Looking at Display Technologies

A projection system in a classroom with an Internet connection provides a window on the world. Until recently, projectors were expensive and difficult to maintain. Technological advances have resulted in solid-state projectors that require little maintenance and cost no more than a computer.

Adding a second or third computer to a classroom allows a few more students access. Addition of a projection system allows the entire class to view the screen. Now that effective classroom projectors cost less than $1,000, it may be time to consider equipping your classroom with one. Background information on the characteristics of the different projection technologies may be helpful as you consider selecting one.

Moving to Solid State Technology

The first generation of computer projection systems employed cathode ray tubes (CRTs). This analog technology is based on the same principle as a television. A CRT projector works in much the same way as a television or computer monitor except that the front of the screen is transparent. A lens allows a beam of light to be focused and projected on a screen at the front of the room. CRT projectors are expensive, bulky, and require periodic maintenance. These characteristics made widespread deployment in classrooms impractical.

Current classroom projectors employ either liquid crystal display (LCD) or digital light projection (DLP) technology. Each of these solid state technologies has its own characteristics.

Liquid Crystal Displays

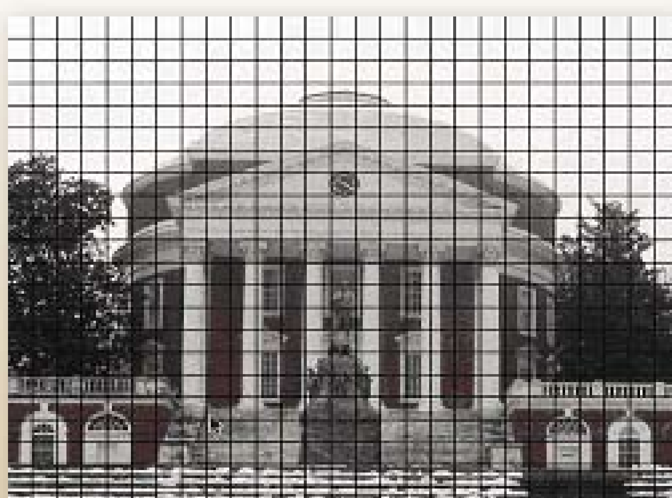
LCD technology was first used in calculators and watches. A liquid crystal cell consists of a polarized sandwich of glass and liquid crystals. The first versions used LCD segments on a chip that could be activated to produce a numeric display.

As the cost of the technology decreased, it became feasible to fabricate panels of minute LCD crystals that could be used to create rows and columns of picture elements (pixels). Each cell can be turned on and off individually to form a picture. In the case of a computer monitor with a 1024 × 768 resolution a total of 786,432 cells are required to form a grid on the face of the screen.

LCD panels are lighter and thinner than bulkier CRT tubes. LCD screens made laptop computers practical and are now beginning to replace CRT monitors in many desktop computers. In addition, because pixels can be turned on and off individually, the need to periodically refresh the screen is eliminated, creating a flicker-free display.

An LCD projector works by shining a bright light through the LCD panel. LCD projectors are quite practical for school settings. They are small—typically about the size of a lunchbox, affordable, and equally important, quite bright. Some models

A seven-segment LCD numeric display.



LCD crystals are arranged in columns and rows to create a display.

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can be used with the room lights on, a significant advantage in a classroom environment.

Digital Light Projectors

The most recent projection technology, DLP, is based on a digital micro-mirror optical semiconductor chip. This technology was invented in the Texas Instruments research laboratories. A DLP chip contains more than a million micro-mirrors, each measuring less than one-fifth the width of a human hair. A hinge in each mirror allows it to be tilted toward or away from a light source. Electrodes beneath each mirror control the tilt of the mirror, reflecting light onto a lens.

Light passes through a spinning color wheel with red, green, and blue segments to create colors. A purple pixel is formed, for example, by directing the lens toward the light when it is passing through the red and blue color segments. The idea of a million tiny mirrors individually controlled and tilted sounds like the stuff of science fiction. However, the technology is very real, and it represents an advance in projection technology.

Many DLP projectors are even smaller and lighter than LCD projectors, often weighing only two or three pounds in the more compact models. This makes it feasible to combine a portable unit with a laptop computer for a portable display system that can easily be moved among classrooms.

Strengths and Limitations

LCD and DLP projectors are available in similar price ranges. Each has its own strengths and limitations. Some characteristics are primarily of interest to videophiles who wish to build home theater systems, and others affect classroom use.

