A History and Future of Stereoscopy in Education

Jared E. Bendis
jared.bendis@case.edu
Creative Director of New Media
http://www.case.edu/its/itac/nms/
Instructional Technology & Academic Computing
Case Western Reserve University

Introduction

As I started to research the uses of stereoscopic imagery in education I came across a book of reprinted articles about stereoscopy. The book cites three reasons for the importance of reprinting the articles, follows:

> (1) To show the utter absurdity of many wide-spread misconceptions, as, for instance, that stereoscopic photographs are of importance mainly as a means for amusement and entertainment rather than for education.
>
> (2) To give an example of intelligent appreciation of stereoscopic views as well as their possibilities to a person who does appreciate them.
>
> (3) To show, what few people know, - the correct way to use stereoscopic views.

Funnily enough those words were written in 1904 in the introduction to Oliver Wendell Holmes' The Stereoscope and Stereoscopic Photographs (p. 1-2). And while much has happened in the 100 years since, the point of this paper is very much the same.

The Origins

In 1932, Sir Charles Wheatstone started to investigate the basic principles involved in stereoscopic imagery and in 1938 presented his findings to the Royal Society of London. Wheatstone's invention, however, was a laboratory instrument used to view geometric drawings (Booth-Clibborn p. 43-44). One year later, in 1939, Daguerre presented the world with the Daguerreotype, and, while Wheatstone thought of using it for his stereoscope, the mirror of the stereoscope and the silver surfaces of the Daguerreotype proved incompatible (Dalzell p.22). To solve this problem, Sir David Brewster invented a closed-box stereoscope that used prisms instead of mirrors. Brewster presented his findings in 1844 at the Royal Scottish Society (Ogram p.54). With the advance of photographic 'print' came the hand-held Holmes stereoscope invented by Oliver Wendell Holmes in 1859 (Darrah, World of Stereographs p. 2). It is interesting to note that Wheatstone, Brewester, and Holmes did not patent their inventions (Darrah p.2-3, Wing 6).

The basic principle in creating stereoscopic views is simple – two images are photographed representing the view seen by each eye. Using a single camera an image is taken; the camera is then moved a few inches and then another image taken (Dyckman p. 9). Homebrew stereoscopic cameras were created pre-1850 and, by 1854, stereoscopic cameras were commercially available (Darrah, World of Stereographs p.3).

The popularity of stereoscopic images during the 1850s is staggering. In the first two years of production, the London Stereoscopic Company sold more than 500,000 Brewster Stereoscopes, and by 1858 over 100,000 images were available for purchase (Darrah, World of Stereographs p.3-4).

The psychological (and educational) impact of these images did not go unnoticed. Dr. Holmes observes that:

> By means of these two different views of an object, the mind, as it were, feels round it and get in idea of solidity, We clasp an object with our eyes as with our arms, or with our hands, or with our thumb and finger, and then we know it to be something more than a surface. (Holmes p. 17)

Stereoscopic views are "a marvel of realism" and are "the best substitute for an actual visit" (Holmes p. 71). In 1897,the booklet The Land of the Pharaohs through the Perfescope describing a series of One hundred original stereoscopic photographs, describes the images as "felt, not as in a painting, but as in fact and substance. The effect […] is almost reality" (Underwood p.1).

In 1870 Hurst and Son of Albany New York produced the "Hurst & Son Natural History Series of birds and mammals for use in schools." The set contained primarily images of animals of the United States (Darrah, World of Stereographs p.156). In 1899 T.C. Porter published his Impressions of America which he illustrated with stereoscopic views. The author points out that at that time he could only find one other book with stereoscopic views in it (Porter xvii). But the Underwood & Keystone companies are really the first to bring stereoscopic views to education

Underwood & Keystone

Stereoscopic photography has had waves of success and decline. In 1896 in the preface to The Elements of Stereoscopic Photography, the author shares that "The many attempts made during the last few years to revive the interest formerly taken in stereoscopic photography and the stereoscope, are at last beginning to bear some result" (Rothwell p. 5). The biggest reason for the turn of the century 'revival' of stereo photography would be the Underwood & Underwood Company. Underwood & Underwood worked differently than other stereo view companies. They sold boxed sets (100+ views), sets with descriptive guidebooks. They developed an extensive library of images, and targeted their subjects specifically to primary and

secondary schools. And probably most importantly they had an aggressive door-to-door sales force; by 1901 Underwood & Underwood was selling more than 7,000,000 views and 300,000 stereoscopes a year (Darrah, Stereo Views p. 109-110). Underwood diversified and in 1912 sold their stereo negatives to the Keystone View Company, the other large door-to-door stereoscopic view company. By 1935 Keystone had accumulated more than 2,000,000 negatives dating back to 1860 (Darrah, Stereo Views p. 113).

