# How to Teach Medical Concepts Using Animations by Designing Multimedia Instructional Application.

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Abstract— **Multimedia has the promise of imparting medical education through novel teaching methods and encourages student interest. Medical educators must adapt to developing such computer and instructional technology to make such presentations a commonplace in the teaching setting. The scope of this paper is limited to the role of a physician in designing an educational multimedia instructional application using animations. It describes the requirements and stages of development of such a program with the goal of maximizing learning effectiveness. The animations entitled "How does blood clot?" are interactive and flash based that focuses and simplifies the complicated concepts of blood coagulation. This animation is currently used as a part of the Problem Based Learning course in the Hematology/Neoplasia domain by second year medical students in the College of Human Medicine, Michigan State University, East Lansing MI. Student feedback/responses are described. The animations were also used to educate pediatric residents and senior medical students (3rd and 4th year) in reviewing the coagulation course. Insights gained from developing such projects are presented as a potential to use animation in computer assisted learning & teaching in medicine for the development of other projects in science learning environments**

## INTRODUCTION[1]

It is becoming increasingly evident that healthcare education will be enhanced through the use multimedia technology. In a study of the learning behavior of students in medical school [1][2] an interesting phenomenon was found: because the quantity of material was so large, students would look for anything to make it more unforgettable; some kind of hook or key idea. Unfortunately, students often over-simplified, stubbornly relying on a simple analogy presented during class. Many principles have been identified for effective learning and overall design, including instructional, interactive, interface and usability design. Given the variety of multimedia tools and design possibilities, there are a number of ways to design instructional multimedia to advance learning

There are several studies that demonstrate effectiveness of multimedia in the learning process. In a report regarding the educational impact of a computer-based training tutorial on dementia in long term care for licensed practice nursing students [3] came to similar conclusions. The overall student response to the "Language of Dermatology" as a learning tool was positive with 78% of the students finding the web site to be of high quality [4].The study "A computer-based training module for suturing" suggests that this training module for basic suturing may be an effective tool for teaching undergraduate medical student [5].

The studies that did not find educational multimedia presentations to be effective quoted lack of proper (accurate?) content and found most of the medical teaching websites were endowed with good technical support but were surprisingly falling short in reflecting the principles of learning.[6]. Currently, there is a deficit of good educational software in dentistry and that which does exist is not indexed on the networks in the same way as journal articles or books [7]. In the Development of Multimedia Evaluation Criteria and a Program of Evaluation for Computer Aided Learning it was found that too often multimedia developers do not assure congruence between learning objectives and instruction, This puts the responsibility back on the content experts to clearly articulate what the objectives of the module are and to create the content in line with these objectives.[8]. Another major concern regarding computer assisted learning programs is the failure to utilize them even when available. Perceived obstacles include poor planning and integration with other forms of learning, and cultural resistance from staff.

The user-centered design is an approach which views knowledge about users and their involvement in the design process as a central concern [9]. This therefore implies that the optimal designer of such a program would be none other than a physician who would presumably be in contact with other physicians using the program.

## PREREQUISITES

This section of the paper deals with prerequisites required in developing an educational learning and teaching program using animations from a physician's point of view. The physician needs to understand that this process takes considerable effort and time. The physician as the educator coordinates his/her expertise with the program designer in executing the project.

[1] A multimedia version of this article is available at http://reddymed.com/minformatics

A. *The Physician*

The physician is responsible for the content of the program. An ideal medical teaching program that the physician should aim for must be strong in content, up-to-date and completed with references. One of the features of a computer based learning systems is that these references can be easily accessed from anywhere in the program. It is this interactivity that appears to have a strong positive effect on learning.[10]. If the cross reference leads to a subject matter involving different specialties further collaboration with other consultants becomes necessary. If the physician does not have enough time as what happens to most academicians, a medical educationist may have to fill this gap to educate the designer on the subject.