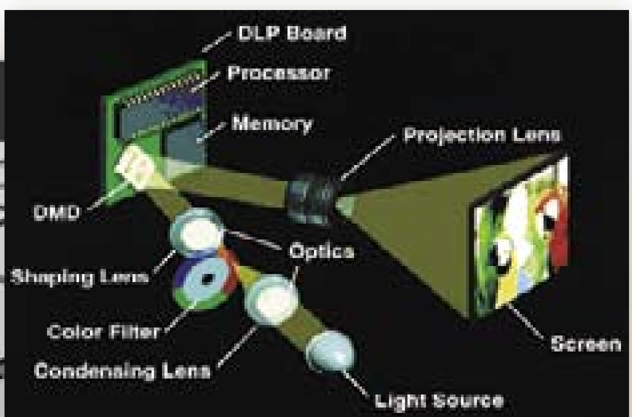
LCD cells have a small space between each cell that can be visible when the screen is viewed at a close distance. This phenomenon is known as the screen door effect because it may be compared to the effect of viewing a landscape through a screen door. LCD projectors also have limitations in black levels and contrast levels achieved for viewing of movies.

A weakness of first-generation DLP projectors is related to artifacts generated by the spinning color wheel known as the rainbow effect. A small percentage of the population can see this artifact. In some cases, associated eyestrain and headaches have been reported. Currently there is little research on the potential effect on students viewing a DLP projector in a school setting, but it is an area that deserves consideration. Experts assert that the rainbow effect can cause affected students to lose attention, obviously not a positive situation.

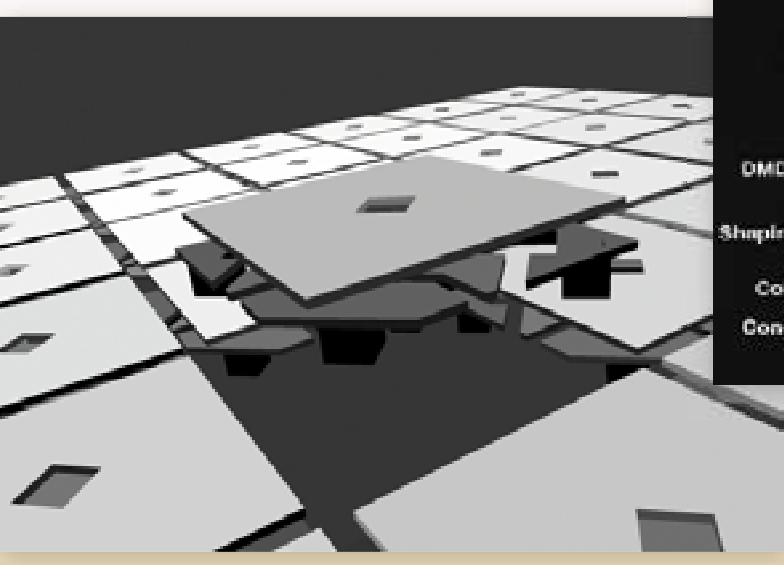
In the second generation of DLP projectors, the speed at which the color wheel is spun was doubled. Later generations also double the number of color segments from three to six, effectively doubling the rate again. Some DLP projectors now triple the rotation speed as well. These advances have reduced the percentage of individuals who are affected by the rainbow effect. Therefore, the more recent generations of DLP projectors with higher speed color wheels are recommended in preference to the earlier generations for school use. Teachers should also be aware of the potential side effects in the event that students in their classes are affected.

Resolution

Resolution, brightness, and loudness are three characteristics to consider in a classroom projector. The number of rows and columns of pixels is known as the *native resolution* of the projector. For example, a projector with SVGA resolution would have 800 × 600 pixels (i.e., 800 pixels across with 600 pixels in each



Micro-mirrors are tilted to reflect light through a lens to form an image projected onto a screen. (Image courtesy of Texas Instruments.)



Schematic depiction of a DLP micro-mirror. (Image courtesy of Texas Instruments.)

column), and a projector with XGA resolution would have 1024 × 768 pixels. In general, SVGA resolution is sufficient for PowerPoint presentations, charts, and graphs.

The clearest picture will be obtained when the native resolution of the projector is matched to the output of the graphics card of the computer. For example, a laptop with an SVGA graphics adapter will produce the clearest picture when matched to a projector with the same resolution.

Fortunately most projectors can scale an image that is not matched to the native resolution of the projector. The image will not be as crisp as one that matches the native resolution, but will still be viewable.

Lumens and Decibels

Brightness is measured in lumens. Lumens measured by a light meter are calibrated to a standard. You can't simply rely on published specifications because a projector can be adjusted in a variety of ways that affect its light output. Further, there are a variety of ways in which the light meter can be used, from a single measurement at the center of the screen to an average of several different measurements. Consequently, this measurement is just a rough guide that may still be useful as a starting point.

