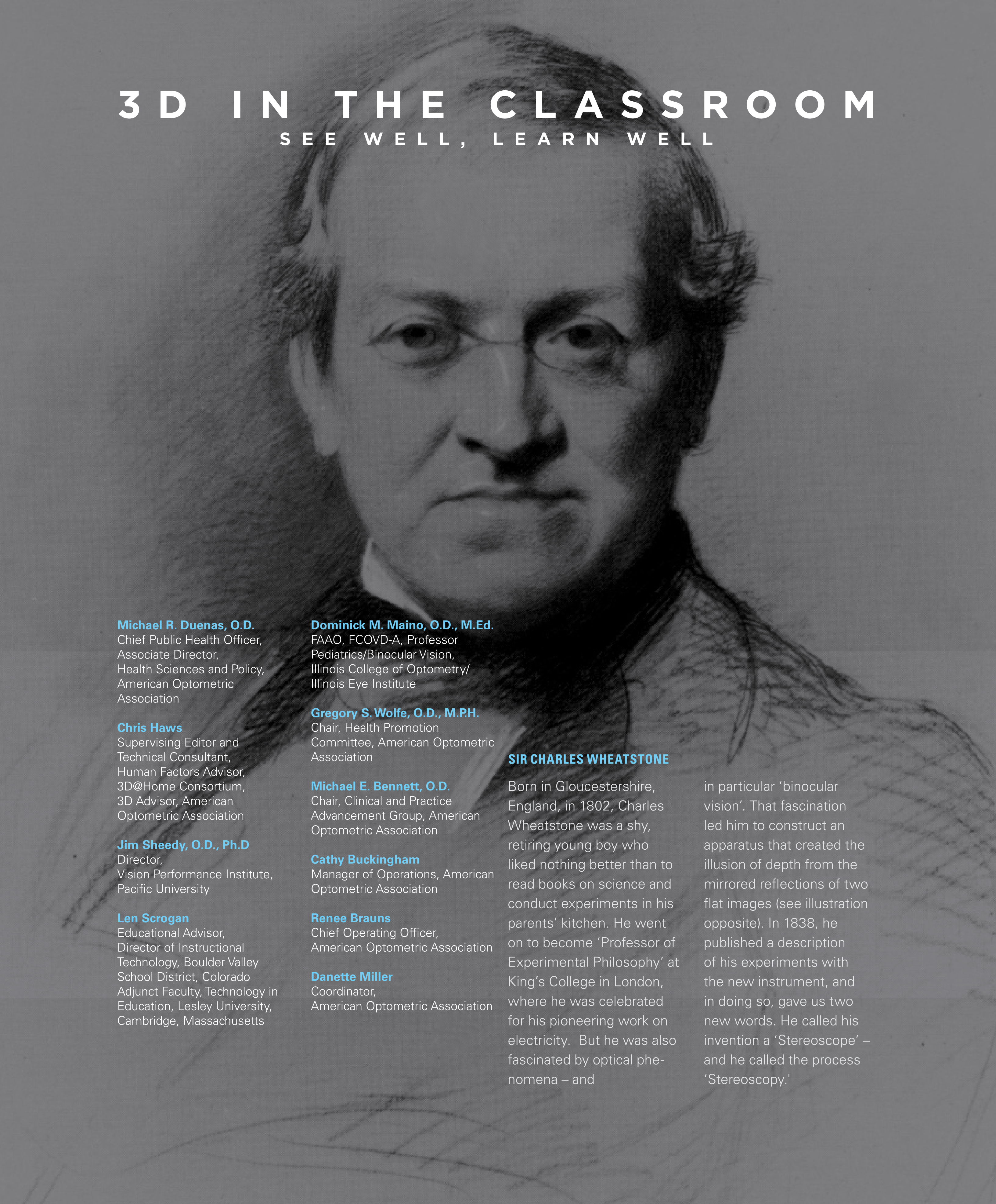
American Optometric Association

3D IN THE CLASSROOM

SEE WELL, LEARN WELL

PUBLIC HEALTH REPORT

www.3deyehealth.org



3D IN THE CLASSROOM

SEE WELL, LEARN WELL

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SIR CHARLES WHEATSTONE

Born in Gloucestershire, England, in 1802, Charles Wheatstone was a shy, retiring young boy who liked nothing better than to read books on science and conduct experiments in his parents' kitchen. He went on to become 'Professor of Experimental Philosophy' at King's College in London, where he was celebrated for his pioneering work on electricity. But he was also fascinated by optical phenomena – and in particular 'binocular vision'. That fascination led him to construct an apparatus that created the illusion of depth from the mirrored reflections of two flat images (see illustration opposite). In 1838, he published a description of his experiments with the new instrument, and in doing so, gave us two new words. He called his invention a 'Stereoscope' – and he called the process 'Stereoscopy.'

SIR CHARLES WHEATSTONE'S 'STEREOSCOPE,' 1838

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FOREWORD

" Most important, this report highlights essential conduits to learning and health that will ensure all students excel, not only in the 3D classroom, but in their general classroom activities as well."

LETTER FROM THE PRESIDENT

Discovering innovative solutions to teaching and assuring school readiness will ultimately determine our nation's ability to build a successful 21st-Century Education Model for America. Bold transformational approaches are now necessary.

As you will read in this first-of-its kind report; **3D in the Classroom, See Well Learn Well,** new 3D approaches to learning can serve as a fulcrum for enhanced teaching and improved assurance of school readiness. The report describes steps that can be taken to help guarantee 3D classroom opportunities that allow students to thrive and learn more efficiently in subjects ranging from mathematics to the sciences and the arts; better preparing them for life and advancing career challenges ahead.

These new 3D opportunities are underscored by two essential facts, 1) children often learn faster and retain more information in the 3D environment, and 2) the ability to perceive depth in a 3D presentation turns out to be a highly sensitive assessment tool, able to assess a range of vision health indicators with much higher sensitivity than the standard eye chart that has been in use for the last 150 years.

The good news is that for the estimated 1 in 4 children that have underlying issues with overall vision, 3D viewing can unmask previously undiagnosed deficiencies and help identify and even treat these problems. This is because 3D viewing requires that both eyes function in a coordinated manner, as they converge, focus and track the 3D image.

If deficiencies are identified the student can be directed to care consisting of a comprehensive eye exam and treatment with glasses and/or individualized rehabilitative vision therapy. As an added benefit, this course of action may also assist the child in most all reading and learning tasks. Overall, these 3D viewing potentials, tied to enhanced and protected vision, provide increased assurance that no child will be denied lifetime opportunities and an equal chance to succeed in school and later in life.

Sincerely,

Dori M. Carlson, OD

Dori Carlson, O.D.

