Determining the minimum display size for classroom settings

Optimizing the learning experience

Texas Instruments

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One common question in the design of educational settings involves a visual display standard.

There are many attributes of visual displays that impact educational effectiveness, but arguably none are as important as the ability to clearly see the text and images presented, and that is largely limited by 1) the distance from the viewer to the display and 2) the size of the display.

Instead of two separate values, we simplify the problem by creating a Distance to Screen Height Ratio (DSHR), which is the ratio of distance to viewer to height of the screen:

Screen Height Ratio (DSHR) = Distance from viewer to screen / height of the screen

Note that if the distance to screen and height of the screen are in the same units DSHR has no dimensions.

Distance to Screen Height Ratio (DSHR) is the ratio of distance to viewer to height of the screen

In an ideal classroom setting the clarity of the display would be independent of the seating location in the room: students in the front and the last row would see the presentation just as clearly. How can this be attained?

Rule of thumb: the 4-6-8 rule

Traditionally A/V implementations have followed the "4-6-8 Rule"[1]. This rule divides audiences of viewers into three functional categories:

- General, or passive viewing (movies, video content with few symbols or text)
- Detailed (presentations, web sites, spreadsheets)
- Inspection (medical images, maps, etc.)

Educational environments are in the "Detailed" group. The 4-6-8 rule sets the minimum screen size for each group:

- General viewing: DSHR = 8
- Detailed viewing: DSHR = 6
- Inspection viewing: DSHR = 4

As an example, in a classroom with 30 ft. from the screen to the most distant student, applying the 4-6-8 Rule would require:

Screen height = Distance to screen / DSHR = 30 ft. / 6 = 5 ft. = 60 inches

This is the *minimum* recommended size. Note that this is the screen height. Most screens are organized and sold by the diagonal size, which is related to the screen height by the screen aspect ratio.

The 4-6-8 Rule was not created by rigorous studies on information comprehension and retention. It was simply a "rule of thumb" used by audio visual designers to follow what seemed appropriate. Ideally, an improved standard based on visual acuity would be a suitable replacement.

[1] http://proavbiz-europe.com/index.php?option=com_content&view=article&id=4926:visual-presentation-spaces-understanding-the-468-rule&catid=20&Itemid=0

ANSI/Infocomm V202.01

In 2016 a new standard, *ANSI/Infocomm V202.01:2016 display image size for 2D content in audiovisual systems*[2] was approved. Infocomm (now AVIXA) is a trade association for audio/visual industries. In the vocabulary of V202 there are two categories of viewers:

- Basic Decision Making (BDM) – comparable to the Detailed Viewing group in 4-6-8 Rule. BDM is based on accurately resolving symbols (letters, numbers, etc.). Examples include classrooms, boardrooms and multipurpose rooms.
- Analytical Decision Making (ADM) – comparable to the Inspection Viewing in 4-6-8 Rule. ADM is based on accurately resolving pixels in the image. Examples include medical images, fine arts and photographic image inspection.

V202 alone cannot answer the question of display size for classroom settings.

Educational environments are BDM. Using known visual acuity rules V202 successfully relates screen height to viewing distance for ADM viewers, but, unfortunately, the relationship for BDM is far less useful. For BDM viewers, V202 relates viewing distance to "%Element Height" which is the ratio of the symbol height to the screen height. In other words, if the presenter used a sufficiently large font point size almost any size screen could be made serviceable. Of course, as the font point size increases the amount of information displayed is reduced. Information comprehension depends on understanding information in context – using what is known to understand what is not known – so the simultaneous display of information (a proof in mathematics, a block of text in literature, etc.) is critical. Unless additional research can determine a critical minimum level of data content for simultaneous display, V202 alone cannot answer the question of display size for classroom settings.

