monitor) or aural (speakers). Any action the user wishes to carryout, be it simply unconstrained user movement or assessing a patient, is made by inputting their choice by keyboard (actions bound to a specific key) or by mouse (button click).

The Predefined response to the users' choice is then relayed back through the monitor, through the speakers, or both. The first and most important usability aspect we looked at was the user's avatar itself. How would the user move the character? How would the user know he/she moved the character? Given our input devices constraint, we felt that the use of the arrow keys would be the easiest means of character

movement. JDoc generally uses the 3rd person model but in any instance where the blind spot behind the model causes an obstruction the view changes to first person. This method still detracts from the fidelity of the game; however, user feedback has shown that it is adequate, especially when one considers the lack of sophisticated output devices.

Assessing the patient is another area in which good usability practices are essential to extend the fidelity of JDoc. This area differs from the first as it is dynamic. Again taking the available basic input devices, it was decided to use on-screen buttons and drop-down menus for the users to input their actions. This method is sufficient as it leaves the user thinking about what action to undertake rather than how to undertake it. Where responses cannot be predefined in button or text boxes we use input boxes for the user to explain their actions by writing whatever they feel is relevant. Good usability practice plays a vital role in JDoc. It is these practices that differentiate JDoc from a simple text based simulator. The use of good audio, camera positioning etc, creates an atmosphere inside JDoc that brings the users state of mind somewhat near the level needed in a real life scenario.

Figure 4: Here we see the view the user gets in first person while interacting with others.

The Usability Test

To evaluate our implemented framework from an end-users' perspective, a rapid usability test was performed. A test group of N junior doctors ranging from age 21-32 and mixed sex, N = 24, from Cork University Hospital participated.

Question	Yes	No	50%
Would the simulator benefit junior doctors?	100%	0%	0%
Do you think the data was represented appropriately?	90%	0%	10%
Did you think the sound effects were realistic?	100%	0%	0%

Do you think the model of the hospital was realistic and captured the feeling of a real hospital?	80%	10%	10%
Did you find the player character easy to control?	60%	20%	20%
Did you find the button interface easy to follow?	100%	0%	0%

Table 1: Results from the junior doctor usability

To further understand some of our results we performed another rapid usability test this time on a control group, M = 14 “gamers” again of age 21-32 and mixed sex.

Question	Yes	No	50%
Do you think the simulator would benefit junior doctors?	70%	0%	30%
Do you think the data was represented appropriately?	70%	0%	30%
Did you think the sound effects were realistic?	100%	0%	0%
Do you think the model of the hospital was realistic and captured the feeling of a real hospital?	50%	50%	0%
Did you find the player character easy to control?	100%	0%	0%
Did you find the button	100%	0%	0%

interface easy to follow and use?			

Table 2: Results from the control group usability

From these initial tests we are able to infer that the simulator will benefit junior doctors; the data and sound was acceptable, realism was acceptable for junior doctors but in the gaming world only adequate. The main point taken from these tests is the movement of the character. Gamers who have used these controls found them excellent therefore allowing us to presume, although some doctors struggled with these controls, with minimal experience they would become more proficient. The simulator was also tested on a hallway group but the tests were deemed invalid as the users' within this group kept becoming distracted by medical terminology unknown to them. The hi-fi prototyping had the advantage that end-users both participated and were studied in a realistic setting. [10]

Comparison and Simulator Effectiveness

Roger Schank, founder of virtual learning company CognitiveArts put the use of simulation in context by saying, "Which would you rather your airplane pilot have — 90 hours of the flight simulator, or 90 hours of book study?". He also makes that point that real world experience is essential but failing that simulation is the only other option: "I can give a child the best instruction money can buy in how to ride a bicycle. I can show her a step-by-step procedure for getting on the bike and pedalling it; I can show her films that demonstrate how one keeps one's balance while pedalling; I can inspire her with stories of bicycling daring. But unless the child gets on the bike, gets help when she falls off, and practices until she doesn't fall again, she's never going to learn how to ride."

Simulation in Medicine

From Wachter's studies in the use of medical training in sectors like radiology, surgery and anaesthesiology, he concludes that in many areas of medicine, simulations are the *only* means by which physicians can practice procedures without life/death consequences, and it also gives them exposure to rare situations they don't normally see in the field. He states that "simulators can effectively identify errors and appropriateness of decision making," These two advantages can make simulation-based training more beneficial than even on-the-job experience! [13]

Simulation in Business

A.J Faria conducted a survey on training with simulators in business schools. His results found that: **"**97.5% of accredited business schools include simulation-based training in their curriculum. 65% use simulation-based training in business policy courses, 63% in marketing, and 44% in management. What's more, a survey of instructors using

simulations in their classes rank them as the most effective means of training, well ahead of the case method or lectures".[14]

