Display Size Matters

How using the **Equivalent Visibility Rule** sets display sizing for successful Collaboration and Conferencing Rooms

White Paper

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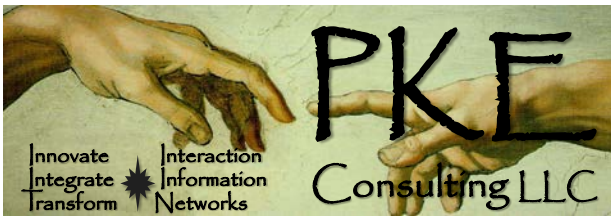

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Introduction

As organizations modernize conference rooms with equipment to enable both in-room and remote collaboration, a major challenge has emerged. Traditionally, conference room displays have been used primarily for static presentations and more recently for video conferencing. However, with the move to open floor plans, cubicles and hoteling, conference rooms (small and large) are being used as collaborative spaces with electronic information in the form of documents and other items shared and edited using a wall mounted display. In the AV industry, the oft used size of 4/6/8 times the height of the display for maximum distance from the display to the participants is used. In many cases, when using this methodology the chosen display will be far too small for a quality experience for the participants in the room.

This paper will demonstrate the issues to the often used 4/6/8 rule and provide an alternative method, Equivalent Visibility, to determine the required size displays for effective use. We will focus on defining and delivering an equivalent and optimal experience in your conference rooms that is based on how your users work in the ergonomic environment of their desktop, not a minimal experience based on generic rules. It will demonstrate why even in smaller spaces, typically chosen displays based on the 4/6/8 logic may, in fact, dramatically degrade the collaborative experience. This is often made worse by assuming that the 4/6/8 is applied where 4 is a good case, enabling many environments to be actual 6 or more times the height of the screen to the farthest participant, resulting in an environment that is virtually unusable for immersive collaboration. This is the primary flaw with the 4/6/8, while it defines an absolute maximum, it does not define an optimal experience.

We will then show how to apply the significant scientific information about the ergonomics for personal workspaces and the effective user experience of a person and his/her individual display to designing a group meeting space that is effective for all participants. Using that data we will analyze typical small, medium and large conference rooms for the display size required for a high quality collaboration or video conferencing experience. Throughout this paper, we will refer to well defined standards for desktop display set-up and use and human eyesight, from organizations like ANSI, Apple, OSHA, the Cornell University Ergonomics Lab, noted Optometrists, as well as other industry sources. This comprehensive analysis specifies the ideal set-up for viewing and how to optimize the investment in a collaboration room.

The conclusion is that choosing the right size display for a room may have a 5-10% impact on the overall cost, but will dramatically increase the utilization, effectiveness, and acceptance of the resource. In fact, the capability of the conference room displays you install may be a major component in achieving the productivity benefits often included in the ROI analysis of collaboration and communications systems.

It is important to understand how this analysis compares to the popular “rule” for AV displays called 4/6/8. This says the maximum distance should be 4, 6, or 8 times the vertical height of the display based

on the room use. The 8 times height is usually described as the absolute maximum for "Basic Viewing" meaning passive viewing of content such as a movie or video content viewing as well as for presentation slides. The 6 times height is generally used as the absolute maximum for "Basic Viewing", a more active viewing such as video conferencing, though this will not generally yield a quality video conference experience, as most telepresence systems use a ratio of just 2 times the height to the viewer. The 4 times height is the absolute maximum specified for "Analytical Viewing " of collaborative content such as documents, spreadsheets, etc. The document will show how maximums derived from typical desktop display experiences translate into rooms of different sizes and why the 4 in 4/6/8 will generate a generally inferior experience. While all of the display sizes in the document are shown as diagonal as that is the normal specification, all calculations have been done using vertical measurements, to better reconcile with the 4/6/8 rule as well as character height, a key factor in display size and usage. In addition to a range of scientific data, this paper includes tools to enable you to see, using your own desktop display, how a display of any specific size will look in your conference room.

Conference Space Use Cases: Collaboration, Video Conferencing and Presentations

Conference rooms used to be physical spaces, however, in the last 10 years they have increasingly become electronic. This first started by having a projector to show slides, then for video conferencing, and, today for active collaboration on documents, web sites and other data. Where larger rooms used to be "display" enabled, today even smaller rooms are now. And especially in those smaller rooms, the use of that display is increasingly for active collaboration on the content on the screen, using tools that are common on the user's desktop. For purposes of this paper, we will consider three room use cases:

Collaboration - The participants in the room are actively involved with seeing, analyzing and interpreting data that is being presented or brainstorming ideas. The data is driven by desktop type applications and experiences. This is equivalent to the Analytical viewing experience of the 4 in 4/6/8

Video Conferencing – This is viewing a video image where overall content is important and individual details are less so. While it refers here to video conferencing, it is also the same as the "Basic Viewing" of the 6 in 4/6/8.

Presentations – The use of a space for presentations is the lowest use case and is equivalent to the "Passive Viewing" of the 8 in 4/6/8. In this use case the details are less important.

When architecting your conference rooms, understanding these use cases is essential to have a quality experience users will endorse. The success of your room deployments and their utilization are directly dependent on how well your implementations support the use in the room. Merely putting up a display is not enough, it has to enable an effective working environment. In the past, most conference room

display systems were used for one way presentations, which are designed for screens much smaller than the average desktop when viewed at average distance. Building a room for this singular use case may create a significantly inferior experience for the other two. As the simple presentation use case is the least demanding and best understood, we will not consider it or the design parameters in this paper. As collaboration within a room or remotely is rapidly becoming the dominant use case for a conference room, this paper will begin with that and move to video conferencing second.

Collaboration

In 4/6/8, the 4 is the maximum distance from the display as a multiple of height for a reasonable Collaboration experience where seeing and interpreting data is important. The reality is that, for most of today's users, Collaboration is essentially taking the personal computer environment into a conference room to share and work with others. To understand how this impacts usability, we must first consider the ergonomics of the typical personal computer set-up. The first consideration is what is the size of a typical desktop monitor/display in use in an individual computer environment? According to NPD Display Search, Figure 1 shows the average size of different types of monitors shipped globally in the years 2010 to 2013. As can be seen, the worldwide average is now over 21 inches (assuming the continued size growth from 2010 to 2013 continues into 2014). As this report is global, it includes a large number of economies and environments where monitors are smaller than in the US, so it is safe to assume the average monitor size in the U.S. is 21 inches (diagonal) today.

