# Designing an Interactive Multimedia Rich Tutorial for Medical Students: Beyond a 'Book on a Screen'.

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**This article describes the development of an interactive online tutorial that enables pre-clinical medical students to develop and practice clinical skills such as history taking, examination, investigation and formulating a diagnosis. The development of this multimedia product consisted of four stages: (1) identifying the educational objective (2) content design (3) multimedia build (4) product testing, revision and incorporation into the curriculum. As a result of this development process, the tutorial was seen by students as genuinely student-centred in design and innovative in the way it takes advantage of the technology of the internet.**

## INTRODUCTION

UCD Dublin, like many universities, uses Blackboard® as its Virtual Learning Environment (VLE). A recent survey of VLE use in UCD,[1] revealed, however, that teaching staff were primarily using the VLE as a means of providing material supplemental to face-to-face teaching sessions with the majority of files being text-based. Images, video and animation amounted to less than 20% in total of the file types present. Thus the VLE was being used primarily as a 'digital textbook' from which students would download material for study offline. This is far from being an effective use of the potential of this e-learning environment.

Used effectively, online learning becomes a dynamic process which actively engages the learner and provides feedback on their learning progress: the learning takes place online with web-enabled technology providing an integrated and continuous approach to building knowledge, skills and competencies.[2] The goal of using VLEs should always be the creation of an educational advantage by developing and transforming individual, group and organizational performance through enhanced information processing and greater opportunities for group interaction outside of the classroom. The importance of such interaction, together with an associated emphasis on students taking, at least, some measure of control of the process of the online learning (rather than following teacher directions all the time) is well-established in the literature. [3–7]

Furthermore, students retain knowledge better if they participate in the learning process.[8] Hence, the growing movement, even outside of VLEs, away from *teacher-centred* learning towards processes that place the student at the focus of the learning activity. Producing a quality online experience requires both an effective technological infrastructure and effective pedagogic design.[9–11]

An interactive and stimulating multimedia approach, therefore, should be seen as a necessary but not sufficient precondition to effective online learning. If the experience is to be student-centred, it must also allow the individualization of time, pace and location of learning.

It follows, therefore, that effective use of modern communications technology to enhance teaching and learning should, on the one hand, give student access to experiences not available in the traditional classroom and, on the other, encourage students to review and assess their own work as an integral part of their learning. For example, students can be given the opportunity to review or revisit material they do

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not understand – something that is difficult in a formal lecture setting as it can hold back other learners – or be encouraged to check their understanding at the end of sections through on-line self-assessment.

From a teacher's point of view, the use of web-based technology also allows rapid update of material without great cost and, in medicine, virtual patient systems, can give exposure to cases outside the teaching institution's own patient population.

This article describes the creation, use and evaluation of a learning object (the 'e-tutorial'), which allows pre-clinical medical students to investigate, analyse and plan a course of treatment for a virtual patient.

METHODS

## (1) Identifying the educational objective

The specific learning-improvement goal behind the development of the e-tutorial was to enable medical students to learn about pathology in a manner that mimics how they would encounter the subject matter in later professional life – i.e. through experiencing the scenario of a doctor-patient interaction.

The educational objectives were as follows:

1. The student should be able to take a relevant medical history and perform a physical examination from a virtual patient presenting with the signs and symptoms of a particular disease. For the pilot version of the e-tutorial this was colorectal cancer.
2. Based on these findings the student should be able to formulate a differential diagnosis (i.e. a short-list of most likely possible conditions).
3. The student should then be able to order relevant tests (e.g. radiological or laboratory based) to provide evidence for and against their initial diagnosis which they can use to re-evaluate this initial judgement.
4. The student should be able to indicate which is the most appropriate course of treatment for the patient based on steps 1–3.

The outcome for the student was not only the comprehension of a disease process and its manifestation but, more importantly, the ability to develop clinical reasoning and judgement based on an encounter with a virtual patient. This ability is a key skill which undergraduate medical students must develop in order to become effective clinicians or diagnosticians.

## (2) Content design

During the planning stage, the first-author as content expert/teacher presented the educational challenge to a development team that included an educator and a technology specialist. Together with the first author, a physician, this team drew up a storyboard for the e-tutorial which established the sequence of different screens which the student would encounter. In each of these, the student would be allowed to ask questions, order investigations and, where appropriate, answer questions. They were also required to make an entry into an integral reflective log. It was decided to allow students to choose from a list of pre-generated questions rather than type in their own, on the premise that they would still be novices in the field of clinical reasoning. The question list was seen as 'scaffolding' upon which to develop their clinical skills by allowing them to see a mixed list of high relevancy to low relevancy questions and to choose from them. A limitation to the numbers of questions / requests that could be asked in each screen caused the designers to require students to rank the questions in order of importance as a way of further testing understanding and competence.