Simulation Vs Case-based Study

When comparing training methods Experience Builders comment on work of Wolfe comparing simulation to Case based Study [13]. He states that, "Ample evidence has been presented authenticating the effectiveness of computer-based general management games as vehicles for teaching strategic management. In every study cited, the particular business gaming application produced significant knowledge-level increases. When the business game method was pitted against the case approach, and when case-based evaluation criteria were not employed, the [simulation] approach was *superior* to cases in producing knowledge gains."[15]

Simulation Vs Textbook Approach

Simulation and traditional teaching were seen as competing teaching methods. It is the combination of the two where we see the most benefits. Learning has to be a continuous process. New learning techniques can make learning more interesting or challenging. When Lane did compare the two techniques he found: "training by simulation led to better performance than training using a traditional textbook approach". His test group was 115 students. Each subject that trained with the simulators compared to subjects that only used text books were "apparently more able to recognize key elements of the ill-defined problems embedded in various real world situations and apply the relevant statistical principles".[16]

Who is building the JDoc?

The Junior Doctor Simulator is being built by Aidan Sliney and David Phelan under the supervision of David Murphy. It was a joint venture between IMC Lab of University College Cork and Cork University Hospital. Dr. Deborah Ryan under the supervision of Dr. Mark Corrigan controlled the medical aspects of the JDoc.

Future Works

Future work on the Junior Doctor Simulator has numerous possibilities. Many new scenarios could be built and new models and characters can be continuously added. The big forward step for this project would be to add a Content Management System (CMS) screen for the senior doctors to continuously edit and update the scenarios (fig#). Each new scenario built in each hospital can then be added to a database and then made accessible to any user of JDoc over the internet making the amount of scenarios potentially endless. Critical pedagogy Scenarios will also be built to expand teaching strategies and to prevent the scenarios from becoming static e.g. having actions return incorrect results and letting the user have of the option of flagging these inconsistencies. The data should adapt to individual needs and levels of expertise in

order to enhance cognitive performance. It should learn with the user [12]. Also updates for JDoc could be periodically built and downloaded to each copy of JDoc adding better functionality and diversity to JDoc.

References

[1] R.K. Lowe, “Processing challenges pf understanding complex animated pictures”, 12(2-3), 125-134, (1998)
[2] M. Allen, “Michael Allen’s Guide to e-Learning, Building Interactive, Fun, and Effective Learning Programs for Any Company” Hoboken: John Wiley & Sons Inc. (2003)
[3] S. Guttormsen-Schar, and H. Kruegar, “Using new Learning Technologies with Multimedia. IEEE MultiMedia 7(3), 40-51 (2000)
[4] S. V. Thompson, and R. J. Riding, The effect of animated diagrams on the understanding of a mathematical demonstration in 11- to -14-year-old pupils. *British Journal of Educational Psychology*, 60, 93-98. (1990)
[5] J.M. Loomis, J.J. Blascovich, and A.C Beall, “Immersive virtual environment technology as a basic research tool in psychology”, *Behaviour Research methods Instruments & Computers* 31(4), 557-564 (1999)
[6] J. Chikwe, A. C De Soiuza, and J.R. Pepper, *British Medical Journa,l* (2004)
[7] S. Calnan, “European Working Time Directive – Ireland Failing to Implement New Regulations” (2005)
[8] D. Hanly, "Report of the National Task Force on Medical Staffing" (2003)
[9] C. Stephanidis, and A. Savidis,. “Universal Access in the information Society Methods, Tools and Interaction Technologies.” *Universal Access in the Information Society* 1(1), 40-55 (2001)
[10] T. Memmel, H. Reiterer, and A. Holzinger, “Agile methods and Visual Specification in Software Development” *A Chance to Ensure Universal Access* 454- 461 (2007)
[11] L.L Constantine, “Canonical Abstract Prototypes for Abstract Visual and Interaction Design In: Jorge, J.A., Jardim Nunes, N., Falcao e Cunha, J. (eds.)B DSV-IS 2003.” LNCS, vol. 2844, Springer, Heidelberg (2003)
[12] A. Holzinger, G. Searls, and A. Nischelwitzer, “On some Aspects of Improving Mobile Applications for The Elderly” *Universal Access in HCI. LNCS, vol. 4554,* Springer, Heidelberg 923-932, (2007)
[13] Experience Builders LLC (2003). “A Comparison of Simulation-Based and Conventional Training Methods”
[14] A. J. Faria, *Business Simulation Games: Current Usage Levels—An Update. Simulation and Gaming, Volume 29 number 3, pages 295-308.*(1998).
[15] J. Wolfe, *The Effectiveness of Business Games in Strategic Management Course Work*. Simulation and Gaming, volume 28 number 4, pages 360-376. (1997).
[16] D. M. Lane, and T. Zhihua. “*Effectiveness of Simulation Training on Transfer of Statistical Concepts”.* Journal of Educational Computing Research, volume 22, number 4, pages 383-396 (2000*).*