Title HUBS
Department Anatomy
Paper Code 100 level
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Why did we pursue this project? What was the rationale for it, and the problem we were solving? What did we do to address the problem?

Project beginnings:

The project originally came about as a result of the need to upgrade existing Hypercard stacks which would no longer run on more modern operating systems. In order to facilitate reuse and future adaptability, as well as to take advantage of the considerable 3D modelling and animation skills within Educational Media, we decided to trial the use of a commercial 3D heart model from Zygote. An internal HEDC grant application was completed to fund the purchase of the model (documentation attached).

Once the model had been purchased it was agreed with Justine to start out by producing some specific images and animations, including the cardiac cycle, for the HUBS course and to evaluate the use of these with students. This also gave the designers and animators time to become familiar with the 3D model and the anatomy and function of the heart itself.

In terms of project management the project was fairly small and most communication, setting timelines and agreeing deliverables could be achieved by Justine working directly with Michael Crawford and Michael Chen. Tim was mainly involved in helping to setup the project as part of Educational Media operations and ensuring final deadlines could be met. From start to finish, the cardiac-cycle animation took approximately two months (1.0 FTE) to complete.

Jenny and Justine worked together to develop the evaluation in consultation with the designers/animators.

Project Description:

This project is an interactive animation of the human cardiac cycle. It is used as part of the core laboratory teaching in the new Human Body Systems courses at the University of Otago. These courses form a prerequisite for students who will go on to study in different health sciences professional courses, for example, medicine, physiotherapy, and dentistry.

Understanding the cardiac cycle is central to understanding the important features of cardiovascular physiology. It is also a notoriously difficult concept for first and second year undergraduates to come to grips with.

The cardiac cycle consists of one complete contraction and relaxation of all four chambers of the heart. A key goal in developing this interactive animation was to help students to visualise the different elements of cardiac activity including electrical, mechanical and changes in pressure and volume, and to see how they relate to one another during one complete cardiac cycle.

Students in the first year health sciences courses are typically highly motivated. Their success in this course is essential in order to compete for entry to any of the professional schools. They range in age (in 2007) from 14 to 46 years with the great majority between 16 and 20 years old. The majority of students are NZ nationals or residents with just over 100 international students. We would expect most students to be familiar with the Internet and simple web and Flash applications. The cardiac cycle animation is created in Flash 9.0 and is accessed via a web browser. It is linked to from the University learning management system, Blackboard. Students in HUBS courses use Blackboard extensively for their course information, materials and formative assessments.

We wanted the animation to present an as-real-as-possible representation of the heart. Students at this stage are still coming to grips with the anatomy of the heart, and opportunities to reinforce the structure of the heart help students to understand how it works. By utilising an accurate 3D model of the heart, we were are able to easily show a number of different anatomical views of the heart as well as to create a semi-transparent model that allows students to examine the internal structure and function of the heart. An additional important benefit of the 3D model is that it can be, and in fact already has been, reused to produce a range of animations and diagrams of the heart to support other aspects of the course.

The cardiac cycle is traditionally presented to students through a complicated diagram or series of diagrams. The reason for this is that several things are going on during a single cycle: Electrical activity, changes in left and right atrial and ventricular pressure, changes in pulmonary and aortic pressure, opening and closing of AV, pulmonary and aortic valves, changes in ventricular volume. There are also differences between what is happening on the left and on the right side of the heart.

What we have aimed to do is to clearly separate out the key features of the cycle and present them in such a way that the student can choose to focus on different aspects of the cycle.

Graphs of the ECG, cardiac pressures, ventricular volume and heart sounds are all accessed via a series of horizontal title bars which open and close their corresponding graphs. The graphs are all synchronised to the heart animation. The following are a couple of ways this design can be utilised:

- A student may choose to just look at how the ECG changes during the cycle and think about electrical activity in relation to the contraction and relaxation of the heart.

- Another student may wish to focus on changes in ventricular volume and look at how this relates to changes in pressure.

Tabs to the left of the graph bars allow the user to investigate each of the graphs from the perspective of the right or left side of the heart.

The animation runs at a heart rate of 75 beats/minute or one cardiac cycle every 0.8 seconds. However it is difficult, if not impossible, to make sense of all that is going on at this speed. For this reason the user can slow the animation right down, pause it at any stage and also drag the time scale slider to investigate specific changes at particular points. Familiar interface elements, such as play and pause buttons and sliders were used to achieve this.

Other similar applications, how does it compare?