## (3) Multimedia build

The next phase in the development of the e-tutorial was the transition from a storyboard outline to a working pilot version. This was achieved utilizing Flash [Macromedia™] web authoring software. This particular software application was chosen because it is ubiquitous on the internet, because of its speed (vector-based animations, which can adapt to different display sizes and resolutions and play as they download) and for the smooth way it renders graphics.

Utilising Flash, the tutorial was created as a series of screens which the student would visit sequentially. The screen order was Consultation, Physical Examination, Differential Diagnosis, Investigation, Diagnosis, Treatment and Outcome and Assessment. In addition, introductory and closing screens were also included.

The design of the screen was considered to be a fundamental issue which would impact upon the educational value of the product and hence was required to be visually engaging and easy navigable to allow the student to focus on the clinical problem rather than the technology delivering the problem. Features which were seen as essential for the screen design included:

1. Clarify and simplicity of screen layout (*Figure 1*).
2. Consistency in design of all the screens in order that the student would not be 'bounced' to different screen layouts and become distracted by adapting to different layouts and not concentrating on the tutorial content.
3. A panel for video input.
4. A panel for brief summary data [e.g. patient vital signs].
5. Panels for question and receiving answers.
6. A slot for the reflective log.
7. A progress bar which would allow the student to know how far into the tutorial they had gone and how much was left.

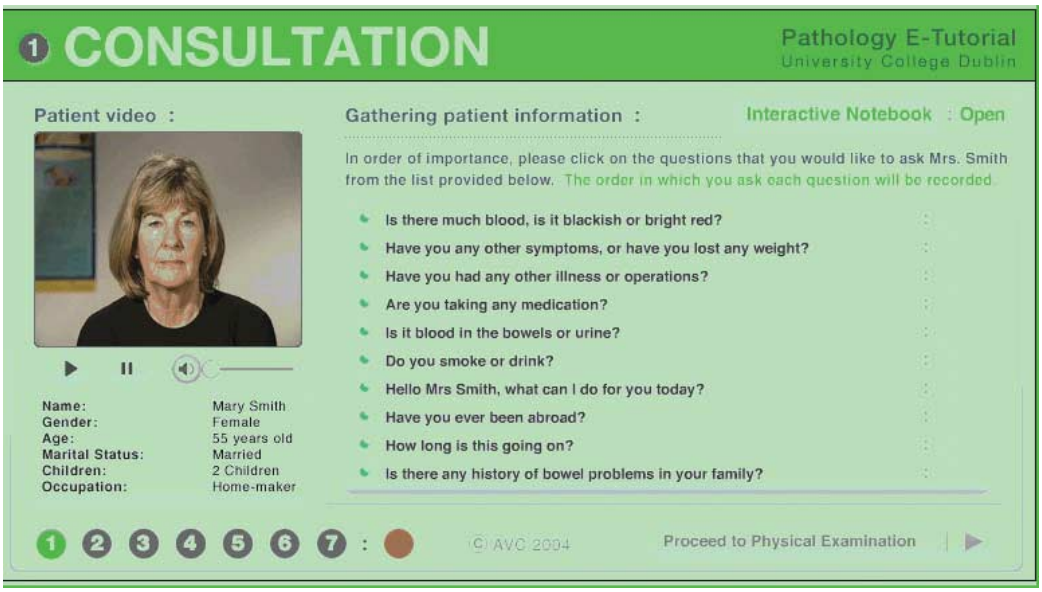


Figure 1. Screen shot of a final version screen from the e-tutorial.

## (4) Product testing, revision and incorporation into the curriculum

### *Review by expert panel*

The pilot version of the e-tutorial was shown to a five-person expert panel consisting of two education developers (one with a particular expertise in e-learning theory; the other with a particular expertise in problem-based learning), a university lecturer teaching in the target curriculum area, a medical doctor and an e-learning software expert. Recommendations and changes resulting from this stage of testing were:

1. Certain factual corrections were made to the content of the e-tutorial and additional information was added in pop-up panels that could be accessed via hyperlink. The two subject specialists on the panel felt that medical students would need this additional information to (a) feel more secure in the choices they were being asked to make and, (b) link learning via the e-tutorial to learning in cognate modules.
2. At the request of the educational developers, image sizes were increased, where possible, as part of the University's commitment to ensure that students with specific learning needs were not disadvantaged by software design wherever this could be avoided. For similar reasons, the choice of colour in page headlines was altered.
3. Navigation icons were standardized.

4. The use of extended matching sets was recommended as an addition to multiple choice questions in the assessed tasks. (Unfortunately, this was not possible in the version of the host VLE in use at the time.)