President, American Optometric Association

American Optometric Association®

INTRODUCTION

3D IN THE CLASSROOM: SEE WELL, LEARN WELL

MOVIES

3D movies are captivating audiences around the world …

TELEVISION

Dedicated 3D TV channels are springing up on every continent …

MOBILE DEVICES

3D hand-held devices are offering viewers new and exciting experiences …

CLASSROOM

3D technology is enhancing the learning environment …

3D IMAGERY is becoming a commonplace **EXPERIENCE** for **EVERY** sector of our **COMMUNITY**

TO LEARN MORE, GO TO

www.3deyehealth.org

3D IN THE CLASSROOM

SOME OF THE BENEFITS

As new 3D display technologies become more sophisticated - while also becoming more affordable - and as new high-quality educational 3D products become increasingly available, **3D in the classroom is proving to be an exciting new tool in the educator's toolbox.**

Studies have shown that the educational benefits of presenting teaching materials in 3D are promising, **generating a significant improvement in comprehension and retention over the more traditional non-3D style of presentation.**

But as 3D technology enters the classroom – and elsewhere in our everyday experience – concerns have occasionally been expressed about the possible adverse effects of watching 3D, from headaches and eyestrain, to dizziness and nausea.

This public health report has been designed to address those concerns and correct some of the misapprehensions that have accompanied the emergence of this new technology.

Prepared under the close supervision of the American Optometric Association, in collaboration with leading educators and 3D technologists, this report will:

- explain the phenomenon of normal 3D vision and describe how it develops,
- explain why some individuals experience difficulty perceiving the stereo effect,
- describe the simple steps that can be taken to optimize the 3D viewing experience in the classroom and minimize any adverse reactions,
- outline how a viewer's reaction to 3D displays may be a sensitive and valuable indicator of underlying vision heath issues – issues that might otherwise have been missed, and that may be fully amenable to treatment by an optometrist.

So your exciting and effective new teaching tool may also be an important public health tool. One that could suggest the importance of having a professional eye examination – a step which could transform the lives of a number of your students who may be struggling to cope with less than optimal visual abilities – without knowing it.

3D BENEFITS

NO EVIDENCE OF HARM

The American Optometric Association, along with other vision health professionals, has stated publicly – and frequently – that **there is no evidence that viewing or attempting to view 3D images will harm a child's eyes.**

Indeed, the majority of children by the age of 5 will be able to readily appreciate and enjoy the 3D experience, whether in the classroom, the movie theater or the home.

However, it is known that a significant percentage of young children have some degree of impaired vision and may therefore experience an impaired or uncomfortable 3D experience. Such youngsters typically do not know that their vision is impaired, nor do they think that they see differently from anyone else.

Importantly, these occasional 'impaired experiences' have been described as a 'blessing in disguise' by leaders of the optometric community, precisely because they can lead to further investigation and treatment.

THE IMPLICATIONS ARE PROFOUND.

In nearly all cases, after a comprehensive eye examination and appropriate treatment, normal levels of 'stereopsis' (the ability to see in 3D) can be achieved. Importantly, compromised vision does not just exclusively prevent a person from enjoying the full effect of the 3D experience. In young students it can also hinder their educational progress in the classroom, leading to reduced attention, poor reading ability, and suboptimal academic and social achievement.

And outside of the classroom, the ability to see in 3D has equally profound implications, ranging from participating in sports, to driving an automobile, to operating complex machinery, or to executing fine motor activities – such as **threading a needle.**

Indeed, evolutionary biologists believe that stereopsis evolved precisely in order for our early ancestors to be able to undertake delicate manual tasks, such as preparing food or fashioning tools.

Image courtesy of The Abbey School

"It helped to see a 3D view of things. It was easier for me to understand the structure of what we were seeing."

High school biology student, Colorado

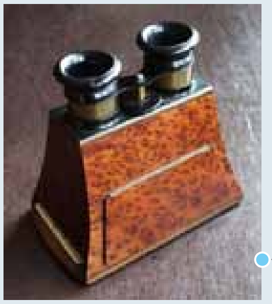
THE HISTORY OF 3D

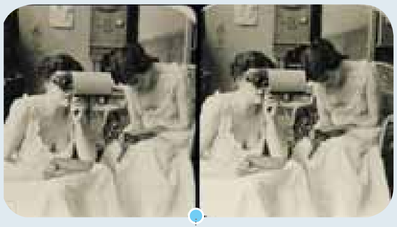
A TIMELINE

300 BC
Euclid observes that each eye sees objects differently – and is intrigued.

1611
Johannes Kepler notices that binocular vision necessarily involves disparities and double vision.

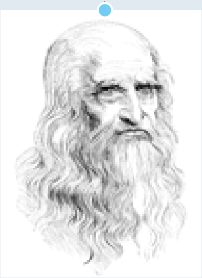
1849
Sir David Brewster builds a dual-lensed still camera and the 'Lenticular Stereoscope' viewer.





1862
Oliver Wendell Holmes invents the cheap, simple 'Stereopticon' and the 3D craze takes off in the USA. 300 million stereo-scopic photographic pairs are published and sold. 'A stereo viewer in every parlor' was the claim.

1515 1615 1825 1835 1845 1855 1865 1885



1519
Leonardo da Vinci suggests that it is binocular (two-eyed) vision that adds a quality of depth to the perception of objects.

1826
Niecephore Niepce takes the first still photograph - a farmyard view from his bedroom window. (Exposure time – 8 hours.)

1833
Sir Charles Wheatstone concludes that image disparities and parallax are the source of depth perception - or stereopsis. Later (1838) he coins the word 'Stereoscope' to describe his 3D viewing instrument.

1851
Queen Victoria is enchanted by the new technology and stereography becomes fashionable.

1889
Thomas Edison invents the Kinetoscope, a movie display device housed in a cabinet for individual viewers.

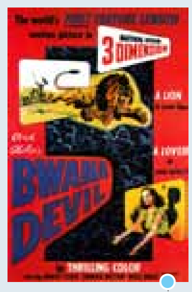
American Optometric Association

1915
A collection of short 3D movie scenes are displayed at the Astor Theater in New York - thought to be the first public exhibition of 3D movies.

1936
The first color 3D movie is displayed in Berlin – 'Zum Griefen Nah' (You Can Nearly Touch It) and the Nazi Party produces two propaganda films in 3D.

1932
Edwin Land patents 'Polaroid Filters.'

1952
The seminal 'Bwana Devil' produced and directed by Arch Oboler is the first color 3D feature film presentation, starring Robert Stack, Barbara Britton and Nigel Bruce.



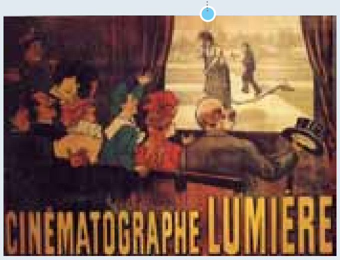
1954
'Dial M for Murder' by Alfred Hitchcock is thought to be one of the best 3D films ever made, despite (or because of) Hitchcock's resistance to the new technique.

2010
3D@Home Consortium - 3D Symposium on Human Factors.

2011
The AOA and 3D@ Home Consortium sign Memorandum of Understanding.

www.3deyehealth.org is launched.

