What Everyone Should Know About Flat-Panel Speakers in Schools

Compact flat-panel speaker technology is a common way to amplify audio from MP3 players and other personal electronics in a relatively small area. But some companies, such as Lightspeed™, suggest that one of these speakers could serve an *entire* classroom. Referencing two independent researchers, this paper examines the validity of the following major claims about flat-panel speakers used in schools:

- That flat-panel speakers provide *great sound coverage*
- That flat-panel speakers provide *great sound quality*
- That flat-panel speakers provide the *easiest installation*

Sound Coverage: Are *all* students hearing the lesson?

Lightspeed claims that its flat-panel technology provides room-filling sound by utilizing the entire flat-panel surface to emit audio in all directions, creating "excellent sound distribution from a single speaker."

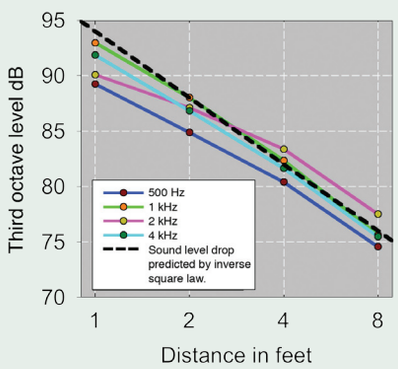
Be wary of such claims because flat-panel systems are no more effective than any other single speaker at delivering equal sound throughout the seating area. They still follow the inverse square law – a well known law of physics – that states that the average sound level falls by 6 decibels (dB) for every doubling of distance from its source. In other words, the farther students are from the flat-panel speaker, the harder it will be for them to hear the lesson clearly.

Despite the claims, flat-panel systems simply can't "throw" sound farther than speakers placed throughout the room or in a line array *(See Figure 1)*. For the same reason you wouldn't think of lighting a whole classroom with a single light bulb, your students won't benefit optimally from just one speaker.

Figure 1

REDCAT® Sound Quality Over Distance

Source: Evaluation of Lightspeed Flat-Panel Loudspeaker SP007661, Arthur Boothroyd. 2006.



Lightspeed claims that sound level falls less with its REDCAT flat-panel speaker than the inverse square law would predict. However, as the measured data in this graph shows, there is no evidence for the claim that the REDCAT can "throw" sound farther than a conventional speaker. One speaker simply cannot adequately cover an entire classroom.

As quoted in the independent report *Sound Field Speaker Coverage Modeling Study,*[1] "All single-speaker solutions that have a coverage pattern that approximates a spherical wave front, and therefore inverse square law attenuation of the direct sound, have the same basic limitation in covering a large area uniformly. This is the same basic behavior as an unaided talker. The only way to be loud enough in the back is to talk louder in the front." As the report continues, "For any single-speaker installation, there will be significant drop in the direct sound level with increasing distance, and this will always result in having the sound levels be much higher for the listener close to the speaker than the most distant listener would experience. If the distance is large enough *it may be too loud for the closest listener when it is adequately loud at the most distant listener.*"

In other words, some children will be over-amplified with flat-panel systems, while others won't get the clarity they need for learning. In order for a single sound source (of any kind) to adequately reach students far from the speaker, the volume needs to be turned up significantly, which can cause hot spots and feedback. To reduce the chance of feedback, you can turn up the volume – but then students sitting near the side walls and at the back of the class may miss out on fragile consonant sounds, like "s", "f" and "th" that are crucial to comprehension and language development.

[1] *Sound Field Speaker Coverage Modeling Study*, McSquared System Design Group, Inc. 2004.

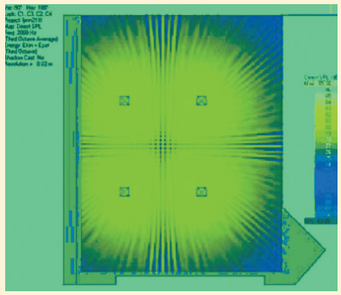
The only way to solve this conundrum is to put more speakers in the room — in either a multi-speaker installation or a line array. A multi-speaker system works simply because every student is close enough to at least one speaker to understand clearly at a comfortable volume. Alternatively, line arrays take advantage of the effects of constructive interference by sound waves from multiple speakers to more evenly disperse audio *(See sidebar on page 4)*.

