INTEGRATING COMPUTER SIMULATION TRAINING INTO MEDICAL CURRICULUM — A QUICK AND BASIC APPROACH

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Abstract

This paper reports on the integration of a radiological computer simulation into a clinical practice course for undergraduate nurse students and on the evaluation of this integration. The primary objective is to investigate whether a quick and basic approach to integration is sufficient in order to promote learning. We evaluate the integration as a product from a student perspective by inquiring, through interviews, into their experiences of learning with this simulation training and into their estimates of key integration design choices. Our overall conclusion is that a quick and basic approach to integration such as ours can be sufficient in promoting learning.

Introduction

This paper will report an attempt to integrate a computer simulation into a university course for nurses. Simulations have been used for training purposes in medical education for some time and are now widespread, they are however not thoroughly researched (Bradley, 2006). One important function they serve is to prepare trainees for a practice in which there is little or no space for trial and error, and achieving this in a milieu that is safe and ethically defensible. In medical education, undergraduate training on actual patients is sometimes impossible because it is not safe or not ethically defensible. (For further introductions see for instance Issenberg et al., 2005 and Gaba, 2004). One example of this is learning to perform radiographic examinations. Correct positioning of the patient, X-ray tube and film, as well as interpretation of X-ray images, is essential in preventing diagnostic errors that can lead to excessive radiation exposure and/or poor patient outcomes. The risks associated with radiation prohibit pure training on peers and patients.

This motivated the Learning Radiology in Simulated Environments project, within which educational, medical and technical expertise has cooperated in developing and evaluating training with a radiological simulator. This has been done in primarily *experimental* settings and results implied for instance that simulation training improve proficiency development in comparison to conventional training even though the activity in the latter seemed more in line with theoretical ideals (Söderström et al., 2008). However, the links between experiments and educational practice are not absolute, and integration and evaluation of computer simulation training in practice is thus a necessary supplement.

Other researchers, such as Davies (2002) and Rystedt and Lindström (2001), have argued that not only the simulator but the learning environment as a whole and the integration of simulation into curriculum is crucial in order to promote learning. Rystedt and Lindström, one of the few examples of Swedish educational researchers in this field, argue that "both the integration of the simulation and the design of the simulation itself are decisive for the consequences for learning" (2001, p. 139). This suggests that integration is not to be taken lightly. However, as a teacher you may not have the time or motivation to engage in a potentially complex and time-consuming processes of integration but still want to introduce the technology to the students.

With this paper we therefore want to investigate whether quick and basic integration is sufficient in promoting learning. This is done by integrating simulation training into a university course for nurses and evaluating it as a product from a student learning perspective.

Design

This section will describe the university course studied, the cervical spine simulator, the integration of simulation into the course and the evaluation.

A University Course for Nurses

Nursing Procedures in Conventional Radiological Procedures is a 30 credits clinical practice course for students attending the second year on the Diagnostic Radiology Nursing Programme at Umeå University. This course considers care, method and technology in computer tomography and ultrasound procedures as well as conventional radiological procedures. It is divided in two parts, one part given on the third semester and one given on the fourth. It is into the latter that the simulation has been integrated. It is a ten-week course with eight weeks dedicated to clinical practice training at local and regional hospitals. The first week is dedicated to theoretical, methodical and practical preparations, the following eight weeks to training and the last week to exams and closure.

The reasons for choosing this course were that the simulation matched its content and because that it was given at a time and place that suited our project.

The Cervical Spine Simulator

The simulator is a standard PC equipped with simulation software. It has two monitors: one representing a three-dimensional anatomical model, X-ray tube and film; the other representing two-dimensional X-ray images. The control peripherals used for interaction include a standard keyboard and mouse as well as a special mouse-like device.

Using the simulator the students can perform real time radiographic examinations of patients' cervical spine, which is one of the examinations studied and practiced in this course. It allows the user to position the three-dimensional model of the patient, X-ray tube and the film. X-ray images can then be 'exposed' at will by students, immediately presented by the simulator as geometrically correct radiographs rendered from the positions of the models. Exercises have been developed for the simulator including replication of standard views, replication of incorrect views. It is also possible to view the two-dimensional X-ray image change in real-time as the model is manipulated and experiment in an improvised manner. Training is thus performed in a safe environment without the use of ionizing radiation. For further technical specifications and description of validity see Nilsson (2007).