B. *The Program Designer*

The program designer is responsible for the content as well as designing the animations and managing a complex set of processes such as script design, interactive design, production, and computer programming. He should be well versed with using software programs meant for animation.

## CONTENT

Developing content for an animation based teaching program requires thorough planning. Unlike the other forms of multimedia the physician has not only to be very precise and accurate regarding the content but also meticulous as mistakes soon become evident and are difficult to rectify in the later stages of the animations. Initially a thorough research of the subject is crucial as is being specific of what needs to be included in the animations.

The content of any program broadly can be divided into the following categories. Each category has its own difficulty when translating that information to the program designer and finding a suitable way to animate that content.

*A. Structure* Anatomy*, Pathology, Histology or equipment.* Describing a known structure to the program designer is the easiest of all categories. For example asking a designer to show parts of a heart beat would involve showing a picture of a heart for a reference. This also applies to histology or any object visible to the eye. Describing the various parts of equipments, instruments and other structures also falls in this category. However the problem the physician faces will be in making the program designer understand the proper shape, details, proper color and background accurately. It is important that the graphic designer be well educated about the exact shape, size, color, details and background of the elements for even small mistakes are magnified in an animation based program. For example a round platelet is easily identified as a wrong shape and an oval shape as the correct one no matter how small it is. Similarly finer details viewed even in an electron microscope are very important and need to be shown accurately. Accurate depiction of color is of utmost importance as slight changes in color may give a different meaning in medicine. Presence or absence of a background may convey clarity to the animation. Sometimes a background helps and sometimes it distracts the attention of the viewer. The physician will have to decide the relevance of having a background on an individual basis.

*B. Motion: Physiology*.

Describing physiology is more challenging than describing anatomy - for example, in the simple animation of glucose entering a cell, while depicting the cell is relatively simple; however, illustrating a glucose molecule is more complicated; using the chemical formula of glucose makes the animation difficult to comprehend. This leads to the inevitable conclusion that in order to comprehend the animation, glucose should be represented by a symbol and a cross reference be given where a more detail explanation is available.

The question is who would design this symbol? It is best for the physician to think about these symbols while working with the designer as his issues would deal with animating the suggested symbol. The next logical question would be how does this glucose enter the cell, does it simply pass through; Is there an opening or a trap door, if there is one how does it look like? What controls this trap door? These are the questions that the physician will have to consider. Trying to get a correct answer would require knowledge of cell biology. This is where a consultant may be helpful. It is up to the physician to decide the degree of detail in his content and involvement of other consultants in the project.

A proper sequence to events is very critical while making animations. Failure to convey this may come back to haunt the physicians when the error is realized after the completion of the project. It is time consuming and sometimes impossible to correct the mistakes after completion of the project. An example of this would be an animation that shows a sequence of events that happen when the platelet encounters an injured endothelium. The correct sequence should show a protein called von Willebrand factor first tether the platelet to the sub endothelium, following which the platelet changes shape. In the wrong sequence the platelet adheres to the injured endothelium, changes shape and then the von Willebrand factor tethers it to the sub endothelium. Though the sequence is almost identical, it is the von Willebrand factor that induces the platelet to change its shape and the wrong sequence fails to communicate this piece of information.

Timing and duration of animations are very important in conveying the right content. A simple example of this would be animating a heart beat, where the diastole is longer than systole. If the diastole and systole are animated in equal length of time it creates problems further down the animation when it will have to be timed with EKG, echocardiogram or other actions involving the cardiac cycle.

### *C. Abstract: Understanding*

Describing an abstract understanding is perhaps the most difficult challenge since there is no known anatomic structure.