With multi-speaker and line array sound systems, *all* areas of the class are at an optimum signal-to-noise ratio *(See Figure 2)*. That means no matter where the students are seated, they will always be able to hear the teacher's lesson, information from peers, or streaming media content. As the teacher moves around the room – effectively putting every child at the back of the class at some point – there is no worry that educational content will be missed. This includes "healthy hearers," students with hearing loss or auditory deficits, and kids with special needs *(See Figure 3)*.

Figure 2

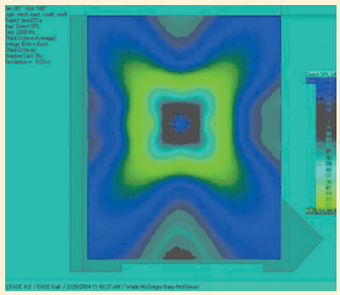
Multi-Speaker Set-Up in a Classroom – Evenly Dispersed Sound

Source: Sound Field Speaker Coverage Modeling Study, McSquared System Design Group, Inc. 2004.



Multi-speaker systems ensure that sound is spread uniformly around the classroom. This creates less chance of feedback, less variance between the maximum and minimum sound level, and no hotspots. All areas of the class are at an optimum signal-to-noise ratio. In this EASE plot, the green area covers the seating area fairly well, only falling off at the edges of the room.

Flat-Panel Speaker Set-Up in a Classroom – Poor Sound Distribution

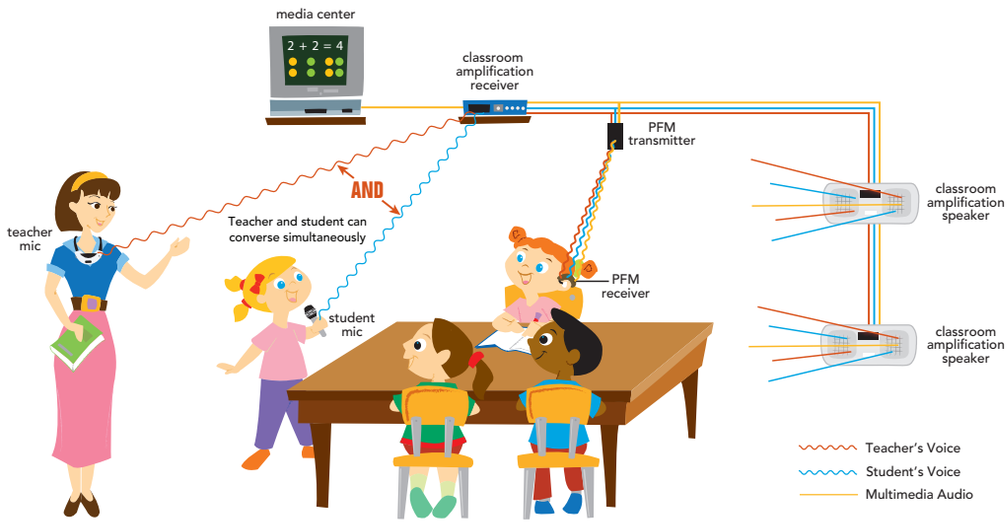


A single flat-panel speaker is not magic — it is still subject to the inverse square law – meaning its sound level falls off dramatically with distance. Attempting to use it to reach students sitting far away can cause hotspots and feedback. In this EASE plot, you can also see a deep null in the coverage of the seats near the side walls — students sitting here will not be adequately served.

Figure 3

FrontRow Total Auditory Integration for More Inclusive Classrooms

Source: How to Combine Personal FM and Classroom Sound Systems: The Total Auditory Integration Method for Students' Benefit, Maureen Doty-Tomasula. 2011.



FrontRow systems distribute the teacher's voice and sound from all multimedia sources to every point of the classroom. Students with hearing loss (wearing personal FM systems) have equal access to all audio, ensuring a more inclusive classroom.

Sound Quality: Is it clear enough for language and literacy development?