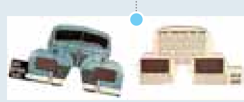
1895 | 1910 | 1920 | 1930 | 1940 | 1950 | 2010 | 2011



1895
The Lumiere Brothers invent the Cinematographe and begin projecting their movies at Le Salon Indien du Grand Café in Paris.

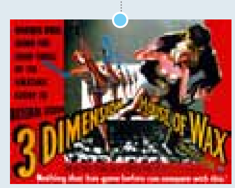
1922
The Power of Love is the first 3D feature film, shown at the Ambassador Hotel Theater in Los Angeles, to favorable reviews.

1928
"John Logie Baird Produces Moving Images Which Are Given the Appearance of Solidity" Radio News 1928... the first demonstration of 3D TV.



1940
Chrysler Motors displays the 3D assembly of a Plymouth sedan at the New York World Fair. Titled 'New Dimensions,' more than 1.5 million people see it.

1953
Warner Bros releases House of Wax, starring Vincent Price. It was the highest grossing 3D movie ever (at the time). Directed by Andre de Toth – who had only one eye!



DLP® 3D READY

2010
DLP 3D technology is introduced into classrooms.

2010
'Avatar' (Cameron). The highest grossing movie ever made – in either 2D or 3D - with worldwide box office receipts exceeding $2 billion.

DEPTH PERCEPTION

HOW DO WE DO IT?

We perceive depth in the world around us by using a variety of cues, learned from experience as we grow. The apparent size of a familiar object will indicate whether it is near or far from us. Or when one object partly obscures another object, we understand that it has to be the closer of the two. And when changes in texture, color or lighting occur in our field of view, we assign spatial values to the objects in the scene that tell us something about their distances from us and each other.

These two-dimensional depth cues are often referred to as 'monocular' cues because they do not rely on having two functioning eyes, acting in precise coordination with each other. Even if we close one eye, we can still attribute some sense of depth to our environment using these monocular cues. So, even though the photograph of the railway tracks receding into the distance on this page is a flat, two dimensional image, the perception of depth in the landscape is unavoidable.

But three-dimensional, or 'binocular' depth perception, requires both of our eyes to be working together as a team.

This type of perception is also known as **'Stereopsis.'**

Modern 3D displays, such as those used in movies, televisions, mobile devices and now in the classroom, require us to be able to achieve stereopsis in order to perceive the 3D effect. And if our eyes are not working together, we simply will not see the effect.

But stereopsis is a very complex process – and there are a number of physiological and neurological conditions that need to be met before stereopsis can be achieved.

"The more we study stereopsis, the more incredible it seems. So many subtle factors are at play in our eyes and in our brain. I love watching 2-year-olds mastering the concept of depth in their world."

JIM SHEEDY, O.D., Ph.D.
Director, The Vision Performance Institute
Pacific University, Oregon

First, you need two well-functioning eyes, with clear vision in each.

Second, you need to have mastered the task of focusing on objects near and far.

Third, you need to develop the ability to coordinate the movement of your eyes.

Fourth, you need to be able to 'fuse' the different images coming from each eye into one 3D perception.

THE ABILITY TO PERFORM STEREOPSIS

Babies are not born with the ability to perform stereopsis, but typically most will have rudimentary binocular depth perception by the age of 6 months. By the time they are 2 years old, toddlers usually exhibit a useful degree of functional stereopsis - but even then, vision scientists have shown that binocular depth perception is continuing to develop.

And it is not until the age of 5 or 6 that a child's stereopsis is likely to be approaching full maturity. Some neuroscientists suggest that it may take even longer. But if vision problems exist or emerge during this period, then stereopsis may not fully develop, and in some cases, it may not develop at all…

THE EYES HAVE IT

FUN FACTS

PREDATOR - OR PREY ?

Most animals don't see in 3D. That's because they don't need to.

What they need instead is to be very aware of their surroundings, particularly if there could be a marauding lion, tiger, wolf or eagle in the neighborhood. The harsh fact is that, in the wild, nearly everyone is on someone else's lunch menu!

As a general rule of thumb, it's possible to tell whether a creature has evolved primarily as prey, or as a predator, from the position of their eyes on their heads. If their eyes are located on the side of their heads – they're prey.

So herbivorous animals, such as deer, horses and rabbits, have clearly evolved as prey, and their specialized vision has developed to perceive the slightest hint of danger, wherever it may be coming from – even from directly behind.

But when an animal's eyes face forward, like a tiger, (or your pet kitten), it's probably a meat-eating predator, equipped with some degree of 3D perception to help it when it's hunting.

So cats, dogs, some reptiles, certain birds and of course humans can all be classified as hunters, just from the position of their eyes!

FUN FACTS ABOUT VISION IN NATURE

TWO EYES ? TRY EIGHT !

One of the champions in the super-eyesight stakes would have to be the eight-eyed jumping spider.

Looking like an alien from a science fiction novel, these tiny monsters have two pairs of eyes on the side of their heads for situational awareness, two large telescopic targeting eyes in the center of their 'face' and two smaller, hyper-accurate, range-finding eyes outside of those, which enable the spider to pluck a fast-moving insect from the air with bewildering ease and speed.

The depth and motion vector computations required for these feats have resulted in the tiny spider's brain being as large, proportionately, as its gut.

SWIVEL VISION ?

The creature that continues to baffle and amaze vision scientists is the **chameleon.** Look closely and you'll see that its two turreted eyes seem to operate independently of each other. They can look forward and backward, up and down - at the same time!

What must that be like?

Researchers now believe that chameleons attend to each eye sequentially, switching between the left and right about once a second as each scans the forest environment for food – or danger.

But once the chameleon spies a tasty morsel, like a moth or a grasshopper, it switches to 'stereo mode', employing an entirely different set of neural pathways in its brain. Locking both eyes onto the target and computing the range to within a millimeter, the chameleon will then fire its long, sticky tongue out to distances that are greater than the entire length of its body and tail to snatch its lunch right out of thin air.

SEEING IN THE DARK...

Many predators - such as cats and dogs - don't have very detailed daylight vision, compared to us. They also don't see all the colors that we see, such as reds and greens. But in the dim, blue, starlit or moonlit world of the night - which is when these animals evolved to hunt – some of them can see **six** times as well as us.

One of the reasons for this remarkable ability lies in a thin layer of crystals overlaying the photosensitive retinas of their eyes, called the **'tapetum lucidum.'**

This layer reflects the small amount of available light that's present at night time back onto the retina, thereby amplifying the light energy and enhancing the animal's ability to see its prey.

You can see the tapetum lucidum in a dog's or cat's eyes as **'eyeshine.'** That's the name for the bright yellow, green or orange glow that seems to come from their eyes when the lighting is just right – such as when taking a flash photo of your pet.

IF STEREOPSIS DOES NOT DEVELOP

HOW CAN WE TELL ?