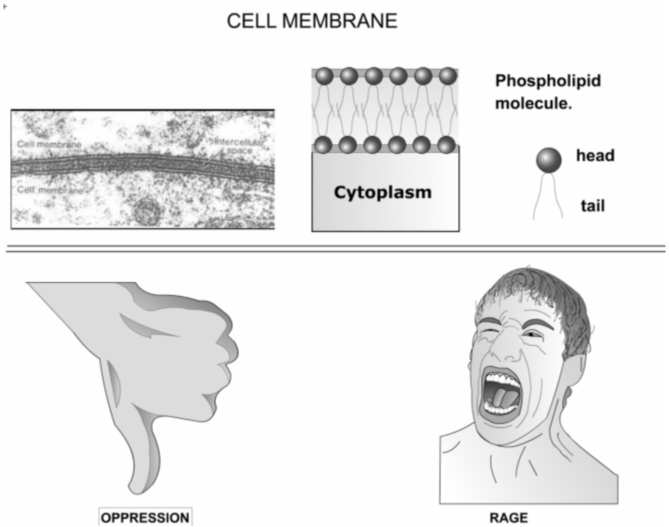


Fig. 1. Effective use of Symbols : Cell membrane, Oppression and Rage.

A typical example would involve a psychiatrist wanting to develop a program which deals with concepts like emotions, idealization, matching or confidence In this case physician and the designer working in collaboration have to come up with an appropriate symbol and a story board. Symbols can be used then to represent abstract thoughts and ideas and also drawing a complicated.

The Fig.1 shows how symbols can be used in different situations. The top half is a magnified view of an actual cell membrane (*This is taken from Bloom and Fawcett, A Textbook of Histology, Chapman and Hall, N.Y., 12th edition, 1994, Figure 1-2*. It however does not allow one to conceptualize the components. To its right is a symbol of the composition of the cell membrane. The cell membrane is composed of a phospholipid bilayer. Each phospholipid molecule is composed of a head is composed of glycerol and a phosphate group The tail is composed of fatty acids made up of long carbon and hydrogen chains. Below are two symbols representing oppression and rage.

### *D. Content Labels Text, Captions*

Adding text to the animation helps the viewer understand the animation much better. Studies have shown that information gained from reading text is retained longer than that gained from narration. The problem facing the designer would be that this text competes with the animation for space. Therefore it is a good idea to plan the amount of text or explanation needed to capture the attention of the viewer about the animation and give a link for detail text.

### *E. Navigation and interactive buttons*

The program designer is an expert in placing these buttons. Apart from buttons that take the viewer to different sections there are buttons that can hold, slow down or replay the animation. Interactive buttons can be used to refer to more detail .Any text or shape can be converted into an interactive button. The physician should plan on such buttons while planning the content. If the picture is very busy it is always possible to make the label appear on mouse over.

It is for the physician ultimately to make sure that these shapes and symbols accurately portray the intended information. The physician should have some idea about animations and what type of animation would better convey his content. Armed with this knowledge he can take an important role in developing concepts about how the animations are presented. Najjar and associates in a paper published " Principles of educational multimedia user interface design" quotes that the learning effectiveness of multimedia applications depends on several factors such as content of multimedia, learner, learning task and tests for learning.[11]. It is important to recognize these factors when designing a multimedia instructional application.

## CONCEPT

From the contents built so far the next step is to developing a concept. It is important for the physician to have some concepts in mind before he sees the designer. Below are some concepts for various situations,

### *A. Structures*

Animations can be used to identify structures in an otherwise busy picture. In the snap shot of the animation "Structure of Platelet" below the buttons are seen to the left. Upon clicking the buttons another page opens isolation the labeled structure as seen below