In 1922 (originally published in 1906) the Keystone View Company published the "Keystone 600" a series of stereo views "specifically selected to meet school needs and with cross reference classifications to make quickly available the teaching content of the set" (Keystone p. iii). The set was edited by 62 educators and broken into the general topics of Geography, History & Civics, English, Agriculture, Nature Study, Vocational Guidance, Domestic Science & Arts, Industrial Arts, Health, Fine Arts, For The Little Folks, and Travelogues (Keystone p. iv-vi). The accompanying Teacher's Guide is full of useful information on how to find and incorporate the stereo views into the curriculum. The following excerpt from the Teacher's Guide emphasizes Keystone's belief in and commitment to the value of stereo images in education:

> Because the stereographs give a third dimension or depth to a scene, they give a semblance of reality as to produce in the child's mind the same reaction that would follow the actual sight of the thing photographed. To all intents and purposes he is looking at the real scene. If stereographs could do no more than correct and make definite the ideas gained from reading, their position would be secure; but they serve a far greater purpose. The stereographs seen through the stereoscope give a real visual experience and, therefore, constantly add new ideas of a definitely related character. Nothing is isolated. They show views of object related in time and space their permanency permits the child to see the same things over and over in the same relations. They also show details. The stereoscope shuts of the immediate surroundings and provides a complete new environment. For these reasons the stereograph is a powerful stimulant to thought. (Keystone p. xvi)

Both Keystone & Underwood understood that stereoscopic images to be effective had to be presented in a context, supported by supplemental instruction, and most importantly the images were not to be merely observed but studied in order to give the viewer an immersive experience. Stereoscopic imagery declined again in the 1920's probably because of movies, radio, and even the car (Darrah, Stereo Views p. v). The Keystone View Company finally closed its doors in 1976.

View-Master

At the New York and San Francisco World's Fairs in 1939, Sawyers introduced a new type of stereoscopic viewer: the View-Master. The View-Master uses reels of 7 stereo images instead of prints. The reels were compact, ease to organize, and most importantly offered full color views of the world. Sawyer created reels on a variety of topics. During World War II the Army and Navy saw the educational value of the View-Master and used it for training recruits to identify enemy ships and aircraft, to the tune of over 5,000,000 reels (van Keulen p. 15).

In addition to the entertainment and children's reels, set topics have ranged from travel and plants to architectural and historical images. The "Stereoscopic Atlas of Human Anatomy," started in 1948 and completed in 1962, consists of 221 View-Master Reels with 1,554 color stereo views of dissections. The project was created by David L. Bassett, M.D., who performed the dissections, and William B. Gruber, the inventor of the View-Master system, who did the stereo photography (Berezin).

View-Master has had a fun ride and has been bought and sold many times over the years. ViewMaster is now owned by Mattel and is marketed under the Fisher Price label. Over 1,000,000,000 reels have been produced since 1939 (ViewMaster).

The 1950s

The 1950s are known for 2 major innovations in the world of stereoscopic imagery: 3D Movies & Do-It-Yourself Stereoscopy. 3D movies existed long before the 1950s, and while there is little indication that there has been any educational or instructional value to these movies, the 1950s created the undesirable side-effect that I like to call The Creature from the Black Lagoon syndrome. Often when people are introduced to stereoscopic photography they make b-movie jokes about the 1950s and this, more than anything else, has detracted from the real value of the educational use of stereoscopic imagery. 3D cinema attempted to take a traditionally solo experience and turn it into a group one, and while the content may have been lacking, the presentation techniques are still used today. To project stereoscopic film (or slides or video) the images are projected through 2 projectors (or a special stereoscopic projector) with each side using a polarized filter – at 90 degrees from the other. Viewers wearing correspondingly polarized glasses only see the left image in the left eye and the right image in the right eye. The polarized images only work however if projected onto a silver screen (Ogram p. 101-110).

