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## THE USES OF VIDEO IN TEACHING STATISTICS

David S. Moore

*Department of Statistics*

*Purdue University, West Lafayette, IN 47907-1399, USA*

### 1. Introduction

Video, in the form of broadcast television, is the most popular medium for entertainment and news in the developed world. A television set is one of the first substantial purchases made by households in developing areas as their wealth increases. These phenomena testify to the power of video to hold attention, a power which can also be applied to formal teaching. Video can be used for teaching in several settings: learning at a distance for geographically scattered students, as a supplement in traditional classroom settings, and as a component of new technological learning systems. In each case, wise use of video requires an understanding of both the strengths and weaknesses of the medium. This paper will review these strengths and weaknesses, drawing both on practical experience and on cognitive research. We will then suggest appropriate uses of video for teaching statistics in the three settings just mentioned.

### 2. Strengths of video in teaching

One of the most obvious advantages of broadcast television is *reach*, the ability to convey information at a distance. The power of television compared with radio lies in the *visual* aspect of the information conveyed. It is here that the greatest advantages of video reside, advantages that are unrelated to geographic reach.

Most essentially, *video compresses time and space by making distant or past events present in visual form*. Students of statistics can visit clinical trials, government statistical offices, and factories to see and hear medical researchers, government officials, and quality engineers describe and apply statistical techniques. Direct viewing replaces the attempt to imagine a setting described by the instructor. Video compresses time and space in other ways as well. Slow motion and time-lapse photography expand the scale of time over which phenomena are visible to us, and views recorded from microscopes and telescopes expand the scale of space that is

accessible. Students can observe the growth of crops or tumors (time lapse), the etching of semiconductor chips (microscopy), and interviews with sample survey participants. Applications of statistics become both more understandable and more interesting.

Even without these explicit extensions of scale, carefully edited video material compresses space and time: we move quickly from place to place and across time to concentrate on essential aspects of the phenomena presented. We can observe in quick succession the planning of a sample survey, the training of interviewers, excerpts from interviews with respondents, followup, data coding and analysis, and presentation of the results. For clear, concentrated presentation of a message, video is often more effective than personally viewing the phenomenon. From the early days of film this power has been used to persuade, both for propaganda and for advertising. We can also use it to instruct.

A second strength of video is the ability to present *dynamic graphics*. Movement and color enhance the effectiveness of many data graphics. Contemporary computer graphics recognizes this, but even traditional graphs are often easier for students to grasp when presented dynamically with narrative comment on each feature. Consider Minard's now-classic graph of the fate of Napoleon's army in the Russian campaign of 1812 and 1813 (Tufte, 1983, p. 41). This may be, as Tufte says, "the best statistical graphic ever drawn", but it records six variables and requires very careful study to understand. A dynamic version that unfolds the campaign month by month, ending with Minard's static graphic, is much easier to follow.

Video offers to statistics teaching standard graphics of a quality beyond the level (for now) of most student computer systems. More important in the long run, video can present custom graphics such as a dynamic version of Minard's classic. Some statistical concepts, such as sampling distributions, are inherently dynamic: "How does this statistic behave in many repeated samples?" A custom dynamic graphic that represents the drawing of repeated samples and pictorially builds up the sampling distribution is a natural teaching tool.

Finally, we must note the subliminal effects of video as well as its more obvious advantages. *Video communicates more through feelings and emotions than through linear, rational thought*. This fact, suspected by many critics of the cultural effects of television, is substantiated by psychological studies (Howe, 1983). Video changes attitudes more effectively than it conveys detailed information. Awareness of this aspect of video is essential to informed use of video in teaching. We show video clips of statistical applications not merely to set the stage for exposition of statistical methods, but to change students' attitudes towards statistics.

### 3. Weaknesses of video in teaching

Video as a tool for teaching has striking strengths, but also some striking weaknesses. First, it is *very expensive to produce*. The real-world applications, shot on location and carefully edited, that are video's most valuable contribution to statistics teaching, are particularly expensive. Production costs for U.S. commercial television exceed \$ 500,000 per half-hour program, and many fast action spectacular advertising spots cost that much for 30 seconds. "Talking heads" are much less expensive, but take little advantage of video's greatest strengths.

Technological progress will bring down the cost of video to some extent. Video is now an analog medium, so that editing is similar to frame-by-frame editing of film and transferring computer-generated graphics to video requires special equipment. Video will soon be digitized, so that editing and graphics will be both faster and cheaper. However, location shooting will still require sending camera crews and their equipment to the action. This will always be expensive.