Survey of educational institutions design guidelines

Another approach to determine minimum screen size is to survey educational institution design guidelines. It could be argued that this is a circular argument: these guidelines were written with knowledge of the 4-6-8 rule. However these institutions have sufficient experience to determine what works well in the classroom and could modify

Classroom Design Source	Document Date	DSHR
University of Iowa	2004	5
University of Northern Colorado	2008	5
University of Connecticut	2014	6
UC San Diego	2014	6
Montana State University	2011	6
Emory College	2010	5
University of Washington	2008	4.3
North Carolina State University	2015	5
Florida State University	2013	6
Texas State University	2015	5
University of Hawaii	2013	6
University of Kansas	2017	5
University of New Mexico	2012	6
UC Santa Cruz	2015	6
Arizona State University	2013	6
Indiana University	2010	6
University of North Carolina at Wilmington	2017	6
Ohio State University	2017	6
Average DSHR		**5.49**

***Table 1**. Summary of DSHR from Educational Institution Guidelines.*

[2] https://www.infocomm.org/DiscasCalc/both.html

a rule of thumb starting point to arrive at a better standard – and many have. The following data was collected and compiled using guidelines from 2004 and later to avoid obsolete standards.

The average DSHR is even lower than the 4-6-8 Rule would suggest, with many institutions using values of 5 and as low as 4.3. As a reminder, Detailed Viewing in the 4-6-8 Rule has a suggested DSHR of 6. An additional point is that most design guidelines specify 16:9 or 16:10 aspect ratio screen, with 4:3 screens less common.

Using average DSHR and aspect ratio the screen diagonal can be determined. The details of this derivation can be found in the appendix. The minimum screen sizes for both 16:9, 16:10, and 4:3 aspect screens are shown below.

To clarify, the tables can be used if either the screen size or distance is unknown. For instance, using **Figure 1**, if the most distant student is 30 ft. from the screen, the minimum diagonal screen size is between 120 and 140 inches. Likewise, if a screen has a diagonal of only 85 inches, its use should be limited to classrooms of 18 to 20 ft. depth.

Conclusions

All involved in the educational process want to do what is best for the student. An environment that encourages comprehension and removes hindrances is the goal. By designing learning spaces with displays that exceed minimum sizes, all students can clearly see the presented information. The guidelines of educational institutions - which have been on the mission of improving instruction for many years – give insight into what should be minimum classroom screen size.

	16:9 Screen Diagonal [in]												
Max Viewing Distance [Ft]	**75**	**80**	**85**	**90**	**100**	**110**	**120**	**140**	**160**	**180**	**200**	**240**	**280**
10													
12													
14													
16													
18									Acceptable				
20													
22													
24													
26													
28													
30													
32													
34													
36													
38													
40			Not Acceptable										
42													
44													
46													
48													
50													
52													
54													
56													
58													
60													