*Student testing of the e-tutorial*

The revised e-tutorial was placed on the university VLE during the third undergraduate teaching year as part of the integrated, systems-based, gastrointestinal diseases module. Seventy-four percent (74%) of medical students (class size 200) participated in at least one of a series of evaluation activities, including structured questionnaires and feedback sessions. Questionnaires were adapted from the Biomedical Multimedia Unit at the University of Melbourne.[12]

The students were positive about the fact that the e-tutorial was based on a virtual patient consultation. They regarded highly the 'real life' scenario where they went about performing the tasks of a doctor. This was valued over what students considered to be book learning. ('This is why we study medicine, for the patient, not the books'.) The application of previously learned material (taught didactically for the most part) to 'solving' a problem was also highly valued. In particular, the e-tutorial allowed material taught in a preclinical setting to be applied to the clinical setting. As this was the students' first experience of a clinical setting in the role of physician (albeit simulated), the safe environment provided by the virtual patient software was particularly appreciated. The possibility of making mistakes within the e-tutorial was found to be less stressful than with other forms of simulation as students felt that they had the facility to role-play without the risk, as one student put it, of 'making an absurd fool of one-self in front of people'. In terms of the assessment and feedback, the students valued the multiple-choice questions and the feedback given for each question.

Student feedback found the e-tutorial to be interesting and a 'relief from the non-stop' text-book approach their previous experiences – including text-based e-learning. They appreciated the interactive, multimedia-rich approach and the ability to take staged tests, receive feedback and the facility for reflection using the interactive notebook. The incorporation of a virtual patient to allow the students to perform a clinical consultation was seen as a major strength. Apart from allowing the student to consolidate and apply previously acquired pre-clinical knowledge in an applied clinical setting, it also allowed them to practice their skills as junior doctors in the safety of a simulator. In the words of one student, the e-tutorial was a 'wonderful way to allow us to use all of our knowledge in a constructive way and see the results'. The interactivity of the e-tutorial allowed students to actively engage with the content in a way that is not achievable with paper-based materials and only partially achievable with 'static' web pages.

Criticism of the e-tutorial fell into four categories: (i) the inability to go backwards and correct mistakes made in previous screens, (ii) the quality of the feedback, (iii) the role of the interactive notebook and (iv) technical issues related to the quality of the graphics.

Dealing with the first criticism, it was decided during the design phase of the e-tutorial that students would not be allowed to go backwards and correct mistakes, for example, ask further questions of the virtual patient once they were past the history screen. The aim of the e-tutorial was to simulate a real life scenario and to not resemble a video game. Once you have committed yourself to a course of action, based on data you have weighed previously, you must face the consequences of that action. However, the students were unhappy about this and data from the self-invited interview and focus group discussion felt the ability to 'back-track' should be incorporated into the e-tutorial design.

The quality of feedback given during the tutorial was considered by some students not to be detailed enough and some students did not get feedback on incorrect multiple choice questions whilst other students did receive the correct feedback. The software was designed to provide feedback on all MCQ questions taken by the students, due to time constraints, however, it was not possible to have all the feedback pre-loaded into the tutorial before the trial period. This issue was resolved before the revised product was redeployed into the curriculum.

The interactive notebook formed an integral part of the e-tutorial and was developed to allow students to reflect on their learning experience by either making notes during the course of the e-tutorial or by allowing them to cut and paste data into the notebook from either the e-tutorial or other sources (e.g. via the web from 'PubMed' – the online U.S. National Library of Medicine). It was decided, again at the design

stage, that students had to make an entry into the interactive notebook before proceeding to another screen. The students, whilst finding the notebook valuable (c.f. individual feedback and self-invited interview data), did not feel it was necessary to make entries in the notebook during every screen. They felt it was useful for recording findings from the history, physical examination and investigations, but many did not find particular value in recording events for other screens (e.g. the procedure screen). This was not a universally held opinion, with a minority of students expressing the view that being made to write in the interactive notebook forced them to learn and this was a positive experience. At the time of writing, the authors still feel that it is appropriate to require students to make an entry during every screen as it promotes metacognition because students have to make judgements on what merits recording.

Finally, some of the students commented upon the quality of the graphics in the e-tutorial. The size of the images and the font size were difficult for some students to read. The e-tutorial was designed to open as a smaller, pop-up type window within the Blackboard window on the students PC screen. This was purposefully designed to allow the students to open up Blackboard links during the e-tutorial. The technical team are addressing the issue after the initial feedback and are investigating ways of increasing the font and image size in pop-up screens. In addition, to the graphics issue, several students highlighted hardware issues, the most common being the need to download the Flash player to run the tutorial. A link to the download site was included in the introduction screen. Another problem experienced by the students was the lack of properly-functioning speakers in the University's e-learning laboratories. Interestingly enough, the students had not complained of this problem before the e-tutorial, demonstrating the lack of previous multimedia software programs during traditional e-learning sessions.

Overall, the student evaluation is considered to have validated the final design of the e-tutorial. Subsequent use with a successor cohort has not yielded data suggesting the need for significant further design alterations.