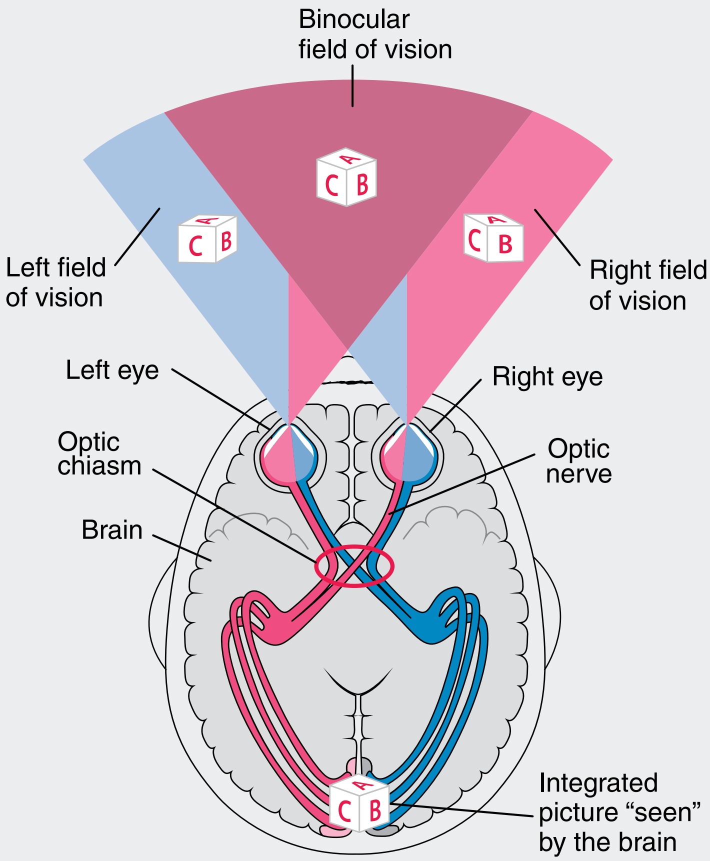
Although we grow up in a three-dimensional environment, impaired stereopsis does not mean that individuals do not develop some sense of depth. They will use the monocular depth cues mentioned earlier. They may not even be aware that their stereopsis is impaired.

But 3D presentations in the classroom, at the movie theater or sitting in front of a 3D TV at home, require stereopsis, which is why previously unidentified problems only become apparent in these "artificial" situations.

In the classroom environment, problems in perceiving the full 3D effect can present themselves in a number of different ways:

- Some children may simply be unable to perceive the 3D effect and will react negatively to the experience.
- Others might experience soreness, fatigue, dryness of the eyes, headache and general eye irritation - all indications of eye strain, known in the health literature as 'asthenopia.'
- Some may complain of blurred or double vision.
- Some may complain of dizziness or nausea.

Educators have also reported that excessive fidgeting, playing with the 3D glasses, or covering an eye can be an indication of problems in the 3D presentation environment.



Even small defects in processing and appreciating full visual fields can cause 3D viewing difficulties.

COMMON CAUSES OF 3D VIEWING CHALLENGES

- **REFRACTIVE PROBLEMS** - nearsightedness (myopia), farsightedness (hyperopia), and astigmatism (image is blurred no matter where you look) can all interfere with 3D viewing.

- **LACK OF BINOCULAR VISION** (Strabismus) - when the two eyes are not properly aligned, a strabismus (eye turn) is present. With this condition, the inputs from the two eyes are not successfully combined in the brain, and a 3D stereoscopic perception will not occur.

- **LAZY EYE** (Amblyopia) - one eye dominates the other and vision signals from the non-dominant eye are ignored. The result is, effectively, monocular vision. Children with amblyopia do not experience stereopsis and need diagnosis and treatment as early as possible. Before using 3D viewing as a risk assessment tool many children with conditions causing amblyopia went undetected and untreated.

- **EYE COORDINATION DIFFICULTIES** (such as 'Convergence Insufficiency') - difficulty in keeping the two eyes aligned with one another. This can result in seeing double, eye fatigue, and the avoidance of close-up work, such as reading. The quality of the 3D viewing experience can also be compromised.

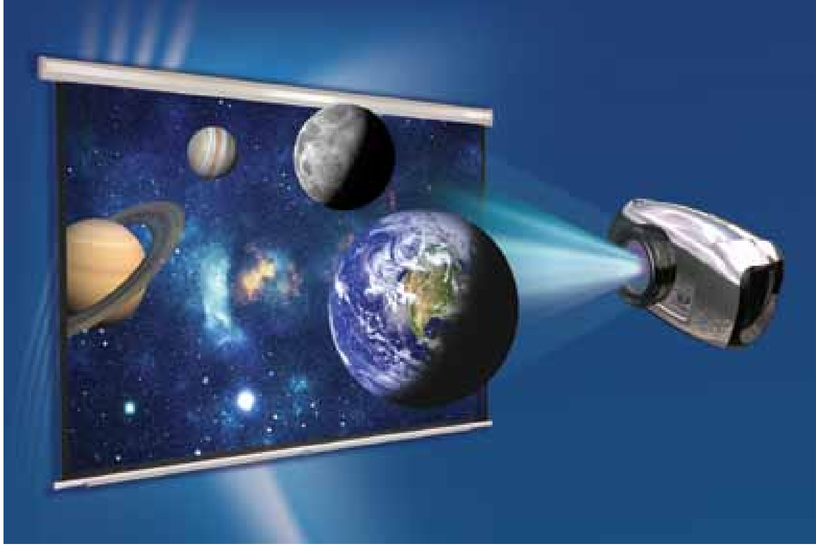
- **EYE FOCUSING** (Accommodation) **DIFFICULTIES** - our eyes need to precisely change their focus (or "accommodate") when we view objects at different distances. Children experiencing difficulty in performing this function can experience symptoms of blur, headache and discomfort when viewing 3D displays.

- **DIZZINESS AND NAUSEA** - can be caused by rapid motion effects in the 3D content. These vision-induced sensations of movement disagree with the "vestibular," or balance system that informs the child that s/he is not moving. This conflicting sensory information can cause vision-induced motion sickness.

STEREOPSIS

HOW 3D DISPLAYS WORK

TECHNOLOGY OVERVIEW



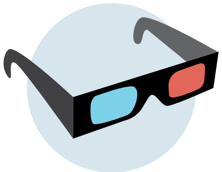
Normal stereopsis is a consequence of the fact that our eyes are spaced about two and a half inches apart – and so each of them sees a slightly different view of the world. In order to create the virtual stereoscopic effect, 3D displays also need to send a slightly different – and unique - view to each eye, without the other eye seeing the image that is not intended for it.

Historically, this has been achieved by projecting the two stereo images onto a screen from the same side as the audience (front projection), or from behind the screen (rear projection). Both approaches are still in use in movie theaters, museums, homes and classrooms, depending on the size and requirements of the location and the audience.

