# Significant learning of microbiology from visual teaching aids

# Aprendizaje significativo de microbiología con ayudas visuales para la enseñanza

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***Abstract***

*Many scientific subjects deal with phenomena that are not static, but highly motile and dynamic. Teaching students about them with only words or diagrams is limiting because, while a picture paints a thousand words, a movie paints many words per second. Communicating with your own movies allows magnified views of organisms or equipment and class discussion while action is paused. Movies may be specialized for your lesson plan rather than your lesson plan adapted to materials prepared for another school's situation. You may establish clip libraries and quickly produce yearly updates.*

***Key words****: visual aids, movies, microbiology, ecology.*

***Resumen***

*Muchos temas científicos tienen la base en los fenómenos que no son estáticos, sino dinámicos y altamente móviles. Enseñar a los estudiantes acerca de ellos sólo con palabras o diagramas es la limitación, ya que, al mismo tiempo una imagen vale más que mil palabras pinturas, una película de pinturas tiene muchas palabras por segundo. La comunicación con las propias películas magnificadas permite ver los organismos o los equipos y la discusión en clase, mientras que la acción se detiene. Las películas pueden ser especiales para el plan de la clase en lugar de su plan adaptado a los materiales preparados para la situación de la otra escuela. El maestro podrá crear bibliotecas de clips y producir rápidamente actualizaciones anuales de estos medios visuales.*

***Palabras clave:*** *ayudas visuales, películas, microbiología, ecología.*

## INTRODUCTION

For science teachers with a technical rather than educationalist background, communication of knowledge is sometimes the limiting factor for teaching. One of the popular classroom methods I use is composing MP4 movies to show concepts in cell biology and microbial ecology. At the beginning this was a difficult process for me, but I have found methods to make the process easier and would like to pass them on to colleagues.

Moving images are very valuable teaching tools (HUANG and ALOI, 1991) because biological systems are moving systems and have been popular since video cameras for the microscope became widely available (BAGGOT, 1996, BLISSETT and ATKINS, 1993). However, movies available *via* the internet are almost always very low resolution and contain rough edges that research scientists have not had the time to iron out (HARTLEY, 1994). This is because recording devices must be switched on before the brief event of interest happens, therefore most of an unedited movie clip must be uninteresting. Without using the methods described below teachers may struggle to hold student's interest by saying “this is the boring part” then “it will get interesting any second” which is an uphill battle that cannot be repeated often.

When teaching laboratory classes it is common to use single pieces of specialized equipment, even for classes of twenty or more students. This may lead to a scrum around the equipment during demonstrations where only a few students have a clear view. To solve this problem, short movies may be composed which give students a preliminary indication of laboratory activities, which is followed up by later individual tuition. Teachers may find their initial efforts to produce movies of resolution high enough to project in a lecture room difficult and appreciate the benefits of including their own voice over. The purpose of this paper is to show that high quality educational movies can be made with equipment that is often already in place and using software that has become commonly available, such as Windows Movie Maker (WIKIPEDIA, 2008a), or inexpensive such as PowerDirector (WIKIPEDIA, 2008b). Previous papers have mentioned video production (HARTLEY, 1994), but have not described the new technical devices that have made educational video production much more accessible to teachers. Recent reviews concentrate on simple cartoons (SIMSEK, 2009) or transient podcasting and blogging methods rather than production of high quality edited movies (KARLSSON and IVARSSON, 2007). This paper will concentrate on low budget or free methods, which may sometimes seem circuitous but are strongly oriented for maneuvering around budget barriers.

## METHODS

Early stages of movie making projects may not have a budget so it is important to take advantage of materials already present in a teaching department. Any camera that can take a movie may be used, for example the Panasonic DMC-FZ3 which is a camera primarily for still images but has a movie function. A relatively small 250Mbyte memory card is sufficient for creating small movie clips that can be pooled later. Music players for MP3 files with microphone attachment such as the Sansa M240 may also be used for voice over recording. An ordinary desktop computer and free Trial Version of PowerDirector can be used before committing to the purchase of software. The computer hard disk used had 37.2 gigabytes and it was possible to free 16 gigabytes for producing movies. Even so, it may be useful to keep a shuttle system of movie clips on CD for files to be added to the hard drive for editing and producing movies then deleted immediately, i.e. clip collections should be stored as CD only. A critical improvement to hardware can be made by purchasing a high capacity, but low cost external computer device. A suitable example is the Western Digital External Hard Drive (640 gigabytes) which increased the memory available to these projects by 4000%, but only incurred 5% of the cost of the internal memory (Megabyte for Megabyte).