The other major innovation in the 1950s is the proliferation of stereoscopic cameras for home use. One of the most popular stereoscopic cameras was the Stereo Realist produced by the David White Company starting in 1947 (Morgan & Symmes p. 32; see also Ogram p.26-27). As well as a strong product, the David White Company had an intense marketing campaign: The Realist "simplified and publicized" stereoscopic imagery into a "modern color sensation" (Morgan & Symmes p. 33). In 1952, Stereocraft Engineering Company began producing the View-Master Personal cameras for Sawyer, thereby allowing home users to create their own View-Master reels (Morgan & Symmes p. 43; see also Ogram p. 32).

Stereoscopic cameras of this period are used to produce stereo 'slides' that are mounted and then viewed either in a handheld viewer or projected in the aforementioned process.

The Stereo Realist stopped being manufactured in 1971, but are still readily available to be purchased via collectors and other stereo cameras are still manufactured today.

The educational impact of this period is more indirect. During this period more of the techniques and systems that are in place

today were created. Also during this period was the formation of stereoscopic clubs that allow for stereoscopic knowledge dissemination; these clubs and associations have kept the torch burning.

Stereoscopy Today

Today the most prominent use of stereoscopic imaging in education is inside the world of Virtual Reality. While the term Virtual Reality is hard to define, the use of stereoscopic imagery within it is much easier to grasp. Virtual Reality breaks down into two parts; the creation of the stereoscopic imagery, and its display.

To create the stereoscopic imagery, VR systems require fast computers to generate the information for each view as well as the data to create those views (Iovine p. 4). Some systems use head tracking, which allows the view to change based on its angle and location; the computers must then update the images based on these changes (Wegman & Symanzik p. 171).

The simplest way to view the stereoscopic images in a VR environment is to use a Head Mounted Display (HMD) with a separate screen for each eye (Iovine p. 36). Video can be 'passively' projected using the polarized process or 'actively' viewed using LCD shutter glasses. The LCD shutter glasses alternately open and close each eye in sync with the display (or projector) so that each eye sees a different signal. For this to work the sync rate of the display or projector must be fast and constant (McAllister p. 9). Stereoscopic video is possible (and affordable) on regular TV screens but the slow refresh causes a prohibitive flicker and there is limited available content. It is regrettable that as the LCD shutter glasses technology becomes available and affordable for desktop computer use so has the prevalence of LCD displays, which are not compatible with the technology, over CRTs.

These VR environments are used to visualize and manipulate all types of datasets from abstract surfaces to medical imagery (Wegman & Symanzik p. 174); they can even be used for creative and artistic endeavors (Schkolne p. 371).

Outside of virtual reality, stereoscopic edutainment abounds. Anaglyphic children's books such as Les Chateaux Forts (Pommier) or The 3D Solar System Book (Brierley & Thomas) use stereoscopic imagery to create a fun and novel approach to their content but are rarely useful in a classroom setting. In the anaglyphic processed the left and right images are overlaid with the right image printed in red and the left image in cyan. The images are then viewed with red/cyan or red/blue glasses (Ogram p. 149). The process requires no special effort on the part of the manufacturer, just the inclusion of inexpensive red/blue glasses. Regretfully, anaglyph doesn't reproduce color very well (certain colors work better than others) and it is hard to gaze and study an anaglyph image in the way you can other formats.

One of the most interesting developments in edutainment is the development of IMAX 3D. IMAX 3D is a high quality large format stereoscopic movie. James Cameron's Ghosts of the Abyss takes the stereoscopic camera 2.5 miles underwater to film the wreck of the Titanic, while Space Station takes the stereoscopic camera 220 miles out into space onto the International Space Station (Moltenbrey p. 44, IMAX). In Ghosts of the Abyss "the experience is intensified by the visceral nature of the 3D technology" (Moltengrey p. 44). The IMAX 3D movies are intense, informative, and truly immersive experiences (and are as far from The Creature from the Black Lagoon syndrome as you can get).

Educational Uses

When educators decide to use media for teaching they go through one of three paths (in priority of frequency): discover, research, or creation.

Example of discovery: A teacher wants to use a video of physics demonstrations that she saw while watching PBS.

Example of research: A teacher decides he wants to use a video of physics demonstrations and researches to see what is available or useful for his class.

Example of creation: A teacher videotapes him or herself conducting physics experiments to use in class.