More recently – and mainly, but not exclusively, for home use - modern high-definition television sets can display the two unique stereo images in a number of different ways, which are then decoded and presented to the viewer as distinct and separate left eye and right eye views.

But with all of these display technologies, how are the two images separated for each of the eyes of each individual member of the audience, wherever they are sitting in the living room, the movie theater or in the classroom? This has always been the toughest problem for 3D scientists to solve…

Main viewing technologies have evolved, for front projection, rear projection and modern TV 3D presentations…



1. ANAGLYPH

The viewer wears glasses with different-colored filters (usually red and blue) placed in front of each eye. The two stereo images – left eye and right eye – are also colored red and blue. In theory, each eye will therefore only see the image intended for it. Recently, more advanced forms of color separation (known as wavelength multiplex visualization) have been developed, with striking – and economical - results.

2. PASSIVE POLARIZED

The viewer wears glasses with oppositely polarized filters placed in front of each eye. The two stereo images are also projected through oppositely polarized filters, so that each eye only sees the view intended for it. In movie theaters the effect is achieved by using special screens that preserve the polarization of each reflected image, In the home, image electronics and special screen materials produce the polarizing effect.

3. ACTIVE SHUTTER

The viewers wear battery-powered glasses that receive signals from the TV equipment, or the classroom projector, which instructs them to alternately occlude each eye in synchrony with the alternating (left and right eye) images being displayed. This 'eye sequential shuttering' typically occurs 120 times a second–too fast to be perceived. Some movie theaters around the world also use this technology.

4. 'GLASSES-FREE' 3D

...also known as 'autostereoscopy.'

Currently, this technology works best in displays that are viewed at close distances and in carefully controlled environments.

It does have applications in certain specialized signage and entertainment situations, but is not yet suitable for larger audiences.

THE 3D EXPERIENCE

Currently, most educational installations utilize **Active Shutter** technology because it is easy to set up and requires no specialized screens. It is also relatively mobile, so it can be transferred from classroom to classroom as needed.

Active shutter technology is also the most common system for home 3D viewing, although passive polarized viewing technologies are gaining ground as new solutions are being devised. Some companies are developing glasses that can accommodate both active and passive display technologies.

In the United States, movie theaters typically employ polarizing glasses because they are less expensive and easier to maintain. With the exception of 'wavelength multiplex visualization,' image separation using colored filters is no longer as widespread as it was, but some computer and graphics applications still employ it because it is relatively inexpensive and the virtual stereo images are easier to create.

FUN FACTS

'EAGLE EYED' - FACT OR FICTION ?

FACT. *Meet Pearl...*
She's a 35-year-old bald eagle and the star of many national advertisements and movies. Eagle eyed? Of course. But what does that mean? Pearl's eyes are almost as large as a human's, but their acuity (sharpness) is at least six times that of a human's, because of the number of photosensitive cells packed into her retina and the way in which they are arranged. Extra musculature in her eyes also provides for extraordinary focusing power – much better than ours – and as a result, Pearl can see a jackrabbit a mile away. And at a quarter mile, she can even see it twitching its whiskers!

© Joseph Napolitano/TNC

FUN FACTS

MANTIS SHRIMP

Boasting one of the most sophisticated visual systems in nature, these bizarre coral-dwelling arthropods can see colors that we don't even know exist. They also see in infrared and ultraviolet, can differentiate between different types of polarized light, and have three visual fields in each stalk-mounted eye! And why this visual overkill? The usual reasons. Mating and hunting.

When they are courting, amorous mantis shrimp fluoresce, displaying a variety of colors. By analyzing the exact combination of wavelengths that the other shrimp is showing, a Mantis 'Romeo' can tell whether the object of his desire is a 'suitable' Juliet.

And when hunting, the Mantis shrimp waits for its prey (crabs and other small fish) to come within range of its lethal claws and then, in less than the blink of an eye, it lashes out and stuns its supper with nature's fastest sucker punch. Knocks it out cold. And their 3D depth perception is so finely tuned that they never miss.

MATING AND HUNTING

TEACHING AND LEARNING WITH 3D

EXCITING AND EFFECTIVE

Picture Courtesy of DLP Texas Instruments

As 3D makes its way into our nation's classrooms, teachers are using 3D in many forms. Stereoscopic still images, micro-simulations, more complex simulations, short video segments, and even longer 3D educational films all play an important role. There appear to be few limits to its creative application by teachers, who have described their experience of 3D as:

Research on the learning benefits of using 3D in the classroom is ongoing, but early findings indicate that focus, attention span, retention, classroom behavior, and achievement gains are all seeing improvement.

Students have also been responding positively to the 3D experience...

* teacher FEEDBACK

"An engaging and attractive introduction to new material."

"An accessible, yet powerful, way to convey difficult or abstract concepts."

"A way to help students understand how complex systems work."

"A technique to address common or prior misconceptions."

"An effective way to review material that was previously taught."

"A way to assess student learning after traditional delivery of classroom content."

* student FEEDBACK

"It provided a better visualization than the textbook."

"You can see it deeper ... I don't know how to say it ... almost from within."

"Using 3D has helped me look at what we are learning in a different way. It almost makes it look real—it's fascinating..."

"The information sticks with me a lot more."

"3D really helps me learn and visualize complex structures and processes."

"I love seeing what is actually going on."

OPTIMIZING 3D IN THE CLASSROOM

HOW TO MANAGE 3D

MANAGING THE ROOM ENVIRONMENT

- As with any classroom TV or projection system, 3D works best when the ambient light levels are subdued, but not totally dark.
- To get the best and most comfortable 3D effect, psychophysical studies have shown that the ideal viewing distance for a 3D presentation is approximately three times the screen height.
- Students may be seated either in front of, or behind, this optimum distance, according to their comfort with the '3D effect.'
- Similarly, in wide classrooms, being seated too far to one side or other of the screen can distort the 3D effect.
- Counsel the students to avoid side-to-side motion, turning, or tilting their heads. This can distort and disrupt the 3D effect.

MANAGING THE 3D GLASSES

- If the students wear prescription glasses, they should place the 3D glasses over them.
- Currently, glasses from one 3D display system will not usually work with another system. Active glasses and passive glasses cannot generally be interchanged, although some manufacturers are addressing this possibility.
- Active shutter glasses should be fully charged. Low battery power can interfere with the shuttering action, or create double images.
- If the teacher's 3D glasses flicker when glancing back and forth from students to screen, replace them right away. Glasses should only flicker for a few moments, when they are first turned on.
- Disinfect the 3D glasses thoroughly after each use. Antibacterial wipes and UV cabinets have all been shown to be effective. Recommended cleaning methods may vary by manufacturer. It is advisable to check with each individual manufacturer for their suggested cleaning methods.