Quick and Basic Integration — Key Features

The integration was a compromise between three factors: practical conditions framing the course, experiences from our previous experiments and an aspiration to keep things simple. It was done in collaboration with course teachers and included demonstration of the simulator and a meeting focused on practical conditions of the course and experiences from our previous research. In the end all decisions were made by the teachers.

It was decided that the simulation training should be added to existing activities instead of replacing anything and that it should primarily consist of one mandatory training session performed during the first course week. The course schedule allowed for it and it required less effort than replacements would have. Students were also enabled to reserve the simulator for additional independent training throughout the course. Other researchers have indicated that students would use simulators in their spare time if available (Bloom et al., 2003). Also, we assumed that this kind of self-regulated training could promote learning without requiring further investments. Student introductions to the simulator were given in connection to a regular lesson instead of at every group training session. This was complemented by a hand-out with basic instructions to keep the sessions going. Training groups were created in connection to these introductions and training sessions were scheduled. Two hours was reserved for each group, and the students themselves decided how much of this to use. Other key settings for the mandatory training session were as follows.

The number of students in each training group was two. There were three reasons for this. One was that experiences from previous experiments suggested that three students might be too many for this type of training. The second was that the total time needed for the sessions was cut in half in comparison to solo groups. The third was that these nurses, in clinical practice, often will work in groups of two.

The training groups were created by the students themselves, i.e. they choose whom to work with. There were two reasons for this. One was that experiences from previous experiments indicate that the students have opinions about who makes a good partner. The second was that the teachers do not have to put extra effort into the creation of groups.

There was no teacher present, overlooking, the training sessions. There were two reasons for this. First, our belief that this simulation training could be performed without one, that the simulation and hand out instructions in themselves would be sufficient in, to use Grahams (2002) concept, structuring the learning activity. Second, that teacher presence would have required a more intrusive reshuffling of teacher resources.

Evaluation of Simulation Integration

We have chosen to evaluate the simulation training integration as product from a student learning perspective. After all, it is students in the process of learning that this training is supposed to assist. This makes student appreciation of the training an important aim as well as a valuable indicator of integration success. The basic assumption is that a failed integration would produce student rejection and that a successful integration would produce student appreciation. So we wanted to describe students' experiences of actually learning with the simulation training under the given circumstances. We have thus performed interviews, inquiring about students' estimates of the simulation training contribution to learning, to fulfilling course aims and to preparing for future clinical work. We complemented this by inquiring about their estimates of key design choices such as group size, group creation, teacher presence, and the possibility of additional independent simulation training during clinical practice.

Subjects were all undergraduate students taking the Nursing Procedures in Conventional Radiological Procedures course described above. Course population was 12 students. While participation in simulation training was mandatory, participation in this study was of course voluntary. One of the students chose not to participate due to matters of private nature, giving a total of 11 interviews.

The interviews were semi-structured and performed at the end of the course during a period of one week. Each had a time limit of 60 minutes and was conducted in a classroom familiar to the respondents. All interviews were recorded on tape and later transcribed.

Results

This section is divided in two sections: first, student appreciation of simulation training contribution to learning, to fulfilling course aims, and to preparation for future clinical work; second, student appreciation of key design choices for the integration, i.e. group size, group creation, teacher non-presence and the possibility of independent simulation training during clinical practice.