Also, *video is unsuited for detailed explanations and carefully worked examples*. The expense and rapid pace of video, as well as its multichannel nature, make these staples of teaching more suitable for text presentation. It is of course possible, and in some cases even desirable, to simply present a teacher teaching. But a talking head takes little advantage of video's specific strengths. Note that presentation of real-world applications is not an exception to the principle that video is unsuited for detailed explanations. Students who approach video applications as if they were text-style expositions become frustrated: they can't take notes because the presentation moves quickly and has several simultaneous levels which they cannot satisfactorily reduce to a single linear track. Video *shows* rather than tells. It is not an ideal vehicle for exposition.

Most important, *video in its current forms leaves its viewers passive*. They are simply spectators, not actively engaged in their own learning. The passive nature of video viewing is no doubt closely connected with its effects on emotions and attitudes. Current thinking about education emphasizes that students must be actively engaged in their learning, that passive reception of a message from even a live teacher has little effect (Garfield, 1993). Video may change attitudes, but without interaction it is unlikely to be effective in helping students understand concepts, make judgments, and apply skills to complex problems.

#### 4. Video for distant learning

The reach of television makes it attractive for distant learning. The spread of video recorders (now present in over 70% of U.S. households, for example) aids distant learning by freeing the student from the broadcast hour and allowing repeated viewing. The visual aspects of television are essential for disciplines like statistics; radio does not broadcast equations effectively.

Distant learning has obvious disadvantages compared with contact with a live teacher. It is therefore most successful in specific circumstances. A relatively closed or expensive higher education system leaves unfilled demand that distant learning can satisfy. The somewhat closed nature of the older British university system is often cited as a reason for the initial success of the Open University. Geographical distance in areas that are either thinly populated or have few institutions of higher education can create demand for distant learning, as in the case of Open Learning Australia. Specialized training for already-employed students lies behind the widespread televising of post-graduate engineering courses in the U.S., most notably by the National Technological University. In all cases, students are most attracted when distant learning leads to a valued educational credential.

Advanced students will tolerate the talking heads of experts in specialized technical subjects, and have learned to interact with lectures on their own, guided only by problem assignments. Distant learning for advanced students is a setting in which the reach of television cancels its many weaknesses. In general, distant learning requires motivation and maturity on the part of students in order to compensate for reduced interaction with teachers. It is therefore most effective for older or more advanced students. The Open University generally requires students to be at least 21 years old.

Effective distant learning programs understand the weaknesses of video. Video is only a part, and often not the most important part, of a full program. Text material is essential, as is some arrangement for interaction with students via mail, telephone, or modem. Anthony Bates (Bates, 1983) notes that the Open University, a pioneer in distant learning, has gradually reduced the role of video both because of its expense and because of a growing understanding of the best uses of video. His essay is a most valuable account of the lessons of practical experience with distant learning. While distant learning can be effective, and is essential in special circumstances, it is generally "second best" when compared with live instruction.

## 5. Video in the classroom

All agree, for reasons outlined in discussing the weaknesses of video, that *video is not suitable as the sole medium of instruction*. On the other hand, the strengths of video are impressive. What is more, there is evidence that different people learn best via different media, and that video is particularly effective for people with high visual ability (Pezdek *et al.*, 1987). There are therefore strong arguments for including some video in a mixture of media for instruction.

The first principle for effective classroom use of video is obvious: *take advantage of video's strengths and avoid its weaknesses*. Video in the classroom ought not to be considered as a substitute for the teacher. In particular, basic exposition is best done by text and teachers, not by video. Short video excerpts consisting of dynamic graphics or of short documentaries describing statistical applications are very helpful. Documentary segments can motivate a new statistical topic. They can also provide a problem setting which we ask students to discuss with an eye to applying the statistical tools they are learning. I elsewhere (Moore, 1993) offer some specific examples of effective uses of excerpts from the U.S. Corporation for Public Broadcasting telecourse *Against All Odds: Inside Statistics*.

Teachers should remember the great effectiveness of video in changing attitudes. Regular showing of short documentaries illustrating statistical applications is justified by its effects on students' attitude toward statistics quite aside from any specific pedagogical purpose served by each individual excerpt. We need not inquire too closely about the specific technical content conveyed by a five minute visit to a clinical trial. It is enough to know that weekly viewing of such segments persuades students that statistics is useful and important much more convincingly than simply telling them that this is so.