EXPERIENCE

Picture Courtesy of DLP Texas Instruments

MANAGING THE 3D CONTENT AND THE CLASS

- Always preview the 3D materials. Clearly, this requires the teacher to have appropriate vision and eye health to achieve and maintain 3D.
- Identify general student health issues and sensitivities in advance, from known medical disorders and medications being taken, to tendencies to suffer from dizziness or motion sickness.
- Ensure that the students keep the glasses off until the 3D content is ready to view.
- Regularly check with students to ensure they are comfortable.
- Students who are experiencing discomfort may find it better to move farther from the screen or the display.
- Keep the transitions within and between the 3D images slow and smooth. Be judicious about switching from objects in the 'room space' to objects in the 'screen space' too abruptly. Rapid movements in 3D space can be discomforting.
- Fade to black or a neutral screen during breaks or lengthy discussions.
- Use 3D in shorter segments, rather than for an entire class period.
- Students should always remove glasses before standing up or moving around the room.

MANAGING 3D VIEWING DIFFICULTIES

- Students who find the 3D experience to be uncomfortable should immediately report their difficulties to the teacher. Lists of symptoms, causes and actions are referenced in the appendices of this report.
- If students are feeling dizzy or nauseous, take the glasses off immediately, and have them close their eyes for 10 seconds or look at a distant object. (Try to distinguish actual issues from "copy cat" issues. Experience shows that if one student makes a comment about feeling dizzy, others will follow!)
- Students with problems viewing the 3D lesson could view the presentation in 2D, either by disabling one lens, if the software permits, or by covering one of the lenses. Placing a tissue or cotton wool pad behind one of the eyeglass lenses can also assist in temporarily holding the eyelid closed, thus blocking the vision in that eye.
- The teacher should avoid repeatedly looking from screen to class and back again. This can provoke uncomfortable effects for the teacher.
- In every instance where a student, (or the teacher), experiences diminished depth perception, discomfort or dizziness, the recommended course of action is always the same … seek the expert assistance of an eye care professional without delay.

TO SUM UP...

THE 3D EXPERIENCE

Most students enjoy the 3D experience and benefit from it.

Research has shown that 3D educational materials are more engaging and more effective. Students feel that the experience is more immersive, and educators report that the learning objectives are more efficiently and productively achieved. But educators also have a duty to care for their students' well-being - and need to be aware of the vision health issues associated with 3D viewing.

Those issues can be influenced by three separate factors:

1 **Poorly made 3D products** can cause fatigue and eye strain. Varying brightness and contrast levels, excessive and rapid use of the '3D effect,' and insufficient control of objects appearing at the edge of the screen can all be tiring and produce discomfort. Ensure that the teaching materials you use have been professionally produced.

2 **Poorly set up** or inadequately maintained projection systems (including the glasses) and/or non-optimal viewing environments can adversely affect the 3D experience and create fatigue and other symptoms.

3 **Students will differ** in their abilities to achieve stereopsis and educators should be aware of these differences, their causes and the possible remedies.

3D IN THE FUTURE

LOOKING FORWARD


Picture Courtesy of 20th Century Fox

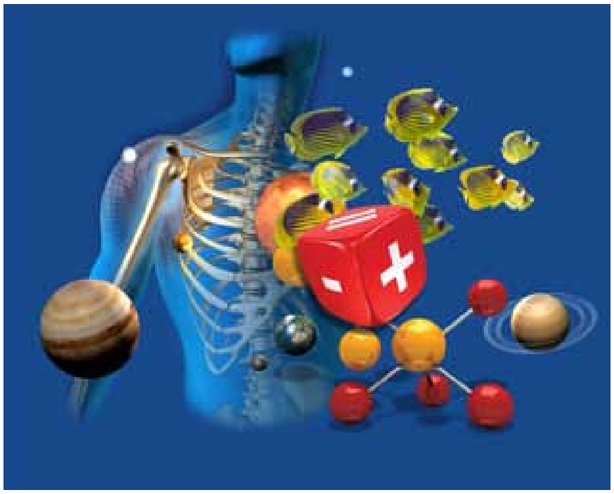
Suboptimal vision health not only prevents a person from enjoying the full effect of the 3D experience. In young students it can also hinder their educational progress in the classroom.

Absent or incomplete **stereoptic ability** has implications outside and beyond the classroom.

From participating in sports, to driving an automobile, to operating complex machinery, to executing fine motor activities, well-developed stereopsis bestows numerous benefits on the majority of us who successfully develop it.

Looking forward, 3D imaging (and the ability to perceive it) will play an increasingly important role in the workplace.

For decades, stereography has been a key feature of military, medical and geophysical imaging. Today, stereography plays a role in an ever wider range of activities, which include…



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Molecular Biology & Protein Synthesis
Nanotechnology
Neurosurgery, Vascular Surgery, Keyhole Surgery
Oil Prospecting & Petrochemistry
Remotely Operated Vehicles, Aircraft And Submarines
Seismology & Vulcanology
Virtual Presence

And many more...

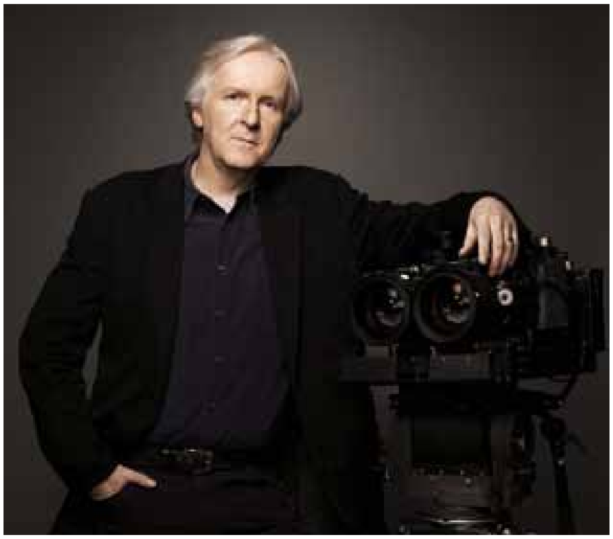
THE FUTURE IS A 3D FUTURE.

"There will come a time when being 'stereo-capable' will be an important component of a student's eligibility for their chosen career path. It will be our duty to ensure – as far as we can - that our students are stereo-capable."

LEN SCROGAN
Boulder Valley School District, Colorado

WHAT 3D PIONEERS SAY...