Table 1: Average Diagonal Size of Key FPD Applications

Key Applications	2010	2011	2012	2013	Average Size Difference (2010-2013)	
Desktop Monitor	19.9"	20.3"	20.7"	20.9"	1.0"	5%
LCD TV	33.2"	34.5"	35.9"	36.1"	2.9"	9%
Mobile PC	13.6"	12.8"	12.1"	12.2"	-1.4"	-10%
Mobile Phone	2.4"	2.6"	3"	3.3"	0.9"	38%
OLED TV	15"		55"	55"	40.0"	267%
Plasma TV	46.3"	47"	48.1"	50"	3.7"	8%
Portable Media Player	2.8"	3.1"	3.1"	3.6"	0.8"	29%
Portable Navigation Device	4.3"	4.5"	4.5"	4.6"	0.3"	7%
Public Display	41.7"	41.3"	44.9"	46.5"	4.8"	12%

Source: NPD DisplaySearch *Quarterly Worldwide FPD Shipment and Forecast Report*

Figure 1 NPD Display Search Average Display Sizes 2010-2014

The next question is how far from the typical monitor an average user sits. There are a wide range of sources on viewing distance. A few of the more prominent ones are shown in Figure 2 (the citation number ties to the reference links at the end of the paper):

Agency	Recommendation	Equivalent Inches	Citation
ANSI/HFS	500mm recommended	19.7	1
	300 mm minimum	11.8	
Apple Ergonomics	Minimum recommended	18.0	2
	Maximum recommended	24.0	
US OSHA	Mimimum recommended	20.0	3
Canadian OHS	400 mm minimum	15.7	4
	700 mm maximum	27.6	
Mil-Std 1472	400 mm for continuous viewing	15.7	5
	250mm minimum for intermittent viewing	9.8	
British HSE	350 mm minimum	13.8	6
	600 mm maximum	23.6	
Cornell Univ Ergonomics Lab	The monitor should be at a comfortable horizontal distance for viewing, which usually is around an arm's length (sit back in your chair and raise your arm and your fingers should touch the screen).		7
About Health	The best computer monitor distance is typically the distance from your shoulder to fingertips if your reach your hand toward your monitor without moving your shoulder out of line.		8

Figure 2 Viewing Distance Recommendations

One technique that seems standard is to have the monitor at arm's length. According to Kodak's Ergonomic Design for People at Work, (9), the average reach of a US male is 25.4 and a female is 23.8 inches. So using the arm's length technique, the average distance would be about 24-26 inches. As modern monitors have increasingly higher resolution, the relative size of the monitor and expectations are increasing. The conclusion from these ergonomic experts is that viewing distance somewhere between 20 and 30 inches is the ideal distance. For this analysis, we will use a viewing distance of 28 inches from a 21 inch diagonal screen as a conservative representation of the average desktop.

How does the 4/6/8 rule reconcile to the reality of today's desktops? To understand, let's apply 4-6-8 to a person's desktop. Figure 3 shows this calculation (using a 16x9 screen ratio) for a range of monitor sizes. As can be seen, using 4 times the height generates distances that are significantly longer than any of the desktop standards. For example, for the average display size of 21 inches diagonal, the 4/6/8 rule recommends a maximum viewing "analytical" distance of 41. 2 inches, almost 3 and a half feet. To understand how this rule applies, use the chart to sit the maximum distance from your desktop display and see how effective it is.

Desktop Monitor Diagonal (inches)	Maximum Viewing Distance for Collaboration Using 4 Times Height (inches)
12	23.5
13	25.5
14	27.5
15	29.4
16	31.4
17	33.3
18	35.3
19	37.3
20	39.2
21	41.2
22	43.1
23	45.1
24	47.1
25	49.0
26	51.0
27	52.9
28	54.9

Figure 3 Four Times Height Calculation for Desktop Monitors

The point is that the 4/6/8 rule is an **absolute** maximum and will not generate an optimal experience or even one that is close to the desktop experience. In fact, in the analysis you will see that the 4 times of 4/6/8 is the very edge of usability for any display in a room

and far from optimal.

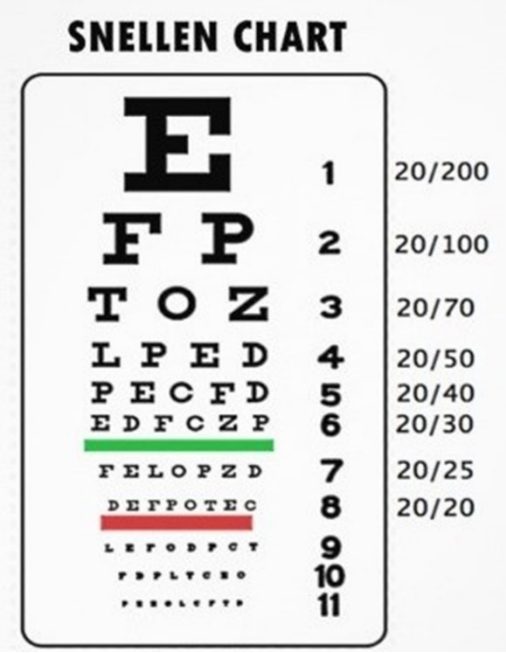


Figure 4 Snellen Eye Chart

Remember ophthalmologist office straining to read the last line on the Snellen vision chart? In fact, Snellen demonstrates the challenges with human vision using characters to evaluate vision. The character for 20/20 vision is a specific size that the average person can discern when 20 feet away from the image. The 20/40 character is the size the same person could see at 40 feet. If someone can only see the 20/40 character at 20 feet and not the 20/20 character, they are said to have 20/40 vision. However, a person with 20/20 vision could see that character from 40 feet. As the characters get larger, it is an indication of progressively worse vision at the same distance. The key is that the 20/40 character is exactly twice the height of the 20/20 character. The result is that the entire science of vision is based on the simple fact that if you are twice as far from the character it needs to be twice as large for equivalent visibility. As the trigonometry for this is all linear, it is a direct proportion of the distance. So, to make an image or display appear the same size when it is twice as far away it needs to be twice as tall or four times the size in area. The other key factor is legibility. The height of the 20/20 Snellen characters are defined as 5 minutes of arc (a minute of arc is 1/60th of a degree). ANSI recommends 20-22 degrees of arc as ideal for a computer user. ANSI recommends a much larger character height than the minimum measured by Snellen. This is shown in Figure 5.

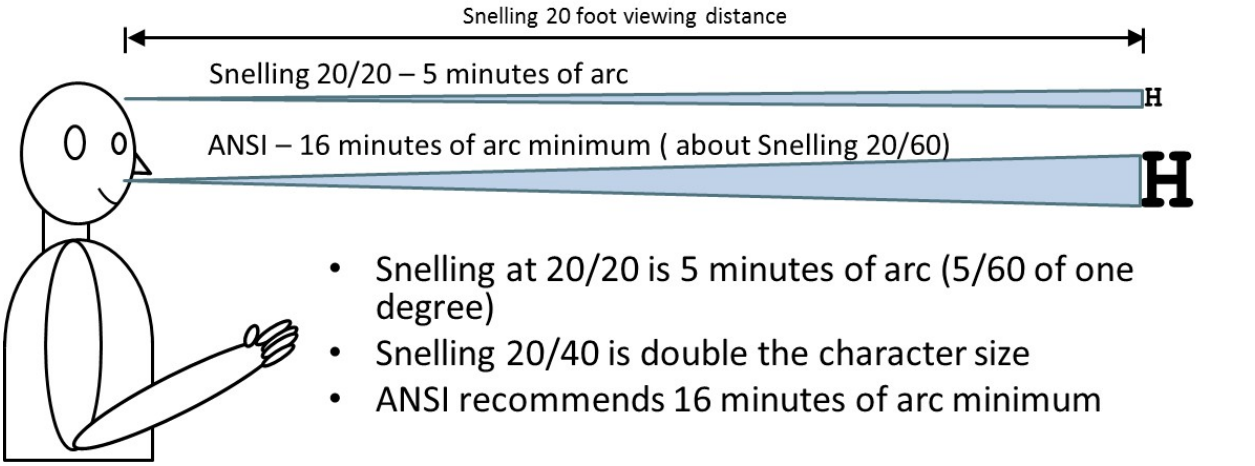


Figure 5 Snellen versus ANSI Recommendations

This is 3- 4 times the height of the Snellen 20/20 characters or equivalent to the Snellen 20/60 characters or a little larger. Figure 6 shows 11 point default font size on a 21 inch monitor viewed from a distance of 28 inches. That character height is almost exactly the 16 minutes of arc minimum character height recommended by ANSI. If the viewer moves farther away from the screen, the entire screen appears smaller. So, if you move twice as far away, the pictures will appear half as tall. While the height is actually reduced by half, the resulting image appears one quarter the size or much smaller. Figure 7 shows this with a sample Excel spreadsheet viewed at double and quadruple the base distance. So, if you were to normally sit 28 inches from your monitor, moving back to double the viewing distance to 56 inches would reduce the height of the display by 50%. Moving back to a viewing distance of 112 inches would reduce the display by another 50% or to 25% of the original height.