## DISCUSSION

The benefits of computer-assisted learning (CAL) in teaching and learning are now well established with research suggesting that it has the potential to reduce the amount of time students need to study by improving the way they process information.[10] It can also improve the performance of students in examinations.[13] Many e-learning systems fail to make the most of the full potential of CAL and are, essentially, little more than 'books on screens' with little or no interaction with assessment of, or feedback to the student. Material is often presented simply as a series of lecture notes (in hypertext) and pictures (as GIFs or JPEGs), without attention being given to the design of the interface. As a result, most of the learning ends up taking place offline.[14] The approach of the authors – ensuring that *e-learning* (learning through electronic media) became *computer-aided learning* (learning where the computer responds to actions of the learner in order to assess what has been learned and to prompt further cognitive development) was shown to have offered the following advantages usually seen only in open and distance learning:

- flexibility of pace, time and, location
- providing students with the ability to control their own learning process.

Students reported a significant improvement in the learning experience as compared to identical and similar material presented as pictures with text. The incorporation of a virtual patient to allow the student to perform a clinical consultation was seen as a major strength of the e-tutorial. Apart from allowing the student to consolidate previously learnt pre-clinical knowledge into clinical practice, it also allowed them to develop their skills as junior doctors in the safety of a simulator. In the words of one student the e-tutorial was a 'wonderful way to allow us to use all of our knowledge in a constructive way and see the results'. Students collectively and unanimously expressed the view that the assessment and feedback received within the system under review led to faster and more effective learning because the material was more easily related to possible real-world experiences. Further, they reported that when they were faced with actors-in-the-role-of patient, they felt more confident in their approach because of the experience gained from the CAL tutorial. Tutors also reported that students were more confident when presented with actors-in-the-role-of-patient – as did experienced actors who took on this function.

The interactivity of the tutorial enabled students to become actively engaged in learning in a way not possible with paper materials or static web pages.[15]

The use of electronic delivery of courseware can be a very powerful and flexible learning tool but failure to use it in an appropriate manner can lead to a compromised learning experience and disillusionment.[16] The results from the survey data obtained suggest that presentation in a structured, navigable, interactive learning environment can significantly improve the learning experience of medical students. The e-tutorial offered mainly the advantages of open and distance learning (flexibility of pace, time, location, and student control over much of the learning process). However, it appears that these advantages are not sufficient to improve learning and need to be underpinned by a pedagogically sound virtual learning environment in which the material is embedded. Designing CAL is a rapidly developing field not only in undergraduate education but also for continuing professional education. Despite this, there appears to be a preponderance of inadequately designed courseware available on the Web and in educational establishments. Our results suggest that adherence to a series of relatively simple rules of interactivity and usability can significantly improve student learning. This paper has explored how an innovative web-based learning tool can help resolve these issues. Without the kinds of innovative uses of technology described in this paper, it is difficult to imagine how the far-reaching curriculum changes described above could be effected in ways that will provide challenging and developmental educational experiences.

The limitations faced were those common to most, if not all, educational contexts, viz. money and access to technical support (even when money was available). These limitations meant that:

a it was not possible to provide the optimal range of experiences within the e-tutorial
b most of the interaction had to be by way of typing-in text
c the program tested student input by asking them to select from a list rather than type in free text
d the amount of student-student interaction was much less than that between student and programme or student and tutor.

Of these limitations, only the fourth is thought to be of high significance.

Although the range of experiences was limited, it was sufficient to provide appropriate challenges to pre-clinical medical students. It is in the development of the model for clinical and post-graduate settings that the need for extended range will be critical.

One of the longest design team discussions was on whether it would be worth seeking out the resources to allow for speech input. It was decided that, at the level of development of the students, it was actually better to require the typing of text that could be more easily stored and reviewed as this would enable subsequent discussion and reflection.

Similarly, requiring students to select from a list was appropriate to the level of development and can be seen as an example of 'scaffolding' in learning.[17] For example, the list of possible questions that the student selected not only tested but taught.

The most significant restriction of the current e-tutorial is that the amount of student-student interaction is limited. This has not been of vital import for the cohort involved in the development of the product as their educational experience included group tutorials where the lessons from the e-tutorial were revisited. It is, however, important that such follow-up sessions are provided given that they are not inherent in the product. The one piece of advice that the authors would give to those seeking to build on this work would be to expand the potential for student-student interaction.

## CONCLUSION

An interactive, easily navigable computer-based learning system, incorporating assessment and feedback has been shown to create a significant improvement in the student learning experience over identical material presented as simply pictures and text in scrollable web pages. Perhaps the words of Confucius can best summarize the objectives which effective e-learning is striving to achieve: 'Tell me and I will forget, show me and I will remember, involve me and I will understand'.

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