Contribution to Learning, Course Aims and Future Clinical Work

Contribution to learning. All participating students claim that the simulation training contributes learning within the course. Some students focus on the development during the training session, while others focus on its value in preparing for the clinical training. One woman says:

> *I understand the basics now, for radiology in general as well, how the image changes when the tube is turned.*

This coming to understand the relationship between the ‘camera angle’, the 3D-model and the 2D X-ray image is a recurring theme in the interviews. This particular respondent claims that this is of general value, not only in relation to this specific examination/body part. Another, male respondent focus on the preparatory aspect of the training when saying:

> *I wasn’t unfamiliar with the examination then [in clinical practice], I could identify the anatomy, know how to correct bad images.*

Contribution to fulfilling course aims. All participants claim that the simulation training contributes to the fulfilling of course aims. Several respondents note, in some way or another, that the cervical spine modelled in the simulation was only one part in a larger course. In response to the direct question a male student says:

> *To some extent. It fulfilled its function well, but the cervical spine is only a minor part of the course. I helped me understand better, to see in different ways.*

Contribution to preparation for future clinical work. All students claim that the simulation training helps prepare them for future clinical work. This is related the previous questions about learning and course aim. A male student commented:

> *Especially as an introduction to it [the future clinical practice]. It is significantly better trying and failing with a simulator or dummy than with a real patient. From a radiation point of view. Absolutely.*

Group Creation, Group Size, Teacher Presence and Independent Training

Group size. All students appreciate working in groups of two. It is preferred before individual training as well as training in groups of three. The benefits stated for working in groups focus on discussion, where different perceptions and perspectives contribute to problem solving and learning, reducing the risk of getting stuck and pressuring students to make their ideas explicit. In the words of a female respondent:

> *It is always beneficial to have two approaches, to be able to discuss and find a way that works for both. So that both understands and can remember later on.*

The benefits stated for working in groups of two instead of working in groups of three or more include more time for each individual to manipulate the simulator, less risk of 'chaos' due to too many opinions, less risk for polarization and someone being excluded, and when sitting in front of a PC simulation three is a crowd.

Group creation. Most students (9/11) explicitly claim that creating groups themselves is beneficial for learning, the other two are ambivalent. The responses reveal that students, as might be suspected, given the chance will pick a friend over someone less familiar to them. The stated benefits of this is that it makes collaboration easier by lowering the threshold for asking questions, lessening the fear of embarrassment, encouraging discussion and participation. Some add that this is more important in larger student classes. However, two of the students raise an interesting question about whether or not learning to collaborate with just about anyone should be an aim since:

> *When you work out [in practice] you don't know who you will end up with.*

Teacher presence. Most students (7/11) claim they see benefits in working without teacher present, as they did during the mandatory simulation training. The reasons for this include that having a teacher present encourage asking for correct solutions instead of actually trying and making valuable mistakes. As one of the male respondents put it:

> *. . . you learn more from making mistakes and correcting them yourself than by having someone showing you what to do.*

Not having someone looking over your shoulder reduces the fear of embarrassment and gives you more time to think things through. However, having a teacher present can be beneficial when working with the simulator for the first time so as to quickly overcome potential technical issues.

Simulation training during clinical training. All students claim that the possibility of simulation training during the clinical training period was not frequently realized. In fact, out of 11 respondents only 3 used the simulation a on their own and in those cases only one time each. The primary reason for not training was that students felt they were choosing between simulation training and clinical training and valued the latter higher. And since clinical training was so intense students felt there was no time so spare for simulation training. A female respondent explains:

> *The lab I was working in treated patients all the time so I had no possibility of leaving. I thought, there will be some slow day I can spend on training. But there weren't many slow days. So I chose to focus on real patients.*

Lack of availability is also stated as a reason for not training, primarily when students were in a clinic out of town.

Discussion

We have evaluated simulation training integration as a product from a student learning perspective. Results indicate that our quick and basic approach has been sufficient in promoting learning. There is no doubt that the students have appreciated the simulation training. They believe that it has contributed to learning, to fulfilling course aims and to preparing them for future clinical work. Several respondents noted that the cervical spine examination is only one among others to be studied within the course. However, the simulators central function of illustrating how the two-dimensional X-ray image transform as the three-dimensional model is manipulated received special notice in the interviews as something principal valuable. This indicates that the training has contributed with a lesson of general value.