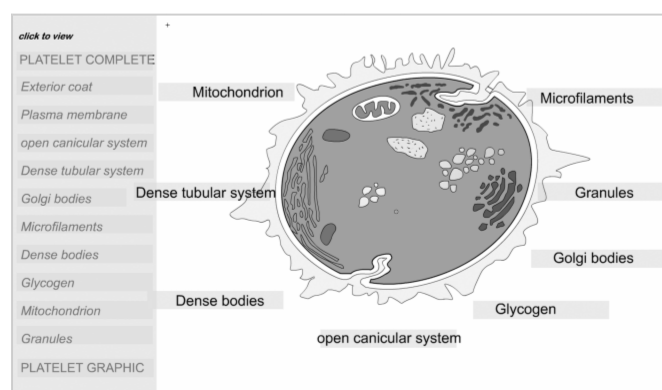


Fig. 2. Structure of a platelet

*B. Motion*

Animations help develop explanatory mental models when trying to convey otherwise invisible system functions and behaviors.[12]Animations by slowing down the sequence of events that happen in body that otherwise happen within a fraction of a second help the viewer grasp the function much better. When specific instructional segments of the film were run at a slow speed and the remaining segments were shown at regular speed, people learned the tasks shown in slow motion better than the tasks shown at regular speed.

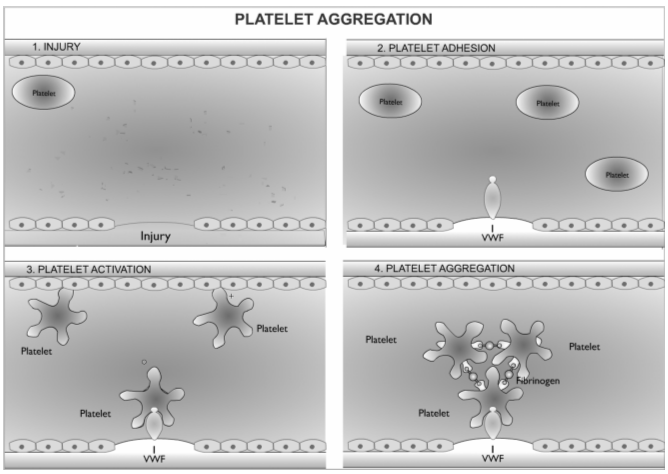


Fig. 3. Platelet Aggregation

*Animations that slow down the process*

Roshal (1961) had over 3,000 Navy recruits learn knot tying using a film that showed motion or a film that showed static images. Knots were tied more accurately when the recruits saw the film in slow motion. Lumsdaine, [13]

Fig. 3 is an illustration of the sequence of events that happen when a platelet comes in contact with an injured endothelium. The von Willebrand factor is a protein that first binds to the sub endothelium. It then grabs a platelet that is flowing in the blood and causes it to stick to the injured endothelium. This is called platelet adhesion. The platelet then changes shape by developing projections all over its surface. This is called activation of platelet. Fibrinogen molecules now bind these activated platelets. This is called Platelet aggregation. As this whole process happens within a fraction of a second it is almost impossible to comprehend the steps of this reaction unless the whole sequence is slowed down making it easy to understand.

*Animations that speed up the process*

Animations also help understand changes that take years to develop. By speeding up the process the changes that happen are clearer to understand. In Fig. 4 snap shots of the animation Hemarthrosis are shown. Hemophilia a congenital bleeding disorder. the body that involves the joints. These changes take several years to develop. In the animation the progressive deterioration of a knee joint is shown. On the top is a normal knee joint with the various structures labeled. In the bottom left are the early changes of hemarthrosis where most of the changes are confined to the synovium. In the bottom right is the late stages of hemarthrosis where the bone and cartilage are also involved and destroyed.

*C. Abstract Concepts*

Animations are useful is showing abstract concepts that are otherwise hard to comprehend. Fig. 5 is a snapshot from the animation “Optical illusion”. In it is depicted a checkerboard with dark and light color squares upon which is placed a mug. Within the checkerboard are 2 squares marked 1 & 2 both having the same color. The figure 2 with a mug, its shadow and a light bulb are on the top right. The figure 2 can be dragged. When this is dragged and the mugs are placed over each other, in the presence of the darker contrast the square 2 which was dark now appears white to the eye though in reality it is the same color. The visual system is not very good at being a physical light meter and this results in a visual illusion. Animations are also very useful in communicating chemical reactions that are not visible to eye. An example of this would be to animate a protein called von Willebrand factor. It is made up of several domains each of which has a specific function. Traditionally the domains have been represented as columns within the bar, each performing a different function. It is hard to imagine the different functions a bar could perform. An animation showing exactly what each domain does is much easier to understand.