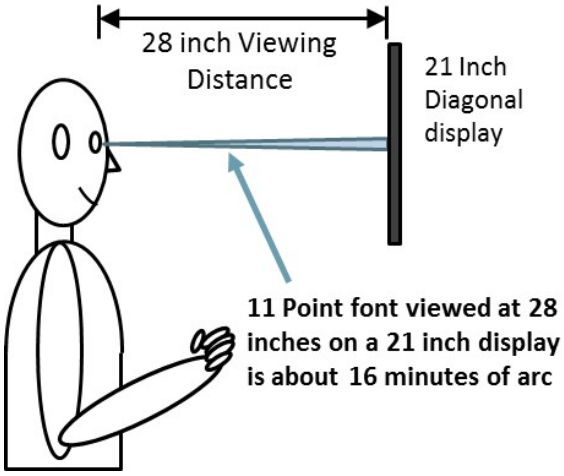
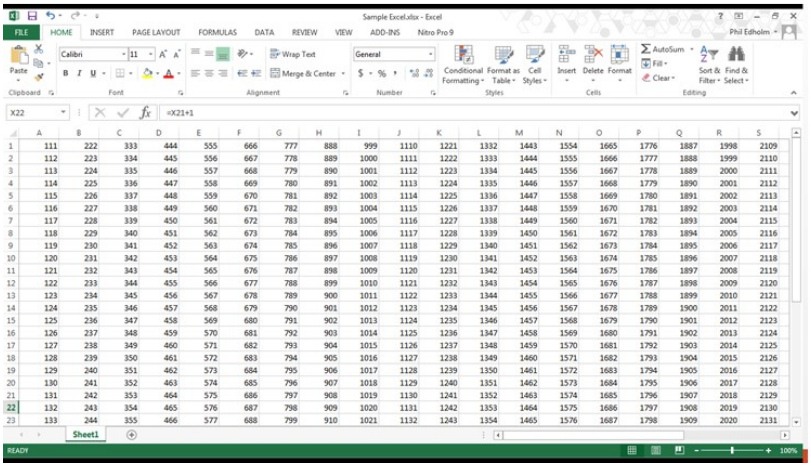


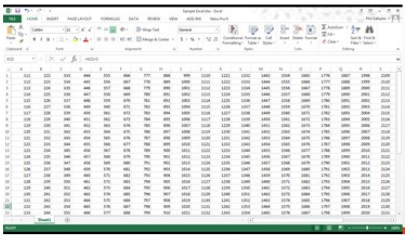
Figure 6 Default font height on a 21 inch display at 28 inch viewing distance

While the height (or width) has only been reduced to half, it is clear that it is much smaller and harder to see or read the information. The four times distance is impossible to read. Smaller dimensions equate to a much smaller viewing area as area is squaring height and width. For example, an 18 inch monitor is only 56% of the area of a 24 inch monitor. Similarly to increasing distance, reducing display size has an equivalent impact. As a point of reference, the first and second images are exactly the same as what would be seen comparing a 50 inch LCD display to a 100 inch projection display at the same distances. You can replicate this in your office by measuring the distance to your monitor and

Excel Spreadsheet Viewed from a Specific Distance X



Viewed from Distance Double X

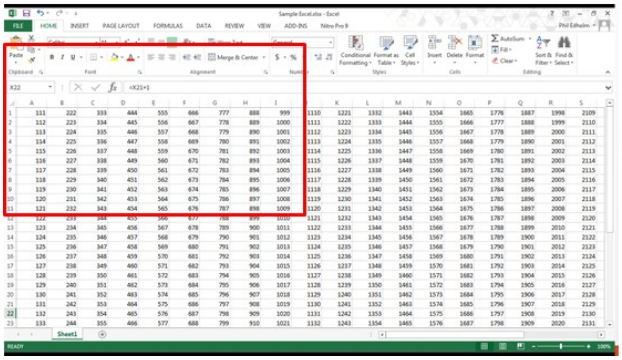


Viewed from Distance Four Times X

Figure 7 Change in Size as Viewing Distance Increases

moving back the same distance to double your viewing distance. You will see your monitor at half height and one quarter the area. Figure 8 shows the same comparison for a website. An alternative is to increase the size of the text in the image as the display gets relatively smaller. Figure 9 shows two views

Excel Spreadsheet at 100%



Excel Spreadsheet at 200%

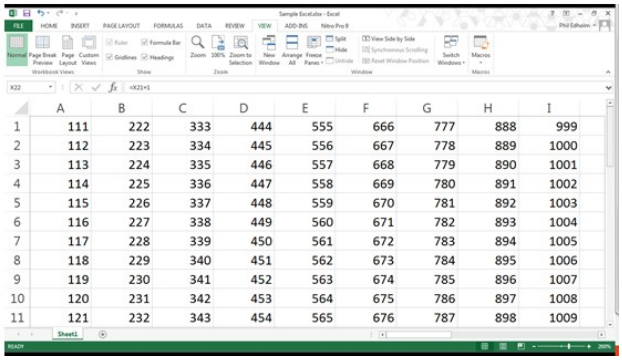
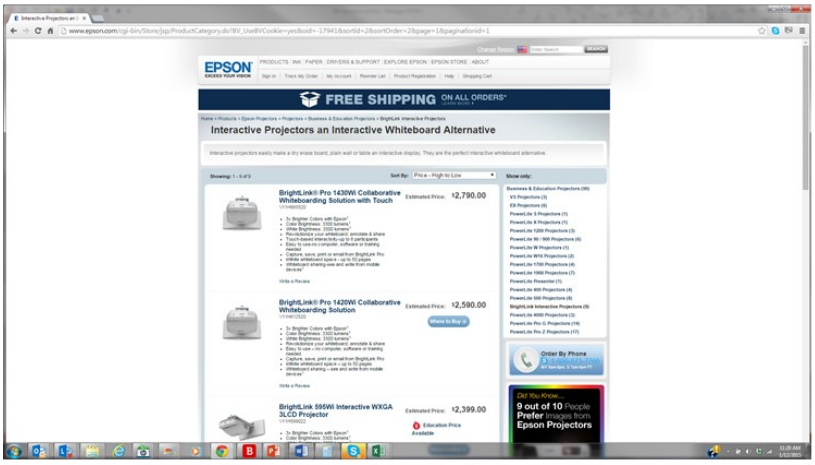
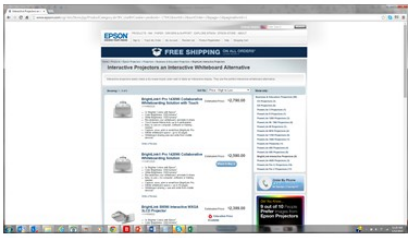


Figure 9 Impact on Viewable Area by Zooming in for Legibility

Web Page Viewed from a Specific Distance X (20/80)



Viewed from Distance Double X (20/40)



Viewed from Distance Four Times X (20/20)

Figure 8 Web Site Size Comparison

of the same sample spreadsheet with the right view doubled in zoom size and reduced by half in image size. This would be equivalent to zooming in on the image in a conference room so it is legible.