The first stage of movie making is to have a clear idea of what the short movie will involve, such as the title and subheading of Figure 1. The method described is based on an abbreviated storyboard format where visual ideas are collected as word concepts or images and then associated with movie clips gathered to correspond to the visual concept. In other words an idea is first made to correspond to the collection of themes such at column 1 of Figure 1. Later each idea is more clearly defined as a group of images or clips such as column 2 of Figure 1. This method is also similar to the Top Down method of composing algorithms as a collection of tasks with increasing detail.

An important feature of this process is that while the author of the movie knows the message being transmitted, audiences sometimes do not and communication can fail to take place. This is why peer review is critical and asking colleagues to view your work during composition is essential. This can take place early, in the form of verbal presentations or circulation of storyboards (Figure 1), and later as movie file drafts.

The last stage of making a movie is Production or Rendering movie clips, stills, audio and effects into a single file. This can be a time consuming process depending on the length of the movie and the speed of your computer. Exporting will result in about 55Mbytes for a 10min movie in MPEG4 format. This size of file is difficult to circulate by email because of the restriction on attachment size defined by many email systems. However, it is possible to circulate large movie files using FTP or if this is not available, a free FTP equivalent (STF, 2008). If movie size is limited to under 100Mbyes and less than 10 minutes then the best method of circulation is to deposit the movie with a video sharing website such as YouTube or JumpCut. This allows circulation by emailing a few ASCII characters to define the address of your composition. Uploading to YouTube requires downloading some free software (Google, 2008) but is generally problem free.

Non-Major undergraduate students were instructed to download and view videos from the appropriate url (WITTY 2009b,d,f) when these were significant to the teaching plan. Assessment of learning from selected videos was conducted using the Pre-Test and Post-Test method of Hartley (1972, 1973). Students were given a ten question multiple choice test on the subject of each video before viewing, then the same test after approximately one week. Average test scores were calculated and differences between them assessed using the Student's T-Test (Student 1908).

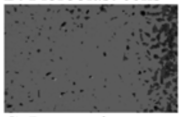
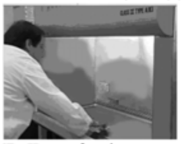
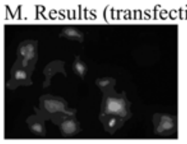
| 1. Themes | 2. Media File Names | 3. Voice Over | 4. Effects |
|---|---|---|---|
| A. Starting materials  | Still of incubator<br>P1010354_Micro<br>P1010355_Micro<br>P1010386_Cells<br>Stock solutions | "We started with layers of mammalian cells growing in 'chambered slides'" | Title caption |
| B. Fibroblast cells  | Starting material<br>DSCN0076<br>DSCN0079<br>DSCN0080<br>DSCN0081 | "These cells are nearly continuous" | |
| C. Preparation<br>D. Laminar flow hood  | P1010400_Swab | "Everything inside the hood should be swabbed with 70% ethanol to prevent contamination later" | |
| E. Transfection<br>F. Lipofectamine  | P1010383_Cationic<br>P1010384<br>P1010385_Cells | "Add ten microlitres of The Lipofectamine reagent to stimulate transfection and then mix well" | Flash symbol |
| | P1010403_Feed<br>P1010414_Phenol | | Flash symbol |
| G. Cultivation<br>H. Fluorescence Scope<br>I. Preparation  | P1010417_Slide | "The cells were grown in a container which can be split to form a microscope slide" | |
| J. Operation  | P1010421_Light<br>P1010419_Dark | "Use the column rod to switch between eyepiece and computer screen view" | |
| K. Software<br>L. Results (control)<br>M. Results (transfection) | P1010422_Soft | | |
|  | Non-transfected | "Shadows show the cytoplasm contains no GFP protein" | |
| | Transfected<br>Trans1-Trans18 | "Transfected cells are fluorescent"<br>"Note cytoplasmic projections which are a feature of fibroblasts" | Credits |