...ABOUT 3D IN THE CLASSROOM

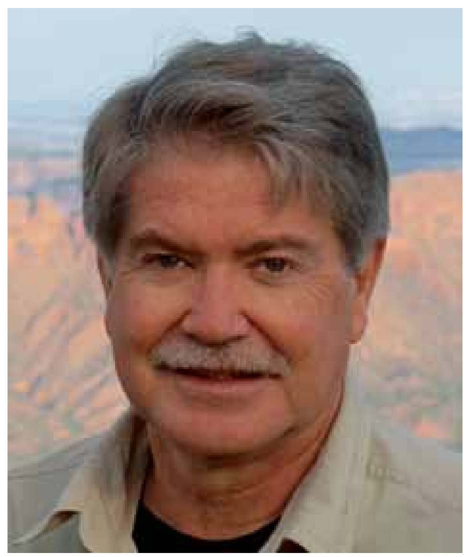


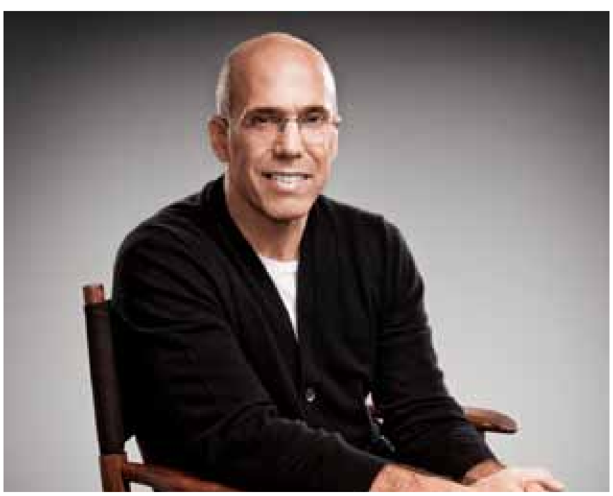
"The ability of 3D to excite, engage and immerse the viewer in previously inaccessible locations makes it an ideal tool for our nation's classrooms. From cellular biology to global geography to ancient history to intergalactic astrophysics, 3D can transport students beyond the boundaries of space and time - and beyond the boundaries of their imagination. No wonder they love it as much as I do."

JAMES CAMERON
Director, *Avatar*

"Discovery has always been about satisfying our natural curiosities in ways that are technologically innovative and creatively challenging. The emerging use of 3D in the Classroom is a perfect example of those core values coming together to provide a learning experience that is not only exciting and immersive, but which is also more effective than the conventional methods of teaching. I almost wish I was back at school..."

JOHN HENDRICKS
Founder and Chairman
Discovery Communications





"It is very exciting to see 3D move into the classroom, where this extraordinary visual technology can now make the learning experience – like the film-going experience before it – much richer and more powerful. Effective education is all about taking students to a greater understanding of their world, and I believe 3D is an incredible tool to help make this happen."

JEFFREY KATZENBERG
CEO. DreamWorks Animations

POST SCRIPT

3D@Home Consortium is proud to help prepare students, teachers and their classroom and home environments for all the creative experiences and bold educational opportunities that 3D has to offer.

As 3D viewing becomes more commonplace in classrooms, the 3D@Home Consortium, together with vision and eye health experts, reinforce that 3D technologies actually have distinct and important consumer benefits.

The 3D@Home Consortium, well known as a leader in ensuring the best possible 3D viewing experience for consumers, is working toward providing new solutions to how consumers manage health and wellness through creative uses of 3D viewing. The report, *3D in the Classroom, See Well, Learn Well* has described how incorporating 3D viewing into the school setting now provides both educational benefits and vision and eye health benefits. These benefits include, increased learning possibilities over traditional teaching methods and improved vision screening sensitivity over typical eye charts. Collectively, 3D viewing helps to provide increased assurance that a child will succeed in their education at school and at home, the extension of the classroom, and not be denied lifetime opportunities and an equal chance to succeed later in life as 3D becomes more common in the workplace.

The 3D@Home Consortium, represents companies from every level of the supply chain, including: entertainment companies, technology companies, manufacturers of 3D displays, drivers and other critical hardware, standards organizations, training and educational institutions. Our members look forward to working with teachers, school administrators, school nurses and eye care professionals as important collaborators in helping better assure that our educational system continues to meet our nation's growing needs. In doing so, we commit to investments in children and to growing our 3D industry responsibly.

Acting responsibly we can better prepare our education system for the 21st Century and further protect our children to the benefit of us all.

Rick Dean
Chairman at 3D@Home Consortium,
Senior Vice President at THX LTD.

3D@Home CONSORTIUM

HELPING CHILDREN SEE WELL, LEARN WELL

for more information, please go to **www.3deyehealth.org**

APPENDIX

Appendix A

3D VISION - CHECKLIST

Using 3D as a Prevention Model To Support Vision And Eye Health

3D VISION

(SHOWN IN THE GRAPHIC BELOW)

A more sensitive assessment tool that identifies more children with vision disorders than a standard eye chart.

Reduces the number of children with eye problems that are missed.

3D Viewing as an Assessment Factor Tool

SYMPTOM CHECKLIST

Lack of or Diminished Depth Perception and/or

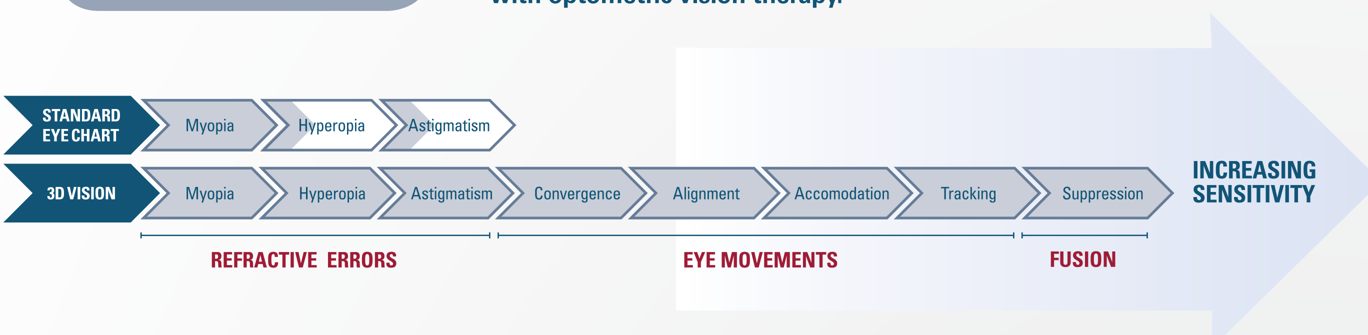
Dizziness
Discomfort
Double Vision
Eye Fatigue
Blurred Vision
Headache

REFERRAL TO EYE CARE PROFESSIONAL

Lower Rates of False Negatives

Compared to 27% sensitivity of **standard eye chart**

A child's vision system is complex. The problems that can develop require prompt diagnosis, afforded by a professional eye examination, and a variety of treatment options. Most vision conditions can be treated effectively with spectacles or contact lenses; however, some are most effectively treated with optometric vision therapy.



A shared national public health goal is that all children and adolescents have healthy vision and achieve at their fullest potential. Crafted through new 3D technologies and the human experience, the 3D Public Health Prevention Model equips teachers and parents with a unique assessment tool, more capable than the standard eye chart.

Together with facilitated actions in attaining necessary care and treatment, most especially for conditions that may have gone undetected and untreated, we can move ever closer to achieving this all-important shared goal.

For additional Information please visit: www.visionandhealth.org/documents/Child_Vision_Report.pdf

Appendix B - Glossary

A SELECTION OF 3D TERMS (courtesy of the 3D@Home Consortium and AOA)

2D
Two-dimensional. An image with only two dimensions, such as width and height.