As can be seen the right image is double the character size (Equivalent to the Snellen 20/40), but only half of the information is available. The red box on the left image shows the limited content that is available. Figure 10 shows the same comparison for a viewed web page with zooming.

Webpage at 100% Webpage at 200%

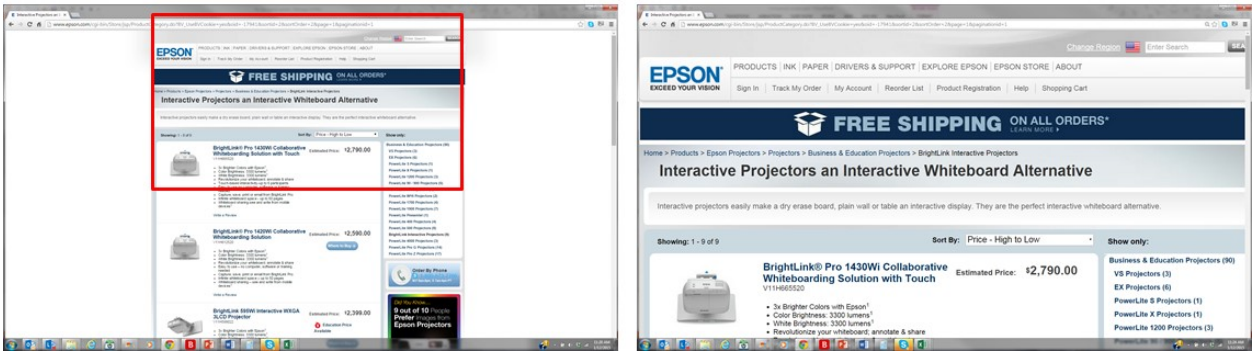


Figure 10 Impact of Website Zooming

As most documents and presentations are prepared on a desktop, trying to view them this way becomes difficult and often the context is lost. The critical value in analyzing the usability of a display is the ratio of the viewing distance to the screen height, expressed as:

$$\text{Viewing Ratio} = \frac{\text{Viewing Distance}}{\text{Display Height}}$$

The Viewing Ratio of viewing distance to height is a critical measure, to maintain the same relative appearance, the same ratio must be maintained for any viewing distance. The 4/6/8 rule is Viewing Distance, expressed as a maximum, as taking the distance divided by the height would equal 4 (or 6 or 8) at the maximum defined viewing distance. As shown in Figure 11, a typical 21 inch monitor viewed at the typical viewing distance of 28 inches yields a 41.2 inch maximum viewing distance (21 x .49 x 4). It is clear that this is much farther than the typical user sits from the monitor. This is the primary flaw with the 4/6/8, while it defines an absolute maximum, it does not define an optimal experience. Figure 12 shows the relative viewing ratios for a range of desktop monitors when viewed at 28 inches. As can be clearly seen, the 4/6/8

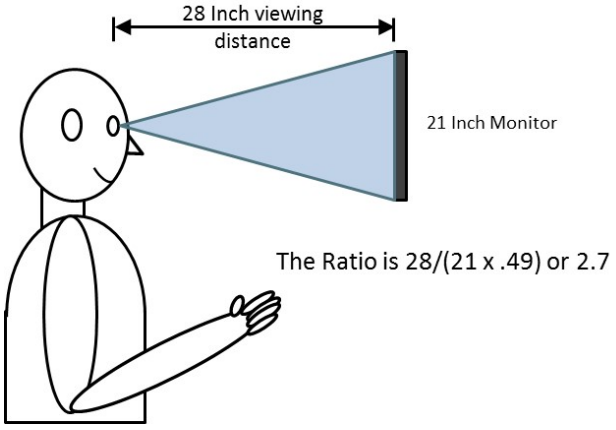


Figure 11 Viewing Ratio for 21 Inch Display and 28 Inch Viewing Distance

rule would prescribe that using a 14.5 inch diagonal display at the desktop as "acceptable" for collaboration. The actual average desktop monitor size of 21 inches is clearly much larger, in fact, it is actually over double the area of the 14.5 inch monitor that would be suggested if the 4/6/8 rule is followed. The typical 21 inch display viewed at 28 inches has a Viewing Ratio of 2.7, significantly less than the 4 of 4/6/8. The result is that the typical desktop appears twice as large as the suggested 4/6/8 display. This is the challenge of using generic AV "rules", the result will be significantly less useable than if desktop equivalency is used. As users are familiar with their desktop ergonomics, the display in a conference room built on the 4/6/8 rule will seem very small, and the documents will not be useable in many if not most cases.

Obviously, to make the image appear the same size at the longer viewing distance it must be larger. When the viewing distance to a display is increased as in a conference room, to maintain the same proportions it must also be expanded. Figure 10 shows this graphically. In Figure 13 the desktop and room system at 8 feet (96 inches) have the same Viewing Ratio. In this case the viewer is 8 feet away from the display. To maintain the same size as a 21 inch desktop monitor viewed from 28 inches in Figure 9, the resulting display needs to be at least a 72 inch diagonal display. Multiplying the Viewing Ratio of .75 times the Viewing Distance of 96 inches.

Desktop Monitor Diagonal (inches)	28 Inch Viewing Ratio
12	4.8
13	4.4
14	4.1
15	3.8
16	3.6
17	3.4
18	3.2
19	3.0
20	2.9
21	2.7
22	2.6
23	2.5
24	2.4
25	2.3
26	2.2
27	2.1
28	2.0

Figure 1211 Viewing distance Ratios for Different Desktop Monitors

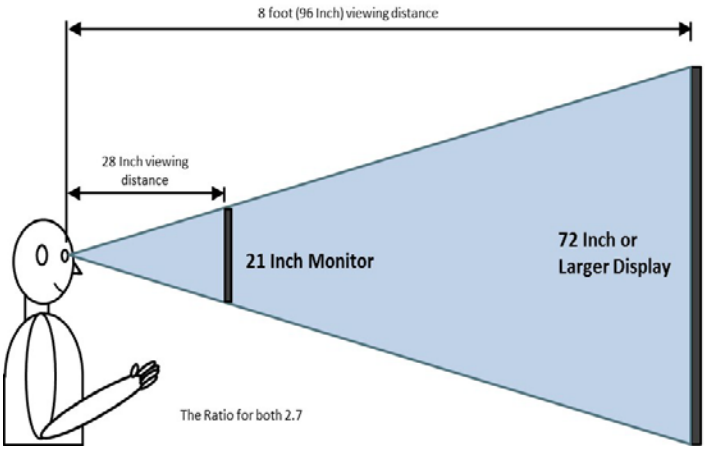


Figure 12 Equivalent Room Display at 8 Foot Viewing distance

Video Conferencing

In a video conference, one or more attendees, either remote on a personal device or in another room, are displayed on the monitor. Video is used for two purposes, primarily to see the other person and, through visual feedback, judge their response to what is being said or discussed. It can also be used in a group meeting to judge attentiveness (no more doing email while "listening"). In either case, seeing the individual in the right scale and resolution is critical.