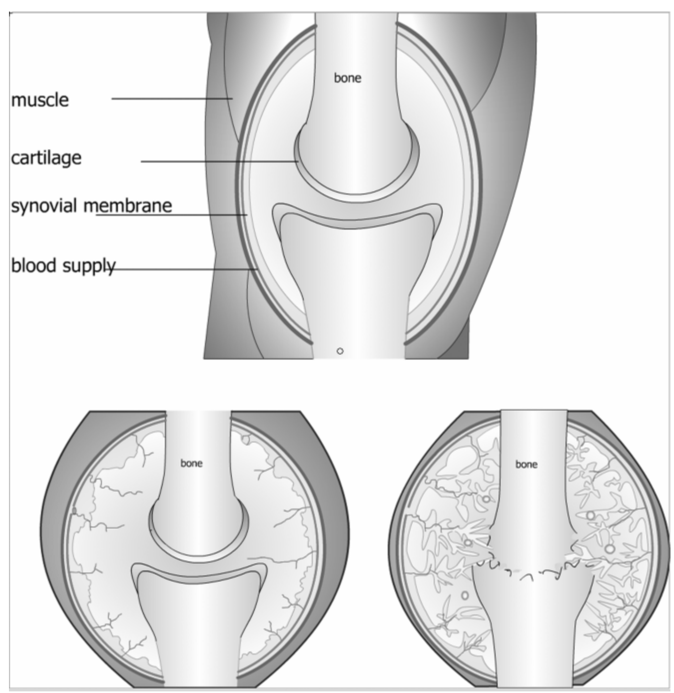


Fig. 4. Hemarthrosis

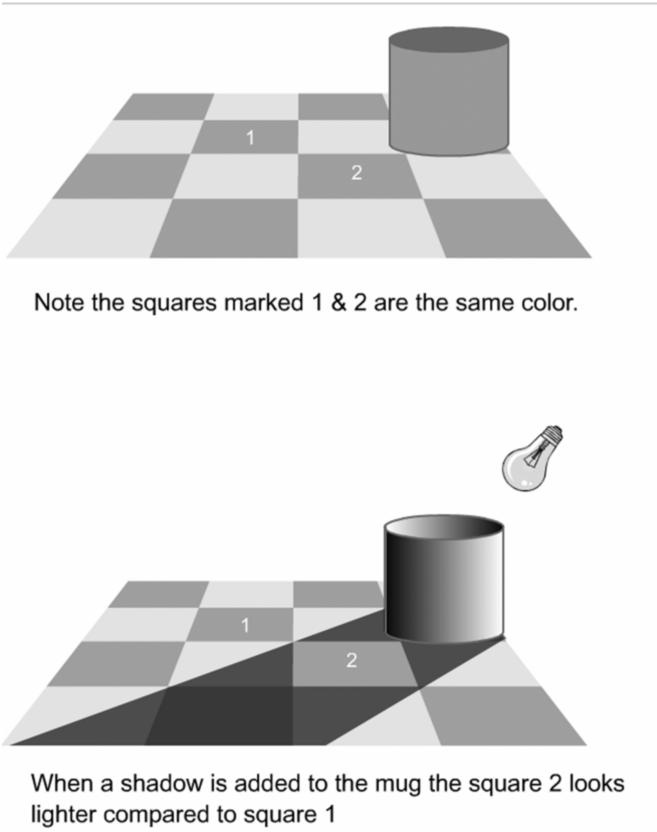


Fig. 5. Optical Illusion

## DEVELOPING

The next step is to develop the program by starting to work with the program designer. The process from now on is as tedious and time consuming as it is exciting. The following are the steps

### *A. Transfer of Information*

This is probably one of the most difficult but nonetheless an important step. Within a short period of time the physician should impart enough information to make the designer almost an expert in the subject he is about to animate. "GIGO—Garbage In, Garbage Out" a term that's been used ad nauseam by programmers however holds true in this case. The designer can only animate what he understands of the subject and it is this that he will ultimately bring alive as animation. One way to accomplish this is to give him first a general idea of the subject content and then a very in-depth discussion prior to every segment he is about to work on. An in-person meeting(s) is very helpful in conveying ideas and sharing the challenges.