Factors that affect visibility include lumen rating, screen gain, image size, content, and ambient light at the screen. As a general guide, a projector with 2,000 lumens should be visible even in ambient light. A projector that is only capable of 1,000 lumens or less may benefit from dimming the room lights. Higher intensity projectors generate heat that must be dissipated with a fan. In general, the brighter the projector, the higher the heat and the greater the air flow required to dissipate the heat, which translates into more intense fan noise levels.

Sound levels are measured in decibels. The lower the decibel level is, the quieter the projector. However, as with lumen output, manufacturers take these measurements in a variety of ways. Even within a range of models by the same manufacturer, projectors that nominally have the same intensity may have different perceived loudness levels. The distribution of frequencies may affect this perception—a higher pitched frequency may be more distracting than a lower pitched noise.

No one enjoys trying to talk over the roar or whine of a projector fan for an entire school day. Therefore, other things being equal, a quieter projector is better for classroom use. A projector with a fan noise that is lower than 30 decibels will generally be whisper quiet. A fan that produces higher levels of noise may be intrusive, depending on a number of factors such as background noise in the classroom and how close listeners are sitting to the projector.

Projector Placement

Projectors vary markedly in flexibility of placement. In the case of a projector that is permanently mounted on the ceiling, this may not be an important consideration. However, it may be a significant issue for a projector that is placed on a cart in the middle of the classroom. Two dimensions of interest are distance from the screen, and the capability for off-center placement with respect to the screen.

When a projector is not centered on the screen, the image may appear to be trapezoidal rather than rectangular. This effect is known as *keystoning*. Some projectors have a physical lens shift capability that allows the projector to be offset from the center of the screen while still maintaining a rectangular image. This feature adds flexibility but also increases cost and complexity. Digital keystone correction has been incorporated into some

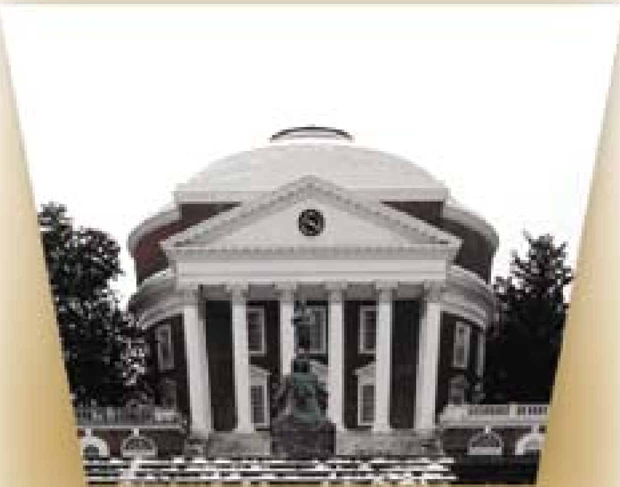


Image with keystone error.

models, achieving the same effect electronically.

The geometry of the lens and the zoom ratio affect distance from the screen. Projectors with a short-throw lens are designed to be placed closer to the screen, and projectors with a long-throw lens are designed to be placed further away. A zoom lens allows a projector to be positioned within a range of distances for a given image size. For example, a projector with a 2× zoom ratio could potentially produce a 100" diagonal image within a range of 10–20 feet from the screen. Other things being equal, a larger zoom ratio allows greater flexibility in placement.

Projector Central (http://www.projectorcentral.com) provides a projection calculator that allows the throw distance to be determined for any given projector. A search feature also allows projectors with specified characteristics to be identified (e.g., all projectors with at least 1,000 lumens and no more than 35 decibels of noise).

Summary

The types of technological advances described have transformed the projection industry. Epson and Sony are among the leading producers of LCD panels used in many brands of projectors. Texas Instruments, of course, licenses DLP technologies. The developers of both technologies are making rapid advances that have led to performance and capabilities at prices that would have been inconceivable only a few years ago.

A new generation of LCD projectors is emerging with a dynamically configured iris that significantly enhances contrast and black levels. The projector detects the type of scene projected and adjusts the opening of the iris accordingly. Advances that reduce or eliminate the screen door effect are also emerging. New generations of wireless projectors are also emerging that allow the computer to be linked without a cable, allowing a laptop or tablet computer to be passed from student to student in the classroom.

The current generation of projectors has crossed the threshold of affordability and usability for classroom use. Because LCD and DLP technologies offer roughly equivalent capabilities, there is an incentive to continue to increase brightness and lower the price, leading to continuing price-performance advances. The consumer is the ultimate beneficiary of this technological arms race.

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