The term Video Scale here refers to the exposed size of the image of the person being transmitted. This can be anything from a simple head shot to a full-body view. What is clear is that a torso view (above the waist to the top of the head) is really required for reasonable analysis of video clues. The terms "poker face" and "body language" refer to a unique facet of human conditioning; while many of us are able to control our facial emotions, often our body language and position gives real clues as to our actual reactions and/or interest. Figure 14 shows a head shot and torso view of the same individual. It is clear that the interpretation of reaction is different between the two images

Figure 13 The Value of Body Language

The History Channel video "Secrets of Body Language" (10) discusses how the elements of body language consists of body posture, gestures, facial expressions, and eye movements. Humans send and interpret such signals almost entirely subconsciously." The point is that it is much more than the face and the eye movements. In this video, the value of body, arm and hand positions and gestures are also discussed. The value of seeing the entire upper body is covered in great detail.

The other factor is resolution. To see changes in facial expression, many of which can last less than 50 Milliseconds (msecs), requires reasonable resolution. This is why HD video and telepresence have been so popular with executives. In a telepresence system, the display size is much larger than a typical desktop. For example, the Society of Motion Picture and Television engineers (SMPTE) recommends viewing with 1.6 times the diagonal from an HDTV screen to see an image clearly, while the THX recommendation is only 1.2. To see a typical 21 inch monitor, this means sitting 24-30 inches away based on movie/video standards. For a 16x9 display, this is converted to the height by essentially doubling the number. So SMPTE recommends a viewing distance of 3.2 times the height, while THX recommends a distance of only 2.4 times the height. It is clear that for effective video conferencing the 6 times recommendation in 4/6/8 is significantly longer than either recommended by video/film or is typically used in bespoke telepresence rooms.

Measuring Your (or multiple) Desktop(s)

To assure that your conference rooms are as close as possible to the desktop experience to optimize collaboration and conferencing, it is first important to measure your desktop. Measure the viewing distance by sitting as you normally would while working and have a colleague measure the distance from your eyes to the screen. As noted earlier, this is typically 18-30 inches, though it is generally dependent on the monitor size. Either use the diagonal measurement of your monitor or measure it yourself using a tape measure to determine the height of your display.

The resulting measurements can be used to calculate the Viewing Ratio of distance divided by height using the formula shown in Figure 15. This ratio can be compared to those listed throughout the document and to the 4/6/8 recommendation. Remember, if the ratio increases significantly, the display is much smaller. To see how your display would be in a room at the 4 times height, move back from your display to the 4 times height distance. To make sure you are meeting the needs of your users, you can measure a number of desktop situations to see what is normal in your organization.

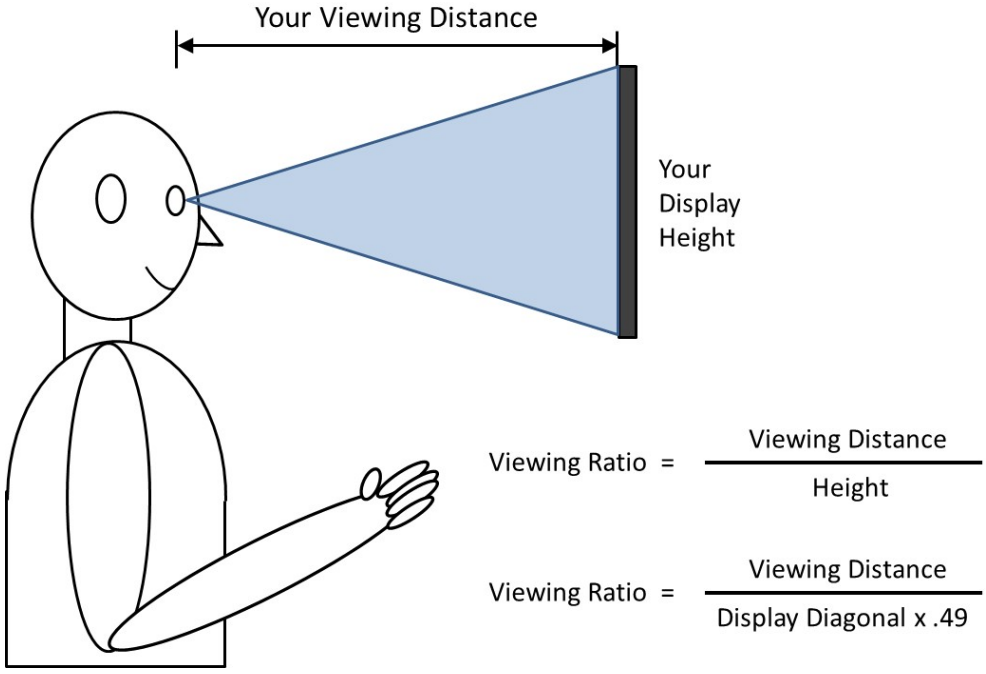


Figure 14 Measuring Your Display

Display Size for Conference Rooms

Based on the above analysis, the ideal conference room will have a display that emulates a 21 inch or larger diagonal desktop when viewed from 28 inches or less. At an absolute minimum, it should be an 18 inch monitor viewed at the same distance. To understand how this impacts the required size of displays, we will analyze three typical conference room sizes.

1. **Medium Conference Room** - A typical 8 seat conference table in a rectangular room of 14x10 foot dimensions.
2. **Large Conference Room** - A larger rectangular conference room with seating for 5 on each side of a conference table, yielding dimensions of 20x14
3. **Small Conference Room** - A small square conference room of 10x10 with a four person table in it. This configuration also works for a rectangular room with the screen on the long wall.

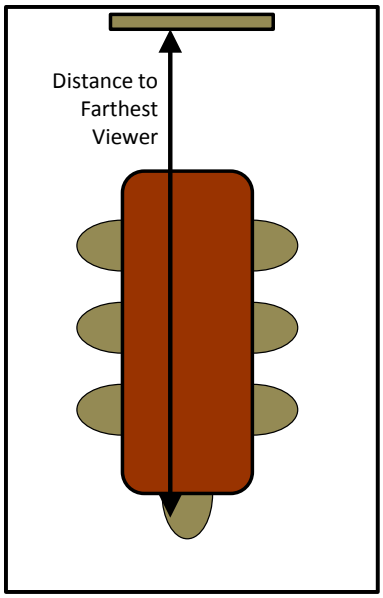


Figure 15 Farthest Viewing Distance in a Conference Room

For each room we will calculate the distance from the farthest participant to the screen as shown in Figure 16 and the required screen size to emulate the average 21 inch desktop monitor when viewed at 28 inches. This will enable us to define the ideal and minimum size screens for each room. Note that the display height is calculated using 16x9 for displays less than 80 inches and 16x10 for displays over 80 inches as larger conference-specific displays generally follow the 16x10 standard, while smaller displays generally follow the consumer 16x9 standard.