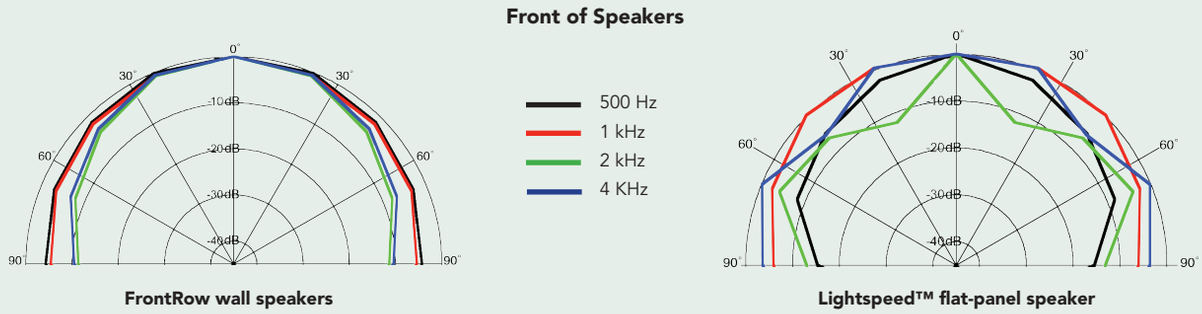
Lightspeed claims that its flat-panel technology provides "bending wave technology," "clear audio," and "high speech intelligibility," but even much higher-quality flat-panel sound systems aren't yet suitable for kids' hearing and language needs. In an independent study,[2] Dr. Arthur Boothroyd found that students sitting at certain angles relative to Lightspeed's flat-panel speaker may suffer drastically reduced clarity because of a 12-14 dB muffling of the critical 2kHz speech frequency. Furthermore, in classrooms where reverberation times are often over .7 seconds, the Lightspeed flat-panel becomes a liability, providing an increased risk of masking important speech frequencies due to its reduced directionality. ("Masking" refers to an acoustical phenomenon in which one sound is obscured by another, harming intelligibility.)

For younger learners especially, sound quality is of huge significance. Since language and literacy development occur early in life – and are both dependent on hearing and understanding – the need for proper speech intelligibility is clear. Kids who have good listening experiences tend to be better readers, which sets the stage for higher academic achievement in later years. It's not just about raising the volume. It's about ensuring the sound is clear and *intelligible*. That's why it's important to be wary of marketing terms like "bending wave technology" that claim better sound quality without the support to back them up. As the measurements in Figure 4 show, flat-panel systems are inherently less crisp and clear than more mature cone speaker technologies. Some people even describe the sound from flat-panel speakers as "muddy."

Figure 4

Sound Distribution Comparision – FrontRow vs. Lightspeed

Source: Evaluation of Lightspeed Flat-Panel Loudspeaker SP007661, Arthur Boothroyd. 2006.



These diagrams illustrate how a flat-panel speaker compares with more mature cone speaker technology in its ability to faithfully and evenly reproduce frequencies needed for student understanding. The FrontRow speaker at left reproduces all frequencies at nearly equal sound levels regardless of what angle we measure from. For students seated between -60 and +60 degrees from the center of the speaker, the output never deviates more than about 6 or 7 dB at the all-important 2 and 4 kHz frequencies. The REDCAT speaker on the right, however, is dramatically inconsistent. Students sitting at roughly 30 degrees to either side of this speaker will suffer from inadequate reproduction of the 2kHz frequencies needed for understanding important consonant sounds.

According to MCSquared System Design Group, Inc., an independent consulting firm providing sound system and other acoustical design services, "Many sound systems are built using packaged 'rock and roll' loudspeakers, and the resulting sound systems can be loud enough and yet still be deficient in speech intelligibility. It is very important to identify the primary purpose of a sound system when designing it."

When it comes to outfitting your classrooms, better sound and improved speech intelligibility should be your priority. Products like the FrontRow Pro Digital not only use appropriate speaker technologies, they also contain special technology to ensure students get the speech intelligibility they need. The Pro Digitial has OptiVoice™, a patented speech-enhancing feature that emphasizes consonant sounds that are critical to language development, but which often get lost in background noise.

When shopping for any classroom sound system, it's important to be alert to designs based on acoustical and audiological science, and those built around spurious marketing stories. The best approach is to consult your district audiologist or AV consultant, and try before you buy.

[2] *Evaluation of Lightspeed Flat-Panel Loudspeaker SP007661*, Arthur Boothroyd. 2006.

Installation: Does it come at the expense of quality?