Creativity and innovation are very subjective concepts. The approach we have taken to answering this question is to provide links to other similar animations readily accessible via the web. The following are links to existing interactive animations of the cardiac cycle. The first URL from Harvard medical school is probably most closely aligned to our animation in terms of content. The remaining animations are the first 7 links accessed from a Google search using the search terms [cardiac cycle animation]:

- From Harvard medical school: http://athome.harvard.edu/programs/hse/video/hse2_2_text.html

Top 7 Google listings

- http://anatimation.com/cardiac-cycle/cardiac-cycle-events-of-the-cardiac-cycle.html
- http://library.med.utah.edu/kw/pharm/hyper_heart1.html
- http://biology.about.com/library/organs/heart/blcardiacanim.htm
- http://bcs.whfreeman.com/thelifewire/content/chp49/49020.html
- http://www.getbodysmart.com/ap/circ/heart/cardiaccycle.htm
- http://www.jdaross.cwc.net/cardiac_cycle.htm
- http://msjensen.education.umn.edu/1135/Links/Animations/Flash/0028-swf_the_cardiac_cy.swf

In terms of pedagogical and technical innovation and creativity we believe our animation is outstanding compared to this selection of alternatives. It is important to realise when viewing some of these resources that our students are not just left with the resource on its own. It is used in conjunction with lecture and laboratory teaching which covers the action of the heart as a pump, electrical activity, cardiac pressures and ventricular volumes, along with opportunities for students to test their understanding.

Learning Design

Animations of the different elements of the cardiac cycle have been used for many years in teaching first year human physiology at Otago. Until recently these were provided in the form of highly stylised black and white Hypercard animations. Students have always appreciated these animations as part of their coursework. This should not be surprising given that it is much easier to understand a dynamic process when you can actually see it operating rather than having to imagine it from static models, diagrams and textbook explanations.

We wanted to upgrade the early hypercard stacks to combine all the elements of the cardiac cycle into one as well as to take fullest advantage of currently available visualisation technologies and techniques. Opportunities for students to test their own understanding have always been provided as part of laboratory “checkout” tests and this remains unchanged.

The cardiac cycle animation was deliberately designed not to impose a particular path or route of study on the student. (For example, Laurillard, 1987). It begins with a standard centre (in-situ) view of the heart and a brief reminder that the cardiac cycle is one complete contraction phase (systole) and relaxation phase (diastole) of the heart. Once the student is ready to proceed they press continue and are presented with the animation which runs along with synchronised heart sound audio.

From this point on, it is up to the student to focus on the aspects they need to focus on. They can choose to view the heart in different positions. They can look at the synchronised graphs, individually or all together, and they can watch the heart valves opening and closing and blood flow at different stages of the cycle.

There is a great deal of material that students need to become familiar with in order to really understand the cardiac cycle. For example, the animation simply presents the ECG trace along with brief roll-over notes (green dots) at key points. The notes themselves assume that the student is already familiar with terms like atrial depolarisation and QRS complex. Electrical activity of the heart has been covered earlier in the course along with a laboratory session where students record their own ECGs. If the student has forgotten what these terms mean then the roll-over notes are intended to provide a cue to the student that these are terms they need to understand.

The ability for the student to precisely control the animation through dragging the time slider, marked off in meaningful cardiac cycle intervals (as opposed to frames per second) means they can closely examine related events. For example: On the left side of the heart, closing of the AV valves coincides with the highest ventricular volume, and is followed by a rapid rise in ventricular pressure.

The aortic valve opens when ventricular pressure exceeds aortic pressure and blood flows rapidly through into the aorta. They can then compare this to what happens on the right side of the heart.

Laurillard, D. (1987). Interactive Media: Working methods and practical applications. London: John Wiley.

What did the students and teachers think of the final product?

The Cardiac Cycle animation has been used in a University of Otago, first year paper entitled Human Body Systems (HUBS192). This paper has been taught by both the Anatomy and Physiology Departments and has had approximately 1440 students.

The inaugural use of The Cardiac Cycle animation has been as part of a self-directed learning module on the cardiovascular and respiratory systems. The students have been directed to go through The Cardiac Cycle animation, accessing the program on the University of Otago computer network in their own time during a four week period. Interestingly, the highest usage of this animation was on Sundays. The students have then completed a series of tasks in a self-directed learning workbook. These tasks have included drawing, onto some existing axes, the graphs of left atrial, left ventricular pressure and volume and heart sounds.