Room 1 Medium Conference Room

A representative medium sized conference room is shown in Figure 17. This room is 14x10 feet with a 4x8 foot conference table located 3 feet from either end wall for clearance. The resulting seating position for the farthest participant (generally the senior person) is 10.5 feet from the screen. This assumes the screen is mounted 4-6 inches off the wall and not recessed.

To clearly understand the comparison of a specific display size in the room to the desktop, the table shown in Figure 18 demonstrates this in two ways: first the minimum display size for the room to be at least the size of a 21 inch diagonal

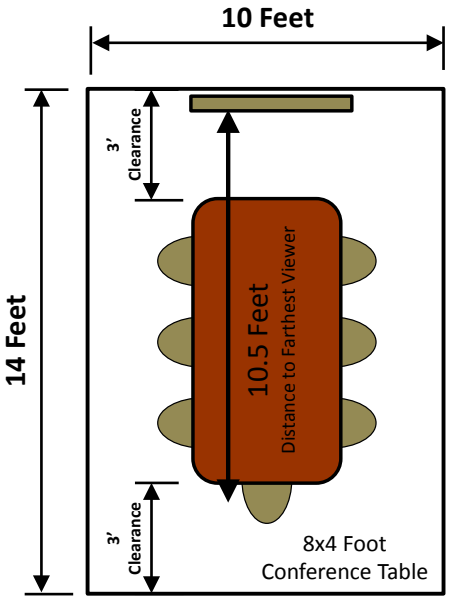


Figure 16 14x10 Foot Small Conference Room Configuration

desktop is calculated. For this room, that is a 99 inch diagonal display. Then, the equivalent desktop monitor size when viewed at 28 inches is calculated for a range of in-room displays, from 50 inches to 150 inches.

The results show clearly that in a 14x10 foot conference any display smaller than about 90 inches is inadequate for effective Collaboration that replicates the average desktop experience. The minimum actual acceptable size for this room is 99 inches. For comparison, if you follow the 4-6-8 rule, you would install a 70 inch monitor in this room as it is the next largest size that is greater than the 4 times ratio. This is equivalent to a 15 inch desktop display or only about 49% of the viewing area if you chose an ideal 100 inch display for this room. Even an 80 inch display delivers an experience that is equivalent to an 18 inch desktop display at 28 inches. If you were to install a 50 inch display in this room, it would be equivalent to asking your employees to use 10.6 inch monitors on their desks to do their work. Even a 70 inch display is only equivalent to a 15 inch monitor, the size found in an ultra-portable laptop. For easy visualization, , a color coding is used that relates to desktop monitor size, with green showing equivalent monitors from 21 to 27 inches, blue greater than 27 inches (oversize), and red less than the 21 inch desktop.

Equivalent Room Displays and Desktop Monitors for 14 x 10 foot Medium Conference Rooms	
Typical Viewing Distance (feet)	11
Typical Viewing Distance (inches)	132
Ideal Screen Size for Equivalent to 21 inch Desktop Display Viewed at 28 inches	
Ideal Display Diagonal	**99 inches**
4 Times Height Suggested Diagonal	**67 inches**
Comparative Desktop Monitor Sizes for Different Room Display Sizes	
Room Display Diagonal	**Equivalent Desktop when viewed at 28 inches**
50 inch Display	10.6 inches
60 inch Display	12.7 inches
70 inch Display	14.8 inches
80 inch Display	18.3 inches
100 inch Display	22.9 inches
120 inch Display	27.5 inches
150 inch Display	34.4 inches

Figure 17 Screen Sizes for 10 x14 Foot Medium Conference Rooms

It is clear that for a medium size 7-8 person conference room a typical 50-60 inch LCD display is woefully inadequate. In fact, Figure 19 shows a comparison of two screens in this size room, one a 67 inch LCD

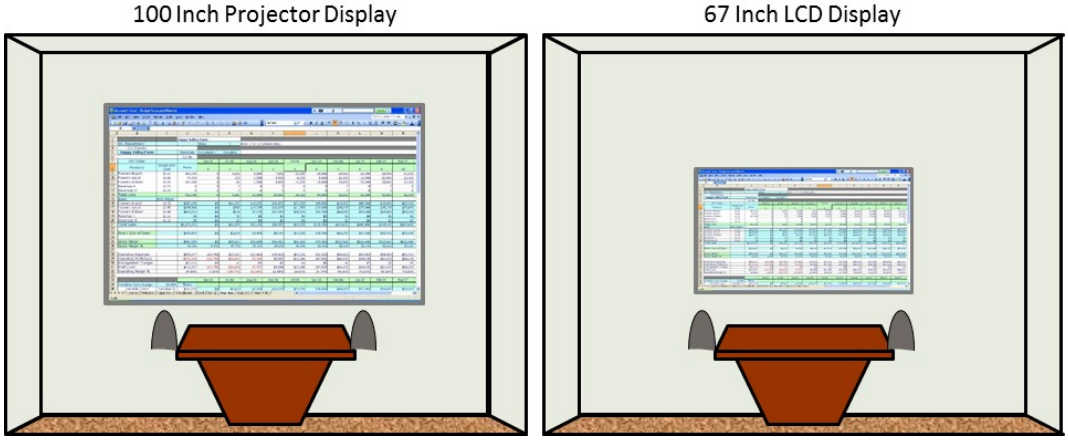


Figure 18 Comparison of 60 Inch LCD and 100 Inch Projectors in a Conference Room

display based on the 4 times height recommendation of 4/6/8 and the other a 100 inch projector. It is clear that the 67 inch LCD is very small in this space.

Room 2 Large Conference Room

The second Room we will consider is a large board room / conference room. This room is 20 feet long and 14 feet wide. Note that the room could be wider for side seating, added width will not impact the calculations. Figure 20 shows the room configuration, including a 6x12 foot conference table. Note that the table could be narrower as well without impacting our calculations.

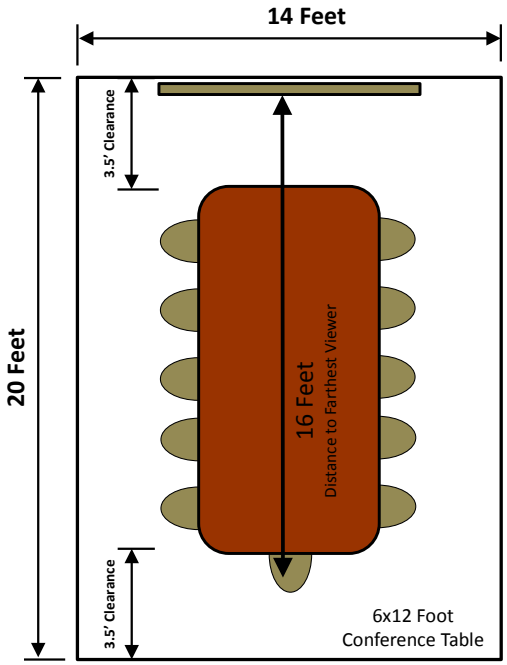


Figure 19 20x14 Large Conference Room Configuration

Figure 21 shows the calculations for this room based on the 16 foot maximum viewing distance. As can be clearly seen, even a 70 inch monitor will be dwarfed in this space. It is equivalent to looking at a 9 inch desktop monitor. While the 100 inch projection system is far more adequate, it is only equivalent to a laptop. Clearly, in this size room a projection system is mandatory. In fact a 150 inch projection on a plain wall or with a screen only achieves the equivalent of a 19 inch monitor when viewed at 28 inches.