Ease of installation is the strongest argument for using flat-panel speakers; however, in reality, feedback makes these speakers a *challenge* to install. Unless they are mounted in the ceiling or very high on the wall (which is impractical for teachers), their susceptibility to feedback can create "no-go zones" for teachers – i.e. teachers can't walk near them without experiencing harsh high-pitched squealing noises. This feedback can be minimized if the speakers are moved away from students (often mounted at the back of the room), but then you negate the benefit of the system. As studied by McSquared, "These [flat-panel] systems will always have an issue where the feedback threshold with an open microphone will limit the maximum available sound level. By the time the system gain is increased to the point where it would be louder than the unaided voice, it will likely be prone to feedback when the teacher was close to the speaker and will operate safely when the teacher is furthest away from the speaker. If this is the only way the system is used, where the single loudspeaker is on the opposite side of the room from the teacher, then there can be some small benefit to the increased sound level at the greatest distance from the teacher, but that also limits how close the teacher can get to the speaker and the students on that side of the room." [3]

In contrast, multi-speaker systems have better speaker design, digital feedback suppression, and speakers positioned in locations that are optimal for sound coverage and avoiding feedback. The powerful ADAPTO® platform on the Pro Digital even optimizes sound quality and power use, and suppresses feedback before it occurs.

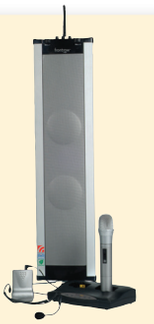
Conclusion – Can a single speaker be expected to do the job of *multiple* speakers?

Flat panels are a novelty technology for MP3 players and other personal consumer electronics meant to cover a small area, but multiple speakers placed around the room or in a line array are the only legitimate way to ensure even coverage and quality necessary for speech intelligibility and reproducible digital content in today's classrooms.

Classroom sound systems that use single-speaker technology – *whether in the form of flat-panels or any other design* – simply can't project sound the way multi-speaker systems can. This is a scientific fact. So in schools, where sound is absolutely vital to learning and comprehension, why would you use one? Placing a single speaker in a classroom and expecting it to do the job only achievable by *multiple* speakers doesn't fit FrontRow's mission of delivering quality education to children, and for this reason, our systems will always be designed with multiple speakers as the foundation.

To learn more about how FrontRow systems enhance the learning environment, visit **www.gofrontrow.com** *or call* **1-800-340-9894.**

Isn't the FrontRow ToGo a single-speaker system?



One might assume that the FrontRow ToGo falls into the same category as Lightspeed's flat-panel system (the REDCAT), since they are both portable systems. However, even though the FrontRow ToGo looks like one speaker, it is actually a sophisticated two-speaker line array. Sound waves from the two precision-mounted elements reinforce each other and direct more sound energy to the back of the classroom where it belongs, rather than into the ceiling or the floor. This remarkably even sound coverage makes the FrontRow ToGo the only all-in-one sound system capable of fully covering an entire classroom.

When asked to explain the different signal distribution between flat-panel and line array speakers, Barry McKinnon of McSquared System Design Group, Inc. noted: *"A well-designed line array generally has more uniform speech range coverage than a flat-panel device. The catch with a line array is that you have to have enough mounting height to graze the heads of students without blocking significant amounts of the speaker's output. Flat-panel devices still fall off in level following the inverse square law (-6dB/doubling of distance), where a line array is typically only -3dB or -4dB drop in level per doubling of distance. So a properly spec'd line array can generally cover a bigger area than a single flat-panel speaker device."*

Barry R. McKinnon is a senior consultant with 15 years of experience in the design, manufacture and installation of sound reinforcement, production, and recording systems in various sizes of venues. Loudspeaker design and measurement are a specialty of his, having spent several years developing and manufacturing speaker systems for both portable use and permanent installations. He has written for several US-based and international trade publications and has authored one of the seminal works about live sound in the late 1970s.

Arthur Boothroyd, Ph.D. is Distinguished Professor Emeritus at City University of New York and Scholar in Residence at San Diego State University. Dr. Boothroyd holds degrees in Physics and Audiology, and has published extensively on room acoustics and its effects on speech reception and perception. In addition, he has consulted on the design and application of classroom amplification systems.

[3] *Sound Field Speaker Coverage Modeling Study,* McSquared System Design Group, Inc. 2004.