A thorough discussion about, shapes, color, text that should be in the animation is essential. As the physician already had made enough research and categorized it, from the physician's point of view this should not be difficult. The designer would have other concerns about the symbols from the view of animation. Like the symbols may be obscured by the background, the relative size of the symbols may need to be changed, or the amount of text in the caption needs to change etc.

The physician should discuss if he needs to hyperlink text or symbols on the screen else where so the programmer may design these links.

Discussion about including self assessment questionnaire is appropriate if it has to be a part of the program.

The designer himself will often have other ideas of presenting the content. It is important that the physician understand that animation is as complicated as the content. The designers go through a great deal of effort to learn different ways and tricks in animation. He would now come up with ideas from the design point of view what would and what would not work. The aim of these discussions should be to come up with the best way to present the content.

### *B. Story Board*

Based on what these discussions the designer will come up with a rough sketch which he calls a story board. In this he will lay out a general plan and design about how the elements would look. This is a good time for the physician to carefully examine the story board and correct mistakes. Correcting mistakes once the animation has begun is a tedious process and hard to correct.

In Fig.6 2 examples are shown. In the top example the physician wants to show "Phagocytosis ". This is a process where cells in the body get rid of foreign material in the body by simply engulfing them. Once the explanations are understood by the designer he then proceeds to the first step called making a story board. In the story board he sketches some end points of animation. The designer may draw this in a paper instead of putting it on the computer as shown in the fig.6. If the physician is satisfied with the shape, color etc he can give approval to proceed with the animations. Now the designer will proceed with the animation.

In the bottom of Fig. 6 is another example of a platelet. The platelet upon activation will change its shape. The physician can present the pictures of a resting platelet and an activated platelet and request an animation where the resting platelet changes to the activated platelet. Not all animations can mimic the picture one hundred percent. The designer may convey that he can only do this when only 5 extensions of the defined shape for adding more extensions though more correct would give a smooth transition – In such cases an agreement has to be reached regarding these issues at this point.

This process goes on for every element and chapter of the content. At this stage the physician should be willing to spend some time to ensure that all the elements in the content are accurately represented. It is also the time to make sure the shape, detail, color , and background are represented properly.

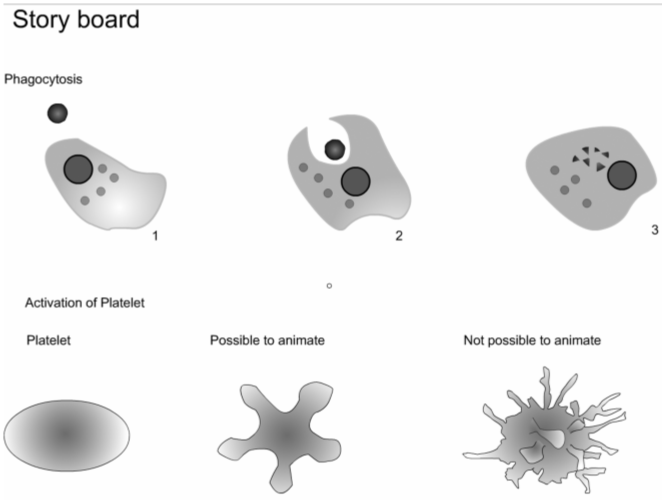


Fig. 6.  Story Board

*C.  Begin Animation*

Once everything is approved the designer will start making the animations. It is best that the physician monitor the progress frequently to make sure the animations are staying true to the content. This is a long process and may take several weeks. The designer can put the progress of the animations on the web and from this point onwards both can communicate with each other through the web or telephone.