A second principle for classroom video use is to *create interaction*. Ask students to discuss what they have seen. If the video segment is more than a few minutes long, stop the tape to ask questions, especially questions that force students to anticipate what comes next in the video. The teacher can compensate for the most serious weakness of video, the passive role in which it places students.

## 6. The future of video: multimedia tools for teaching

One clear conclusion from both research and experience in educational uses of video is that video is most effective in combination with other

media. We can then tailor the use of video to take advantage of its strengths while the other media compensate for its weaknesses. Video has, I have argued, a potentially valuable role in combination with a printed text and interaction with a teacher. Now, however, new technology allows video to be integrated with text, sound, animated graphics, cartoon-style animation, and computing in an individual student workstation. This is a *multimedia* system. The student interacts with the system via keyboard, mouse, and perhaps voice. Advocates argue (not for the first time) that technology will at last supplant live teachers for much instruction. Ambron and Hooper (1990), Grabinger *et al.* (1990), and Steinberg (1991) discuss various aspects of multimedia technology and its use in education.

At the heart of multimedia is the fact that video, now largely analog, can be digitized. There is then no strong distinction between video and computing. Software can compress and store video images and play them in a window on the computer screen. Compression algorithms and storage technologies are important: full-motion video requires 30 frames per second, each frame a full picture's worth of bits. Current multimedia systems store video, still images, text, and software together on a compact disc similar to those used for music. A single CD can hold (in one current system) 650,000 pages of text, five hours of FM stereo sound, one hour of full-screen full-motion video, four hours of quarter-screen full-motion video, or any combination of these.

Multimedia has two clear strengths for education. The first is often called *hypermedia*: rather than a single linear track as in a book or movie, hypermedia offers multiple interconnected paths manipulated by the learner. The screen usually contains several windows, which can present different kinds of information or activities. Students can choose among several levels of exposition, can review a concept by clicking on a keyword, can go at any time to a window in which a statistical software package is operating.

Multimedia's second strength is that it expects *interaction* by the learner. The hypermedia idea requires choice, not simply reading on in a text. In particular, students can manipulate and interact with video rather than merely view it. For example, the learner can choose slow motion, or can freeze a frame and make measurements from the video to produce data for analysis. (Unlike tape, a CD does not wear when a frame is frozen). Text in another window can guide the viewing and interaction by questions or instructions. The data can be entered into a statistical software package (also in a window) for analysis.

Multimedia systems do what is needed to make video at least minimally effective for teaching: combine it with other media and require interaction. The technology does to some extent what a teacher should do

when using video. Of course, it isn't easy to simulate a good teacher. The design of effective multimedia systems for teaching a subject like statistics presents many challenges. Some of the most impressive examples of multimedia instruction allow students to "explore a world". The learner can, for example, browse in an art gallery (represented on the screen) and click on any work presented to learn more about the era, the artist, or the specific work. Browsing and exploring are probably not sufficiently structured for beginning instruction in statistics. The many choices offered by hypermedia can overwhelm beginners, so that controlling complexity and finding a balance between learner choice and imposed structure are essential and difficult tasks.

Although multimedia technology requires interaction by the learner and thus attacks the most serious weakness of video instruction, it is not at all clear that the available interaction is sufficient for effective learning of higher-order skills such as solving multi-step, vaguely-posed problems and communicating the results. The computer finds it difficult to ask or answer "What do you mean?" "Why do you say that?" "Can you tell me more about the purpose of the study?" Yet such dialog is common in conversations between statisticians and clients and between good students and good teachers. Conceptual learning may still require conversation with a human teacher. Group problem-solving and clear communication of findings – essential in statistical practice and central to reform of statistics teaching – also require interaction with other people.

## 7. Conclusion

Video is a technology of great persuasive power that has a definite place in teaching at all levels. The reach of television is important in distant learning, and the impact of video is valuable both in traditional classrooms and as part of multimedia systems. New technology that incorporates video is a yet more powerful tool, which we should develop and employ with enthusiasm. But it is likely that, like video, newer technologies will not entirely replace human teachers. Just as video has strengths and weaknesses, we teachers have more-effective and less effective roles. Careful thinking about teaching will increasingly ask what roles each component – including the human teacher – can best play. In this paper I have tried to say what is the proper place of video. Similar information is available or being discovered for animation, computing (e.g., Biehler, 1993), sound, and text. We ought to aim to replace human efforts with technology where technology is effective, and to reserve valuable human time for roles that humans do best.

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