This animation complemented other more traditional teaching of the cardiac cycle. The material was covered a lecture, and in a laboratory in which the students recorded their own electrocardiogram (ECG) and heart sounds, and examined the temporal relationship between the two recordings.

The students were assessed on this material as part of an online test. They had to answer multi-choice questions on the function of the valves, and the relationships between electrical and mechanical events.

The ease of adoption by other practioners within our department is already apparent. The Cardiac Cycle has already been made available to another second year physiology course, simply by putting the file up on Blackboard with an explanatory note that the animation may be useful. It has also been used as an alternative to a powerpoint file during a second year laboratory on the cardiac cycle. Its use by students for their own study seems limited to the university network because of the slow average streaming speeds of the telecommunications network.

Comments by other teachers have included whether the animation could be further developed to show what happens during left heart failure, and how chest physiotherapy can affect heart function.

Present substantial evidence of critique and evaluation of the resource in terms of learning design and development strategies, including trial of prototype(s). It is also essential to provide substantive evidence of evaluation of the effectiveness of the project/resource/implementation in terms of teaching practice and/or learning outcomes. (An evaluation plan is not acceptable.) (Maximum two pages)
A likert-scale type questionnaire (rating 1 – 5, 1 high) was distributed to students during laboratory sessions which dealt with material directly linked to the cardiac cycle animation. The intention of the questionnaire was to record formative judgements or perceptions from students about the value of the animation along 3 dimensions:

- Ease of access to the animation,
- Useability and quality of the animation,
- Value of the animation in aiding understanding of the topic.

Reflections from teachers and informal feedback and observations of students using the animations, along with the number of accesses provided by Blackboard server logs were used to validate the questionnaire results.

The questionnaire was distributed during 3 streamed laboratory sessions on the 9th of August 2007. There were 288 students, 123 of whom responded giving a response rate of 43%. This response rate is probably about right given the download statistics from the Blackboard server which indicate that 46% of the total class of 1440 accessed the animation at least once during the period when the cardiac cycle was being taught. A complete summary of the questionnaire responses is available on the accompanying CD.

In response to questions about ease of access, the majority of respondents found the link to the animation in Blackboard very easily (75%) and for 62% the animation opened without errors or any other problems.

In response to a series of questions about useability and animation quality, 72% of respondents could play and control the animation. 64% of respondents found the cardiac cycle to be very clearly presented, and 65% found it very easy to use. The nil response rate to more detailed questions about the different views of the heart, heart sounds and so on was high (20%-59%) but of those who did respond to these questions the responses tended to be very positive (majority 1 and 2 ratings).

In response to questions about whether the animation aided their understanding of the cardiac cycle, the majority of those who responded felt that the cardiac cycle animation aided their understanding a great deal, and indicated they would use the animation for revision. 41% of respondents said that this cardiac cycle animation was or would become an essential part of their study. 62% of respondents said they would find animations like this really useful for other parts of the HUBS course.

Overall, the evaluation is positive. Usage rates are perhaps a little lower than we might like but these are possibly a reflection of the fact that the animation was made available for self-study rather than being actually used as part of in-class activity. Of the students who used the animation the responses across all three evaluation dimensions were very positive. We received very few written comments from the students. 3 positive comments were:

> "I found the cardiac cycle animation very helpful as it is often hard to visualise how the heart works in real life, as we only ever look at models and pictures. It definitely enhanced my understanding of how the heart works."
> "Brilliant."
> "Pretty neat, another way to learn for some people. - Maybe can add some boxes to fill in to test understanding."

The only two negative comments related to accessibility:

> "I couldn't get it to go so didn't do it."
> "It would be good to be able to see the entire screen so you don't have to keep shifting the screen around to push all the buttons."

Teacher feedback has been extremely positive with use beyond this course already underway and more opportunities being explored. Relatively informal student observations were used primarily to fine-tune the user interface but also support our impression that students who use it, find the cardiac-cycle animation both useful and engaging.

Aside from the developers testing the animation in-house, evaluation with students included questions relating to the animation opening and playing correctly. Only 2 students out of 123 who completed the evaluation questionnaire indicated they had accessibility problems. One of these related to screen resolution setting and the other simply said they "could not get it to go".

Where to from here?

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Students and staff have responded very positively to the animation in the short time it has been available, and the animation is already being used in courses other than the one for which it was designed.

In addition to the specific project goals opportunities for technical reuse of both the 3D model and the expertise developed through this project have already been exploited and we anticipate the demand for this kind of service/product is likely to increase within health sciences courses.