Figure 1. *16:9 aspect ratio results.*

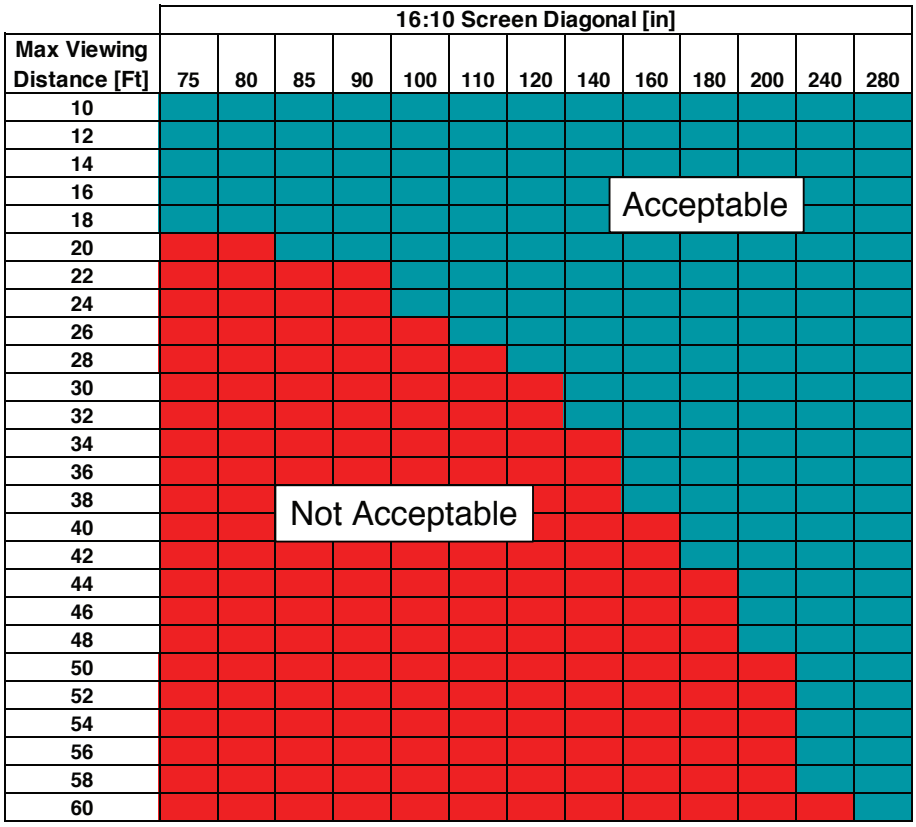

Figure 2. *16:10 aspect ratio results.*

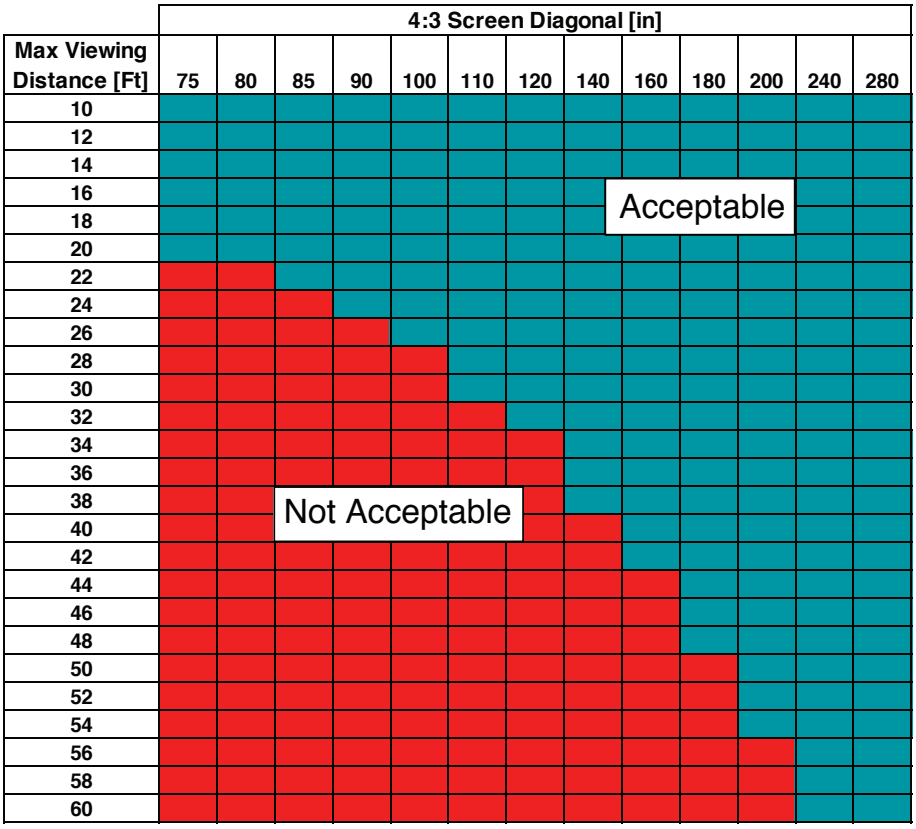

Figure 3. *4:3 aspect ratio results.*

References

Classroom Design Source	URL
University of Iowa	http://www.facilities.uiowa.edu/cfp/spu/Classroom%20Design%20Standards.pdf
University of Northern Colorado	http://www.unco.edu/facilities/pdf/planning-and-construction/UNC-Guidelines-Tech-Classroom-Design-10-22-08.pdf
University of Connecticut	https://updc.uconn.edu/wp-content/uploads/sites/1525/2016/10/Appendix-VI-Classroom_Design_Guide-September-2016.pdf
UC San Diego	https://blink.ucsd.edu/_files/technology-tab/media/services/av-guidelines.pdf
Montana State University	http://www.montana.edu/pdc/documents/MSUClassroomDesignGuidelines.pdf
Emory College	http://college.emory.edu/business-operations/documents/facilities/classroomGuidelines.pdf
University of Washington	https://www.cte.uw.edu/w/images/2/22/Classroom_Design_Guide.pdf
North Carolina State University	https://facilities.ofa.ncsu.edu/files/2015/02/division00_classrooms.pdf
Florida State University	https://www.facilities.fsu.edu/depts/designConstr/New_Design_Guidelines/In_Progress/General%20Planning%20and%20Design%20Guidelines/General%20Classroom%20Design.pdf
Texas State University	http://gato-docs.its.txstate.edu/jcr:6d9171c5-4f52-4e5c-86be-03cd8ac429cb/27_41_16-51-Integrated-Audio-Video-Systems-and-Equipment-for-Classrooms_2013.pdf
University of Hawaii	http://planning.manoa.hawaii.edu/UHM%20Classroom%20Design%20Guidelines-%20July%202013.pdf