*D.  Completion of animation*

Once the animations are completed the designer will get back with the physician for one final time to check and correct any inaccuracies.. By this time the designer would have added labels, caption etc. This is the final version of what the physician will see; it is crucial at this time to meticulously go through the entire animation and be satisfied with its content and depiction.

*E.  Adding Narrative*

If the physician intends for these animations to be used only as presentations then adding narrative is redundant. However if this is meant for distribution as a CD ROM or on the web the physician may want to add a narrative.

The narration should explain what exactly is happening in the animation, and preferably recorded in a studio.

*F.  Preparing files for Power point presentation.*

If the physician intends to present these animations in a power point then he should request the designer to give him the .swf files of the animation. The steps below show how to insert the .swf files into a power point presentation. In power point, go to view -> toolbars -> visual basic .Click on control toolbox button (hammer & wrench) .Click on more controls button (hammer & wrench) .Drag out place holder for "Shockwave Flash Object". Right click to bring up properties of animation.

Movie: enter full path of the movie file .Loop: set to false

Embedded movie: set to true. Otherwise you will have the endless nightmares of setting up the correct paths if you move the files to another machine (especially in situations like 5 minutes before the start of your presentation).If the physician still has doubts the designer can help him with this process.

## EVALUATION

The following studies were conducted at Michigan State University to evaluate the effectiveness of animations as a teaching tool (reference – PAS meeting and ASH abstract).

One hundred 2nd year medical students attending required didactic lecture on coagulation course were divided into two groups of 50 each.  One half of the students were randomly assigned to view animations on "How does blood clot"[14] , in addition to the lectures. Both groups of students were administered a pre and a post test consisting of 12 questions pertaining to the subject covered by both the animations as well as the didactic lectures. While the pretest score were similar in both groups, more students who viewed the animations had a perfect post test score as opposed to those who did not view the animations.

An evaluation of the animation by 36 second year medical students in 2004 suggested that a significant number considered the topic of coagulation complicated and felt that the animations were more appealing, easy and clear to understand and engaged their attention. Following the lecture with a PowerPoint presentation of the animations, a majority of the students accessed the animations on the web and utilized the mouse to stop the animations and predict the next step in the coagulation cascade.

Residents and 3rd year medical students: Responses were similar to the 2nd year medical students and indicated that the residents and students also felt that animations were more appealing than a straight lecture.

Health professionals and lay persons: The animations on coagulation[15] has been presented on numerous occasions to a diverse group of health professionals including surgeons, neurosurgeons, nurses, social workers, pharmaceutical representatives , laboratory personnel as well as to lay persons with bleeding and clotting disorders. Feedback from all these groups have been exceptionally positive and included a better understanding of the disease process, appeal of the animation and enhanced interest in the topic (reference PAS meeting workshop) .

## CONCLUSION

Medical animations, when truly relevant, can improve learning effectiveness and are highly effective teaching tools in the education of health care professionals. They can help direct the learner's attention to the most important information on a subject. They are an important adjunct to traditional learning through lectures and books. The physicians who have used medical animations in their presentations have found them to be very useful and felt that it was an outstanding training tool. Most of them quoted would love to see more of this type of learning tool

Developing computer assisted learning applications is a lengthy and skilled process. The few brave within traditional courses that have welcomed the concept have often produced innovative and high quality material to supplement their existing courses. But these individuals are in a minority; most academics will not become developers or supporters of computer assisted learning unless considerable time and resources are dedicated to supporting this activity.[16] Staff who are sent on "generic" workshops designed to improve their use of computer assisted learning technologies may complain afterwards that they still do not know where to start and feel that the time was not well spent.[17] As Reingold argues, "Fear is an important element in every novice computer user's first attempts to use a new machine or new software: fear of destroying data, fear of hurting the machine, fear of seeming stupid in comparison to others, or even to the machine itself.[18] It is the intention of this paper to take the fear of creating a animation based education program by making the role of the physician in this process clear.

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