**Figure 1.** Storyboard Draft in Simplified Format.

**Figure 1.** An example of a storyboard for circulation to colleagues which shows how to use lipid complexes to transfect mammalian cells grown *in vitro*. The movie describes the concepts and activities of a laboratory class for undergraduates at Monmouth University. The class activity consists of growing mammalian cells in liquid medium contained in chambered microscope slides, transfection with a Green Fluorescent Protein gene and examining cells using a fluorescent microscope. This form of storyboard starts as a few words on a blank sheet of paper and grows as the project develops and features are defined more precisely. In particular, subthemes are captured in media clips (column two filenames) which are edited together to make a movie with a cohesive theme.

No specialized equipment is necessary for collecting media clips, though a tripod is invaluable because it reduces camera shake dramatically. Concepts were filmed repeatedly and later the best version was selected for incorporation into the movie. Using still images for important concepts is important because these can be collected at a higher resolution and will be scrutinized by students most closely.

While microphones are relatively inexpensive it is possible to use an MP3 player with a built in microphone. This was used for creating audio files of single words or phrases then copying to the desktop computer hard disk. Once again it should be a routine to record audio phrases repeatedly then selected the best version for incorporation into column 3 of the storyboard (Figure 1). The Audacity program can convert audio files between several formats (Wikipedia, 2008c). In addition to your own audio files, some online libraries of public domain audio effects may be helpful (e.g. SampleSwap, 2008).

As the clip and still collection for single projects increases it becomes possible to add to column 2 of the Story Board (Figure 1) and prepare a Microsoft Word document suitable for printing and circulation to colleagues. This allows for criticism of the project and for colleagues to indicate what concepts are missing or could be improved. Circulation of a storyboard is easier than circulation of a movie draft because colleagues may resist spending time loading, watching and criticizing your movie. However, they will be used to marking up a paper document – particularly a short, one page document.

When all the media for production of a draft movie have been composed, copy files from CD to a single hard disk folder. The first production drafts were made with a Trial Version of PowerDirector, though many bundles of programs for new computers include Windows Movie Maker as standard. After opening Power Director, movie clips and stills may be loaded with the simple keystroke 'Control Q' and then assembled as a timeline using the mouse. This displays a superimposed collection of movie clips, stills, captions and voice over that may be manipulated and reordered with ease (Figure 2). By examining the movie timeline, requirements for additional material may become apparent and repeated cycles of editing and addition of files can be done. Some movie effects can be incorporated at the storyboard stage, though most effects are added to the timeline, for example transitions between movie clips. Once a timeline is composed yearly updates for movies may also be carried out efficiently (Figure 3), which can dramatically increase the impact of visual aids for students.

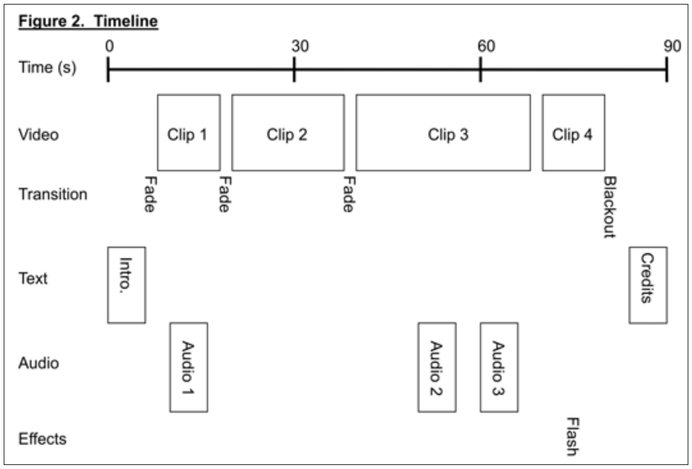



**Figure 2.** Timelines are created semi-automatically by movie software upon loading clips, and resemble this diagram. They may be edited to remove unwanted elements of video, add voice over, still images and subtitles.