Equivalent Room Displays and Desktop Monitors for 14 x 20 foot Large Conference Rooms	
Typical Viewing Distance (feet)	16.5
Typical Viewing Distance (inches)	198
Ideal Screen Size for Equivalent to 21 inch Desktop Display Viewed at 28 inches	
Ideal Display Diagonal	**149 inches**
4 Times Height Suggested Diagonal	**101 inches**
Comparative Desktop Monitor Sizes for Different Room Display Sizes	
Room Display Diagonal	**Equivalent Desktop when viewed at 28 inches**
50 inch Display	7.1 inches
60 inch Display	8.5 inches
70 inch Display	9.9 inches
80 inch Display	12.2 inches
100 inch Display	15.3 inches
120 inch Display	18.3 inches
150 inch Display	22.9 inches

Figure 20 Screen Sizes for 20x14 Foot Large Conference Rooms

Room 3 Small Conference Room

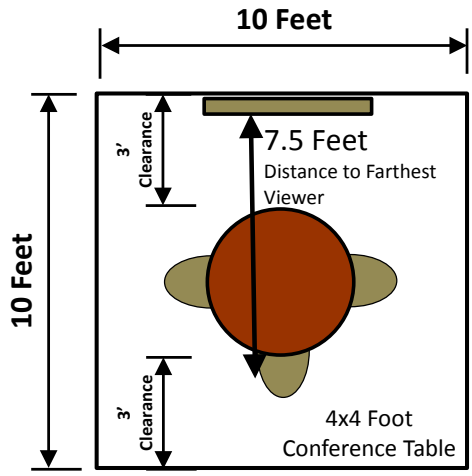


Figure 21 10x10 Small Large Conference Room Configuration

When a room gets as small as 10x10, the distances are now short enough that it would appear, on the surface at least, screen sizes can be smaller. However, increasingly these rooms are where Collaboration is being done, significantly increasing their value and the need for optimization of the experience. Small rooms are ideal for smaller groups and focused Collaboration activities like brainstorming and analysis.

This size can stand in for either a square room or a rectangular room with the screen on the long wall, though this is generally not a good configuration as the camera angles for video do not generally work well and all of the seating is lost on one long side of the table.

Figure 22 shows the configuration for this room. As it is only a small table centered in a small room, the distance to the screen is about 7.5 feet from the farthest position.

In this room, the required screen sizes are indeed smaller as shown in Figure 23, however, even in this size room, a 70 inch LCD screen is delivering a less than desktop experience, only closely equivalent to a 20.5 inch desktop monitor at 28 inches. The 50 inch display recommended by 4 times the height is equivalent to a 15 inch laptop monitor as viewed at 28 inches. It is clear that the experience, while barely adequate, will not get rave reviews from the staff. On the other hand, a projection display at 80 inches achieves the equivalent of a 22 inch monitor at 28 inches. Furthermore, the inherent image scaling in a projector enables it is be further optimized to the room versus a fixed LCD display panel.

Equivalent Room Displays and Desktop Monitors for 10 x 10 foot Small Conference Rooms	
Typical Viewing Distance (feet)	8
Typical Viewing Distance (inches)	96
Ideal Screen Size for Equivalent to 21 inch Desktop Display Viewed at 28 inches	
Ideal Display Diagonal	**72 inches**
4 Times Height Suggested Diagonal	**49 inches**
Comparative Desktop Monitor Sizes for Different Room Display Sizes	
Room Display Diagonal	**Equivalent Desktop when viewed at 28 inches**
50 inch Display	14.6 inches
60 inch Display	17.5 inches
70 inch Display	20.4 inches
80 inch Display	25.2 inches
100 inch Display	31.5 inches
120 inch Display	37.8 inches
150 inch Display	47.3 inches

Figure 22 Screen Sizes for 10x10 Foot Conference Room

Room Orientation

In a large room, placing the display on the short wall may result in long viewing distances. For a participant who is more than 15 feet from the screen, the image size becomes an issue. An alternative is to locate the display on the long wall. While this may be a better structure for viewing, it has an impact on the room use, both with and without the use of the display. Figure 24 shows the 20x14 Large Conference room in both a long end and side display positioning. As can be seen, the maximum viewing distance goes from 16 to 10.5 feet. However, two seats have been lost at the table during a visual collaboration or video conference and the room will generally be less structured as chairs are moved in and out of the table side by the display. In large rooms, using the longer wall display orientation may be a better option, even with the scale of a 100" projection display.

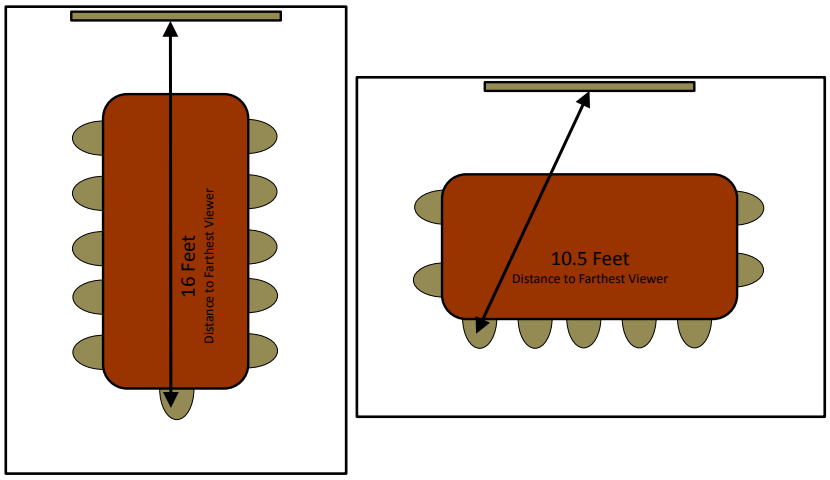


Figure 23 Room Orientation

Conclusions

It is clear from the analysis that using traditional LCD monitors in most conference rooms will not create a collaborative experience that is close to what a user experiences on their desktop. In all but the smallest conference rooms, a 50 to 60 inch LCD display is overwhelmed by the distance and becomes equivalent to looking at a desktop monitor from across the room. Projector technology enables a larger image that makes the conference room significantly more useable, both for information presentation, web conferencing as well as for video conferencing. In both use cases, a small display will make the user experience poor, whether because the details of a spreadsheet or document cannot be seen or that the image of the other participants in a video conference are so small as to not be visible for active watching. In either case, the room will not meet the goal of increasing interaction and eliminating travel and attendant costs often associated with today's advanced communications and collaboration systems. It is clear that replacing the typical small LCD display with a projector display can, at minimal overall cost, dramatically increase the usability and acceptance of your collaboration spaces.

Calculating Your Ideal Screen Size

This table uses the distances and sizes developed earlier.