3D
Having or appearing to have width, height, and depth (three-dimensional).

Accommodation
Focusing the eyes from one distant plane to another.

Active Glasses
Powered shutter glasses that function by alternately allowing each eye to see the left-eye/right-eye images in an eye sequential 3D system.

Amblyopia
"Lazy eye." A visual defect that affects approximately two or three out of every 100 children in the United States. Amblyopia involves lowered visual acuity (clarity) and/or poor muscle control in one eye. The result is often a loss of stereoscopic vision and binocular depth perception.

Anaglyph
A type of stereogram in which the two stereo images are superimposed but are separated by the use of colored filters and viewing spectacles (commonly red and cyan, or red and green) so each eye sees only the desired image.

Asthenopia
Eye strain that may lead to fatigue, pain in or around the eyes, blurred vision, headache and occasional double vision.

Astigmatism
Distorted vision at all distances.

Binocular
Of or involving both eyes at once.

Binocular Depth Perception
The ability to visually perceive three-dimensional space; the ability to visually judge relative distances between objects.

Binocular Disparity
The difference between the view from the left and right eyes.

Convergence
The ability of both eyes to turn inward together, enabling both eyes to look at the same point in space.

Diplopia
'Double vision.'

Disparity
The distance between the same point in the visual field as seen by the two retinas, sometimes called retinal disparity.

Divergence
The ability for the eyes to turn outward together to enable them to look further away. The opposite of convergence.

Eyeshine
The name for the light reflected from the tapetum lucidum layer that overlies the retinas in the eyes of cats, dogs, horses and many other mammals. Humans do not have tapetum lucidum layers in their eyes, so the 'red eye' effect seen in flash photographs is not an example of 'eyeshine.' It is an artificial effect, not seen in nature.

Field of View
Usually measured in degrees, this is the angle that a lens can accept light. For instance, the human eye's horizontal field of view is about 175°.

Fusion
The merging of the two separate views of a stereo pair into a single three-dimensional image.

Ghosting (a.k.a. Crosstalk)
A condition that occurs when the right eye sees a portion of the left image, or vice versa, causing a faint double image to appear on the screen.

Hyperopia
Make farsightedness

Interaxial Distance
The separation between the optical centers of a twin-lens stereo camera or viewer (which may be adjustable).

Interpupillary Distance
The distance between the pupillary centers of a person's eyes. Typically about 63mm, or two and a half inches.

Linear Perspective
A perceptual depth cue in which, for example, lines that are parallel in three-dimensional physical space appear to converge. (See page 8.)

Monocular
Of or involving one eye.

Appendix B - Glossary

A SELECTION OF 3D TERMS (courtesy of the 3D@Home Consortium and AOA)

Myopia
Nearsightedness

Negative Parallax
The situation in which the eyes converge to a point in front of the display, which causes the feature to appear to be in theater space. (see positive parallax)

Parallax
Apparent change in the position of an object when viewed from different points of view.

Pictorial Cues
Monocular depth cues such as relative size, linear perspective, and aerial perspective that are used to denote depth in non-stereoscopic images.

Positive Parallax
The situation in which the eyes converge to a point behind the display, which causes the feature to appear to be in screen space.

Psychophysics
The scientific discipline that investigates and measures the relationship between physical stimuli and perception or sensation.

Screen Space
The region appearing to be within a screen or behind the surface of the screen. Images with positive parallax will appear to be in screen space.

Sensitivity
The probability of testing positive if the disease/disorder is truly present. As the sensitivity of a tool/test increases, the number of persons with the disease/disorder who are missed by being incorrectly classified as test-negative (false negative) will decrease.

Simulator Sickness (a.k.a. 'Cybersickness')
A feeling of unease caused by a conflict between the visual perception system and the vestibular (balance) system.

Stereo Acuity
The ability to distinguish different planes of depth, measured by the smallest angular differences of parallax that can be resolved binocularly.

Stereographer
A person who makes stereo pictures.

Stereo Infinity
The farthest distance at which spatial depth effects are normally discernible, usually regarded as 20 meters for practical purposes.

Stereopsis
The neural process that combines the two slightly different views from each eye to create the visual perception of one three-dimensional image.

Stereoscopy
The art and science of creating images that reproduce the effects of binocular vision by photographic or other graphic means.

Strabismus
A visual condition in which the two eyes point in different directions. One eye may turn in, out, up, or down while the other eye is looking straight ahead. Due to this condition, both eyes do not always aim simultaneously at the same object. This results in a partial or total loss of stereo vision and binocular depth perception.

Suppression
To avoid the experience of double vision (diplopia), the input from one or other eye is suppressed by the brain, resulting in monocular vision.

Theater Space (a.k.a. Audience Space)
The region appearing to be in front of the screen. Images with negative parallax will appear to be in theater space.

Viewer Discomfort
A feeling of unease or fatigue that can sometime result during stereoscopic viewing. Several causes of viewer discomfort have been proposed, including: rapid changes in accommodation and convergence; depth cue conflicts; and unnatural blur.

Vision Therapy
Vision therapy is a sequence of therapeutic procedures prescribed and monitored by the optometrist to develop efficient visual skills and vision information processing. The use of lenses, prisms, filters, occluders, specialized instruments, and computer programs is an integral part of vision therapy. These therapy procedures have been shown to be effective for eye movement disorders, inefficient eye teaming, misalignment of the eyes, poorly developed vision, focusing problems and visual information processing disorders, including visual-motor integration and integration with the other senses.

Appendix C - Useful Links, Further Reading

USEFUL RESOURCES FOR EDUCATORS, PARENTS AND STUDENTS....

WEBSITES

The American Optometric Association	www.aoa.org
3D Eyehealth	www.3deyehealth.org
3D@Home Consortium	www.3DatHome.org
Vision Performance Institute	www.pacificu.edu/optometry/research/College of Optometrists
College of Optometrists in Vision Development	www.covd.org
3D University (Consumer Oriented)	www.3DUniversity.net
Optometric Education Program Foundation	www.oepf.org
Children with Special Needs	www.children-special-needs.org
International 3D Society	www.international3dsociety.com/International_3D_Society/HOME.html
National Commission on Vision and Health	www.visionandhealth.org
DLP Texas Instruments	www.dlp.com/3D

BLOGS

MainosMemos	
Vison Performance	www.mainosmemos.blogspot.com
Vision Help	visionperformance.blogspot.com
3D Blog by Len Scrogan	visionhelp.wordpress.com
Stereoscopy News	future-talk.net
	stereoscopynews.com

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SPECIAL THANKS

3D teachers from the Boulder Valley School District

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Tony Tolbert
Dawne Mangus
Lynn Twietmeyer
Greg All
Will Leary
Holly Colangelo
Rob Linnenberger
and JR Kerbel

3D PIONEERS

James Cameron
John Hendricks
Jeffrey Katzenberg

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20th Century Fox

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St. Louis, MO 63141
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