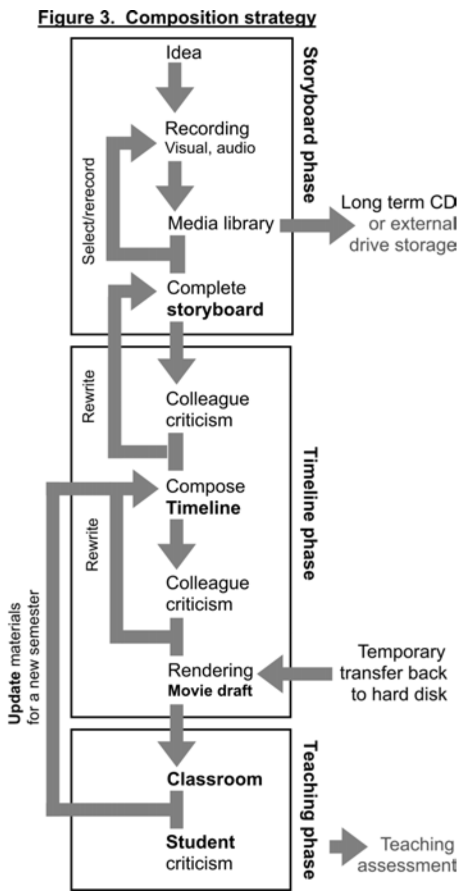



**Figure 3.** Overall strategy for movie composition showing the importance of colleague and student criticism.

## RESULTS

A large library of media clips and story boards was produced (Figure 1) that was adaptable to the class room and individual instruction. My own interest is microscopy to teach Microbial Ecology to undergraduates, which only requires one specialized piece of equipment i.e. the PupilCam (Kenavision, 2008). This is an economical video camera for use with a light microscope and is useful for composing movies which illustrate dynamic microscopic phenomena (Witty, 2008a-c, Witty, 2009a-f). Assessment using the Pre-Test and Post-Test method of Hartley (1972, 1973) has shown significant improvement in student learning from video recording in some cases (Figure 4, Witty, 2009b, Witty, 2009d) but has also identified some material which should be improved (Witty, 2009f).

| Subject | Oligochaete worms | | Protozoan behavior | | Spirochete bacteria | |
|---|---|---|---|---|---|---|
| Content | Anatomy of an oligochaete from soil, showing ingestion, peristalsis and egestion. | | Behavior of a stalked ciliate, showing feeding, response to stimuli and cytoplasmic streaming | | Motion of a spirochete field isolate and comparison to other soil microorganisms | |
| Citation | Witty 2009b | | Witty 2009d | | Witty 2009f | |
| | Pre-Test | Post-Test | Pre-Test | Post-Test | Pre-Test | Post-Test |
| n | 15 | 13 | 15 | 16 | 15 | 22 |
| Average | 2 | 4 | 3 | 5 | 4 | 4 |
| T-Test | 0.0286* | | 0.0064* | | 0.8928 | |

**Figure 4.** Teaching assessment for Non-Major undergraduates.

## DISCUSSION

Most conventional scientific methods produce data that is clear to scientists but not adequately understood by students, the public or even experts from other fields. Common and convenient scientific methods often produce dry results such as tabulated numbers or static images. This is unfortunate because nature is often most beautiful because of dynamic activities. Composing moving visual teaching aids is sometimes difficult and requires planning to produce a high quality result. The process is time consuming to produce a very short movie, and lengths << 5 minutes are recommended, but have great classroom impact and stimulate discussion. The process also requires a large amount of computer storage space and therefore some organization of limited resources i.e. a strategy similar to Figure 3.

## CONCLUSIONS

While organic chemistry is the study of carbon compounds, biology is the study of carbon compounds that can crawl (Adams, quoted in Mougios, 2006). The best way to show this is by using short movies because they record dynamic features. They are also useful for private study or individual tuition because they can be paused and critical sequences replayed by students wishing to study one point that they have personal difficulty following. A good *example* is Microbial Ecology, a subject taught with a microscope where usually only one student may see images of a field sample. This subject even requires the teacher to "take his eye off the ball" while turning the microscope over to a single student. This is more than enough time for a ciliate to swim out of the field of view. Making moving images of phenomena enables teachers to use examples that are otherwise impossible to present in the classroom (Witty, 2008a-c). It was gratifying to have positive feedback for some video material (Witty, 2009b, Witty, 2009d) but also useful to have negative feedback for Witty, 2009f. That is because this material can be improved by returning to the timeline phase of composition (Figure 3) and improving quality. Improved video material may be rendered and subjected to a new round of criticism and analysis.

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