Display Size for Equivalent Visibility

Screen Size Chart for Conference Rooms

Use the table below to select the optimal size display for any conference room.
Look up Room Length on the left and scan across to choose the appropriate display size for a quality experience.
Green provides Equivalent Visibility between optimized personal desktop experiences and meeting rooms. Dimensions are diagonal.
Note: Equivalent Visibility sets the average desktop monitor at 21" diagonal viewed at the typical maximum viewing distance of 30". For more detail reference the Display Size Matters whitepaper by Phil Edholm, PKE Consulting LLC.

Viewing Distance (feet)	Minimum Display Size for Equivalent Viewing to 21 Inch Desktop Display viewed at 28 inches	Minimum Display Size to Meet 4x Height of 4/6/8 Standards (16x9)	Comparative Desktop Monitor Sizes for Different Room Display Sizes and Acceptability Analysis								
			50 inch Display	55 inch Display	60 inch Display	65 inch Display	70 inch Display	80 inch Display	100 inch Display	120 inch Display	150 inch Display
6.0	54	37	19.4	21.4	23.3	25.3	27.2	33.6	42.0	50.4	63.1
6.5	59	40	17.9	19.7	21.5	23.3	25.1	31.0	38.8	46.6	58.2
7.0	63	43	16.7	18.3	20.0	21.7	23.3	28.8	36.0	43.2	54.1
7.5	68	46	15.6	17.1	18.7	20.2	21.8	26.9	33.6	40.4	50.4
8.0	72	49	14.6	16.0	17.5	19.0	20.4	25.2	31.5	37.8	47.3
8.5	77	52	13.7	15.1	16.5	17.8	19.2	23.7	29.7	35.6	44.5
9.0	81	55	13.0	14.3	15.6	16.9	18.1	22.4	28.0	33.6	42.0
9.5	86	58	12.3	13.5	14.7	16.0	17.2	21.2	26.6	31.9	39.8
10.0	90	61	11.7	12.8	14.0	15.2	16.3	20.2	25.2	30.3	37.8
10.5	95	64	11.1	12.2	13.3	14.4	15.6	19.2	24.0	28.8	36.0
11.0	99	67	10.6	11.7	12.7	13.8	14.8	18.3	22.9	27.5	34.4
11.5	104	70	10.1	11.2	12.2	13.2	14.2	17.5	21.9	26.3	32.9
12.0	108	73	9.7	10.7	11.7	12.6	13.6	16.8	21.0	25.2	31.5
12.5	113	76	9.3	10.3	11.2	12.1	13.1	16.1	20.2	24.2	30.3
13.0	117	80	9.0	9.9	10.8	11.7	12.6	15.5	19.4	23.3	29.1
13.5	122	83	8.6	9.5	10.4	11.2	12.1	14.9	18.7	22.4	28.0
14.0	126	86	8.3	9.2	10.0	10.8	11.7	14.4	18.0	21.6	27.0
14.5	131	89	8.0	8.9	9.7	10.5	11.3	13.9	17.4	20.9	26.1
15.0	135	92	7.8	8.6	9.3	10.1	10.9	13.5	16.8	20.2	25.2
15.5	140	95	7.5	8.3	9.0	9.8	10.5	13.0	16.3	19.5	24.4
16.0	144	98	7.3	8.0	8.8	9.5	10.2	12.6	15.8	18.9	23.6
16.5	149	101	7.1	7.8	8.5	9.2	9.9	12.2	15.3	18.3	22.9
17.0	153	104	6.9	7.5	8.2	8.9	9.6	11.9	14.8	17.8	22.3
17.5	158	107	6.7	7.3	8.0	8.7	9.3	11.5	14.4	17.3	21.6
18.0	162	110	6.5	7.1	7.8	8.4	9.1	11.2	14.0	16.8	21.0
Maximum Viewing Distance for Collaboration Based on 4/6/8 standard and emerging ANSI standards. (Decimal Feet)			8.2	9.0	9.8	10.6	11.4	14.1	17.7	21.2	26.5

Color Coding Key	
Excellent / Equivalent Visibility	Larger than a 21 inch but less than 27 inch desktop monitor when viewed at 28 inches This will deliver a room experience that is equivalent to a desktop experience.
Extra Large	These sizes are larger than a 27 inch desktop monitor at 28 inches This size will create an experience significantly bigger than the desktop.
Marginal / Acceptable	Larger than a 15 inch but less than 21 inch desktop monitor when viewed at 28 inches This meets 4/6/8 and ANSI minimums, but is not equivalent to a desktop experience.
Not Recommended	Less than a 21 inch desktop monitor viewed at 28 inches - will be a poor experience This is a poor experience that does not meet any standards

Note: Displays less than 80 inches are assumed to be 16x9, diplays 80 inches or larger are assumed to be 16x10

Analysis and Modelling by PKE Consulting LLC
Leaders in Visual Collaboration Analysis

Figure 24 Optimal Screen Sizes for Different Sized Conference Rooms

This chart in Figure 25 has been color coded for which displays meet the criteria established for Great/Ideal, Adequate, and Poor based on the analysis in this paper. In addition, a column is included to show the recommended 4/6/8 display using the 4 times height rule, as well as the 4 times maximum distance for each display size towards the bottom. These will allow you to decide the ideal for your room, whether to go with the minimum acceptable or optimize the experience to a desktop equivalency. What is clear from this analysis is that typical 50-60 inch LCD displays are adequate only in very small rooms. In fact, a 60 inch display is equivalent to an antiquated 17 inch desktop monitor at an 8 foot viewing distance, typical in a small 10-12 foot long room. In a medium 15 foot room with a 12 foot viewing distance, a 60 inch LCD display will provide a very poor experience, being the same as using a 12 inch laptop or tablet from 28 inches viewing distance. By contrast, a 100 inch projector display will yield a great experience when viewed from about 12 feet, and an useable experience up to a16.5 foot viewing distance, which is the 4 times height distance in the 4/6/8 rule.

Final Thoughts

Organizations are looking to enhanced collaboration and video conferencing to generate significant benefits. These may be hard benefits like reduced travel costs, and productivity benefits through better collaboration. All of these outcomes require that the collaboration/conferencing experience be of high enough quality that users will adopt and use the technology. Organizations like yours are enhancing their existing conference rooms with these tools as they enhance the meeting for the participants in the room and enable those attending remotely to have a great experience. A key to this is having the visual image be of high quality. As this paper has clearly detailed, the investment in collaboration/conference rooms will be defined by the usability of the visual image and size is critical. The mistake of choosing a small LCD display, while saving 5-10% of the total installation and operational cost, may result in significantly reduced conference room usage and acceptance and increased complaints and negative views of IT. While recommendations like the 4/6/8 rule are often used, they are seen as “standards” versus the bare minimum requirements. In most cases the senior person will be sitting at the maximum viewing distance in the room (head of the table, farthest from the display), and will have the poorest experience. Choosing a display based on 4/6/8, while following “common knowledge” will result in a poor experience for those individuals. Designing your conference rooms using the Equivalent Visibility Rule will deliver an optimized experience based on what your users experience at their desktops. This will result in better adoption and satisfied users. It is clear that choosing wisely in the initial install will result in happy users and reduce the possibility of changes in the future.

References and Links

The following are references and links to citations for the data used in preparing this paper.

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