The problem with stereoscopic views is that the priority is reversed. A teacher deciding to use stereoscopic images in education may try to jump in and create her own stereoscopic images instead of researching what is available.

The easiest application of stereoscopic views is in studying history. In Iowa Stereographs, the authors use the images to contemplate "details of nineteenth-century life that may not have been recorded in any other manner" (Bennett & Juhl p. xiii). Archaeologists are taking a page out of the past and reviving archeological stereoscopy or "Victorian virtual reality" as a way of documenting their sites (Nicholson p. 402). When you think of the quantity (and quality) of people, places, and things already captured stereoscopically, the educational implications are enormous.

Outside of history, the number of fields that can benefit from stereoscopic imagery is vast. Medical science uses stereoscopic anatomy, stereoscopic microscopy, and stereoscopic radiography (Judge p. 176,192,209). Stereoscopic astronomy has images of the moon that date back to 1857 (Judge p. 194), while NASA captured stereoscopic images on the Mars Pathfinder Mission (Dennis p. 4). Students studying geography use stereoscopic LANDSAT imagery to view the details of the "size, shape, and spatial relationships of landforms and rock bodies" (Hamblin p. 1).

When studying geometry "nothing is more disconcerting to the student than a mass of intersecting lines, intended to represent planes with different inclinations" (Judge p. 170). More industrious students may try their hand at stereoscopic drawing (Girling, Sales) to create their own geometric representations. Chemists also benefit from stereoscopic drawings. "Geometry of a complex molecule is best understood by holding a three-dimensional ball-and-stick model in the hands. If such a model is not available, the next best thing is a stereoscopic drawing" (Bernal, Hamilton, & Ricci p. 1).

The list is endless, and you would be hard-pressed to find a field of study that could not only benefit from the use of stereoscopic

images but that hasn't at some point in the past already used them in education.

Stereo Viewing

As usability is a key factor in the use of stereoscopic images in education, the following is a quick summary of the ways to view stereoscopic images.

Slides
Stereoscopic slides (such as Realist or View-Master) can be viewed either in a hand viewer or projected onto a silver screen and viewed with polarized glasses (Ogram p. 58-60, 101-110).

Prints
Side by Side stereo prints can be viewed with a handheld viewer or 'free-viewed' with a trained eye (Ogram p. 60-61,47).

Over/Under stereo prints can be viewed with an over under periscopic mirror viewer (Ogram p. 62-63).

Mirror stereo prints (with one image 'flipped' horizontally) can then be viewed with a mirror (Ogram p. 52).

Anaglyphic prints (overlaid images with the right image printed in red and the left image in cyan) can be viewed with red/cyan glasses (Ogram p. 149).

Chromadepth prints (images where depth is represented by color) can be viewed with chromatic lenses (McAllister p. 185)

Lenticular prints (specially prepared images with an overlaid lenticular lens) can be viewed auto-stereoscopically (with no glasses or viewing apparatus) (Ogram p. 121-122).

Video
Video can be prepared and viewed in all the ways that prints can be viewed.

Video images can be viewed with a twin screened Head Mounted Display (Iovine p. 36).

Video can be 'passively' projected using twin polarized projectors, a silver screen, and polarized glasses.

Video can be 'actively' viewed using a fast refreshing display (or projector) and LCD shutter glasses (McAllister p. 9).

Conclusion

It is sad to think that the usefulness of stereoscopic imagery in education is probably less apparent than it was one hundred years ago. However, they keys to the success of stereoscopic imagery in education can be found in its past. To be successful the educator must have a wide selection of content that is well documented and easy to integrate into the curriculum. It must be easy not just to view but to study. While one theory suggests that movies and radio killed stereoscopic imagery it could equally be argued that movies and radio killed our powers of study and observation – skills worthy to achieve once again.

Perhaps we are waiting for the next big break. The Holmes stereoscope put viewers in ever home, Kodachrome allowed us to see in color, cameras allowed use to capture our own world, what will be the next big step? Maybe it is the un-tapped potential of stereoscopic video that will cause the next revival. Or maybe some large company will work with educators and like the "Keystone 600" issue a series of full color images for scholastic use using something like the View-Master. Or, given the interconnected world we live in, maybe a consortium of educators may band together to build their own on-line repository of free stereoscopic images for use in the classroom. Truly, only time will tell.