Our aspiration to keep the integration simple led us to exclude the teacher from the simulation training, enable additional independent training throughout the course and leave work group creation to the students. It is interesting to note that not only do students accept the responsibility of creating groups themselves and training without teacher present, they see benefits in it. It seems to promote student initiative and engagement during the training, suggesting that hand-outs and simulator are sufficient in structuring the learning activity (Graham, 2002). Additional independent training was not frequently performed due to students choosing clinical practice with real patients over simulation training, and due to students periodically being in clinics out of town which limit actual availability to the simulator. This illustrates one limitation of the ‘always available’ argument for using simulators applied by for instance Engum et al. (2003). Promoting actual availability further might increase usage, but in our case only at the cost of purchasing more simulators and distributing them to the hospitals where students perform their clinical practice.

We also note that working in groups of two is appreciated by students. It seems to allow for the benefits of working in collaboration without producing the drawbacks of social complexity associated with larger groups, supporting the *smaller is better* rule of thumb (Graham, 2002).

Like Rystedt and Lindström (2001) we believe that simulation integration can be vital in order to promote learning. What we have shown with this study however is that a quick and basic approach to integration can be sufficient.

Limitations

There are limitations associated with using student appreciation as a measurement of the simulation integration. It excludes, for instance, impact on students’ clinical performance. This is, however, a limitation that is not easily transcended when evaluating actual educational practice. Students have equal rights to the best available education making it hard to defend experiments where students are given different training. Also it is not necessarily obvious how to delimit clinical performance. If both training and practice is collaborative, should we still evaluate individual procedural proficiency?

We also have the issue of how general these results are. Are they valid for other simulations for example? It seems natural that evaluations like ours to some extent will be dependent on the simulation itself. A less intuitive simulation, for instance, may depend on there being a teacher present to help students overcome usability issues. Then again, if the simulation is too complex we have to ask ourselves if it is worth the investment in the first place. There is a wide range of simulations used in medical education differing in a number of ways (see for instance Meller, 1997; Lane et al., 2001), which makes the specifics of the result shifty. The generality of the overall conclusion however need not be dependent on these specifics. Further research on other simulations in other contexts could help us shed light on this issue.

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References

Bloom, M. B., Rawn, C. L., Salzberg, A. D., & Krummel, T. M. (2003). Virtual reality applied to procedural testing: The next era. *Annals of Surgery, 237*(3), 442–448.

Davies, C. H. J. (2002). Student engagement with simulations. *Computers and Education, 39*(3), 271–282.

Engum, S. A., Jeffries, P., & Fisher, L. (2003). Intravenous catheter training system: Computer-based education versus traditional learning methods. *The American Journal of Surgery, 186*(1) 67–74.

Gaba, D. M. (2004). The future vision of simulation in health care. *Quality and Safety in Health Care, 13,* Supplement 1, 2–10.

Graham, C. R. (2002). Factors for effective learning in groups in face-to-face and virtual environments. *The Quarterly Review of Distance Education, (3)*3, 307–319.

Issenberg, S. B., McGaghie, W. C., Petrusa, E. R., Gordon, D. L., & Scalese, R. J. (2005). Features and uses of high-fidelity medical simulations that lead to effective learning: A BEME systematic review. *Medical Teacher, 27*(1), 10–28.

Lane, J. L., Slavin, S., & Ziv, A. (2001). Simulation in medical education: A review. *Simulation & Gaming, 32*(3), 297–314.

Meller, G. (1997). A typology of simulators for medical education. *Journal of Digital Imaging*, *10*(3), Supplement 1, 194–196.

Nilsson, T. (2007). *Simulation supported training in oral radiology: Methods and impact on interpretative skill*. Umeå: Umeå University odontological dissertations.

Rystedt, H., & Lindström, B. (2001). Introducing simulation-technologies in nurse education: A nursing practice perspective. *Nurse Education in Practice*, *1*(3), 134–141.

Söderström, T., Häll, L-O., Nilsson, T., & Ahlqvist, J. (2008). How does computer based simulator-training impact on group interaction and proficiency development? In K. Fernstrom (Ed.), *Proceedings of ICICTE 2008: Readings in technology and education*, (pp. 650–659). Abbotsford, BC: UCFV Press.