University of Kansas	https://classrooms.ku.edu/sites/classrooms.ku.edu/files/docs/ClassroomTechStandards2017.pdf
University of New Mexico	http://pdc.unm.edu/assets/documents/0-LEDG-v.1.0-120224.pdf
UC Santa Cruz	https://its.ucsc.edu/media-system-design/Draft-Classroom-Guidelines-3-12-15.pdf
Arizona State University	https://www.asu.edu/fm/documents/project_guidelines/Classroom-Design-Guidelines.pdf
Indiana University	https://assets.uits.iu.edu/pdf/03-29-2010ClassroomModelDescription.pdf
University of North Carolina at Wilmington	https://uncw.edu/architecturalandconstruction/documents/Design%20Guidelines%20Issue%20September%202017.pdf
Ohio State University	https://fod.osu.edu/sites/default/files/bds.pdf

Appendix

Derivation of minimum screen size equation

S_A = Screen Aspect Ratio

S_W = Screen Width

S_H = Screen Height

S_D = Screen Diagonal

D_S = Distance to furthest student

DSHR = Screen Height Ratio

Now:

$$S_A = \frac{S_W}{S_H}$$

$$S_D{}^2 = S_W{}^2 + S_H{}^2$$

Combining these gives:

$$S_H = S_D \frac{\sqrt{(1 + S_A{}^2)}}{1 + S_A{}^2}$$

We have previously defined DSHR:

$$DSHR = \frac{D_S}{S_H}$$

So:

$$D_S = S_D\, DSHR \frac{\sqrt{(1 + S_A{}^2)}}{1 + S_A{}^2}$$

Or, likewise:

$$S_D = \frac{D_S \sqrt{(1 + S_A{}^2)}}{DSHR}$$

*Using the value from **Table 1** the minimum screen diagonal (S_D) is related to the Distance to the furthest student ($_D$) :*

For 16:9

$$D_S = 2.692\ S_D$$
$$S_D = 0.3715\ D_S$$

For 16:10

$$D_S = 2.91\ S_D$$
$$S_D = 0.3437\ D_S$$

For 4:3

$$D_S = 3.294\ S_D$$
$$S_D = 0.3036\ D_S$$

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