Works Cited

Bennett, Mary and Paul C. Juhl. Iowa Stereographs: Three Dimensional Visions of the
Past. Iowa City: University of Iowa Press, 1997.

Bernal, Ivan, Walter C. Hamilton, and John S. Ricci. Symmetry: A Stereoscopic Guide
for Chemists. San Francisco: W.H. Freeman and Co., 1972.

Berezin Stereo Photography Products. 15 November 2003. <http://www.berezin.com/3d/viewmast.htm>.

Brierley, Jane and Jeff Thomas. The 3D Solar System Book. New York: Barnes &
Noble Books, 2001.

Booth-Clibborn, Edward. Paris in 3D - From Stereoscopy to Virtual Reality 1850-2000.
London: Booth-Clibborn, 2000.

Boyer, Mildred. "The Stereoscope." The American Annual of Photography. 1946: 160-
166.

Darrah, William Culp. Stereo Views: A History of Stereographs in America and Their
Collection. Gettysburg, PA: Times and News Publishing Co., 1964.

Darrah, William Culp. The World of Stereographs. Nashville, TN: Land Yacht Press,
1997.

Dennis, John. "Driving Sojourners on Mars." Stereo World 25.1 (March/April 1988): 4.

Dyckman, Dan. Hidden Dimensions: Use Your Deep Vision to Solve Mazes, Riddles
and Other Perplexing Puzzles. New York: Harmony Books, 1994.

Girling, Arthur N. Stereoscopic Drawing : A Theory of 3-D Vision and Its Application to
Stereoscopic Drawing. London: Self-Published, 1990.

Hamblin, W. Kenneth. Atlas of Stereoscopic Aerial Photographs and Landsat Imagery of
North America. Minneapolis: Tasa Publishing Co., 1980.

Holmes, Oliver Wendell. The Stereoscope and Sterepscopic Photographs. New York:
Underwood & Underwood, 1906

Iovine, John. Step Into Virtual Reality. New York:
Windcrest/McGraw Hill, 1995.

Judge, Arthur W. Stereoscopic Photography – Its Application To Science, Industry And
Education. Boston, MA: American Photographic Publishing Co., 1928.

Keystone View Company, Educational Department. Visual Education, Teacher's Guide
to the Keystone "600 set." Meadville, PA: Keystone View Company, 1922.

IMAX 15 November 2003 <http://www.imax.com>.

The Land of the Pharaohs through the Perfescope – Describing a Series of One
Hundred Original Stereoscopic Photographs. New York: Underwood &
Underwood, 1897.

Louis, Alain and Maurice Pommier. Les Chateaux Forts. Paris: Hachette Jeunesse,
2001.

McAllister, David F., Ed. Stereo Computer Graphics and Other True 3D Technologies.
Princeton NJ: Princeton University Press, 1993.

Moltenbrey, Karen. "Atypical Stereo." Computer Graphics World July 2003: 44-48.

Morgan, Hal and Dan Symmes. Amazing 3D. Boston – Toronto: Little, Brown &
Company, 1982.

Nicholson, Paul T. "Three-Dimensional Imaging in Archeology: Its History and Future."
Antiquity 75.288 (2001): 402-409.

Nicyper, Raymond. Constructing Anaglyph Images (Anaglyptography) on Phantogram
Perspective Charts. West Covina, CA: Jerry Haines Sales, 1994.

Ogram, G.R. Magical Images – A Handbook of Stereo Photography. Stafford: UK: Self-
Published, 2001.

Porter, T.C. Impressions of America. London: C.A. Pearson, 1899.

Rothwell, Charles Frederick Seymour. The Elements of Stereoscopic Photography.
London: Percy Lund & Co.,1896.

Schkolne, Steven. "Drawing with the Hand in Free Space: Creating 3D Shapes with
Gesture in a Semi-Immersive Environment." Leonardo 35.4 (2002): 371-375.

van Keulen, Wim. 3D Past and Present. Borger, The Netherlands: 3D Book
Productions, 1986.

The ViewMaster Ultimate Reel List 15 November 2003 <http://ccwf.cc.utexas.edu/~number6/vm/>.

Wegman, Edward J. and Jurgen Symanzik. "Immersive Projection Technology for
Visual Data Mining." Journal of Computational and Graphical Statistics. 11.1 (2002): 163-188.

Wing, Paul. Stereoscopes: The First One Hundred Years. Nashua, NH: Transition
Publishing, 1996.