

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com

Why do multi-purpose rooms usually have *terrible* acoustics?



Figure 1

And what can be done about it?

Schools Districts build multi-purpose rooms, instead of multiple single-purpose rooms, because of tight budgets. These rooms have to serve a wide variety of functions, ranging from gymnasium and cafeteria, to drama and musical productions. Despite their mundane

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com

origins, these are important performance spaces—for many people these are the first (and perhaps only) places that they will perform for an audience.

Unfortunately, most multi-purpose rooms have really dismal acoustics. Why? I believe it is because of bad design, rooted in false preconceptions.

A common, and erroneous approach to design, is to collect all functions that a space must serve, and then compromise. This approach leads directly to mediocrity. For excellent design, one must first decide what function is really critical, and then work the other functions so that they support the critical function, dropping some less important ones if necessary.

Let's see what this means for the acoustical design of multi-purpose rooms.

Listening is the Critical Function

Most multi-purpose rooms serve three functions: cafeteria, gymnasium, and auditorium. The acoustical requirements for a cafeteria or gymnasium are pretty simple: avoid too much din. The auditorium, then, is the only acoustically critical function. Furthermore, a school auditorium must support two differing *acoustical* functions: musical performance, and speech clarity. More about this later.

If a room works acoustically as a multi-purpose *auditorium*, it will serve just fine as a cafeteria or as a gymnasium.

Keep it Simple

Multi-purpose rooms have poor acoustics because available resources are spread too thin. After all, a multipurpose room exists because money is tight. To produce a well-designed room within a constrained budget requires two things: jettison the superficial, and focus on the essential. Afterwards, one can make choices amongst what is left to improve the design.

Given that the auditorium is the most critical function, what is superficial, and what is essential?

Superficial: the stage house.

Essential: noise control.

Other requirements (in order of importance):

1. control of reverberation
2. raised performance area
3. raised seating

Why do multi-purpose rooms have terrible acoustics
And what to do about it.

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com

4. surfaces to diffuse sound and provide useful sound reflections
5. sound system (keep it simple)
6. adjustable acoustics

What is Superficial?

The stage house



Figure 2

Figure 2 shows a typical stage house tacked on to the end of a gymnasium/auditorium. This room is really a glorified closet, filled with dusty sound-absorbing curtains, buzzing fluorescent lights, and noisy electrical equipment. Lacking a true flyspace, this pathetic little imitation of a proscenium theatre stage house completely isolates performers from their audience.

Why do multi-purpose rooms have terrible acoustics
And what to do about it.

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com

Money is squandered on designing and building these dismal stage houses because a performance space without a curtain is inconceivable to many people—in spite of the fact that not a single great concert hall in the world has a stage curtain.

This common approach results in a performance area that gives no support whatsoever for the sound produced by young performers. To overcome the acoustical shortcomings, more money may be thrown away on amplifying these performers. But this can't be done properly because money and expertise are not up to the task.

I offer a superior alternative: make it simple, but make it good.

What is Essential?

Noise control

Control of background noise from machines is the single most important aspect of the acoustics of any space for listening: vastly more important than any other factor. The problem with background noise is not *distraction*; people are able to ignore a great deal of background noise. The problem is *masking*. Noise, especially steady-state machine noise, covers up what we want to hear. When you consider the power of a typical middle-school performer, this is a serious obstacle. The worst offenders are machines like air-handlers, chillers, refrigerators, transformers, fans, and buzzing lights.

The human ear is so sensitive that we can detect a deflection of the eardrum as small as the diameter of a hydrogen molecule. Yet we rarely experience this miraculous sensitivity because the softest sounds that we can hear are covered by noise. We don't notice background noise, but it determines what we are able to hear.

When you look through a dirty window, you rarely notice the grime, but when you clean that window, the scene is suddenly crystal clear. Similarly with sound—clean up the background noise, and the object of your listening attention will be revealed in all its clarity.

Noise control has to be considered at the earliest stages of design because space planning and budget—two of the earliest design considerations—determine the how much one can control noise.

There are three major noise producers in a typical multi-purpose space.

1. HVAC
2. Lighting
3. Kitchen equipment.

Why do multi-purpose rooms have terrible acoustics
And what to do about it.

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com

HVAC

HVAC is usually the worst offender. The constant noise from HVAC in most multi-purpose spaces obliterates any hope of acoustical quality. To eliminate (yes, I said eliminate) noise from HVAC requires:

- Remote location of machinery,
- Vibration isolation of machinery,
- Devices for attenuation of duct-borne fan noise,
- Control of air velocities to avoid noise-producing turbulence.

It is amazing the improvement that can be realized in many spaces by simply eliminating, yes *eliminating* HVAC noise.

Lighting

Many gymnasiums use halide lights with buzzing ballasts. In many cases, the noise produced by these lights—steady and high-pitched—is as pleasant as a dentist’s drill. This kind of lighting is not acceptable in a gymnasium, and less so in an auditorium.

Locate any lighting controls with fans or transformers to a separate room with sufficient sound and vibration isolation to protect the precious quiet of the auditorium.

Kitchen equipment

Many multi-purpose rooms are located next to kitchens, which contain a whole host of noisy machines—refrigerators are probably the worst with their compressors. If a room adjacent to a kitchen will be used as an auditorium, serious thought has to be given to sealing off the kitchen when the room transforms from cafeteria to auditorium.

Another ubiquitous noise-producer is the soda vending machine. Do not locate these noisy machines anywhere near a space that must double as an auditorium.

These noise control considerations may seem extraordinary, but keep in mind that elimination of background noise is essential to the most critical function of a multi-purpose room.

Acoustical Enhancements

Not all of the features that follow will be possible in every project. But every one can help enhance the auditorium function of the multi-purpose room.

Performance platform

Instead of building a stage house, provide a simple platform on one end of the room, along the shorter wall. Construct the surfaces surrounding this platform entirely out of hard materials to support the sound of the performers. Eliminate any proscenium walls or

Why do multi-purpose rooms have terrible acoustics
And what to do about it.

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com

curtains. The walls defining a proscenium interfere with sound traveling from the platform and to the audience chamber. Curtains absorb the sound that performers work so hard to produce. This simple performance platform should be completely open and within the audience chamber.

Performers, especially musicians, need to be in the same space as their audience. Every single great recital hall or concert hall in the world locates musicians in the same room as the audience, rather than in a separate box. This is particularly important for student musicians.

Although a lot of theater is performed behind a proscenium, it is amazing how effective theatre can be on a simple platform. Both Ancient Greek plays and Shakespeare (for example) were written to be performed on a simple platform, with the audience's imagination providing the elaborate scenery. A proscenium stage may be desirable for the performance of much of the theatrical repertoire—including Broadway Musicals—but the fact is that a multi-purpose space design never has the budget for a true stage house. The usual compromise approach (discussed above) has many more drawbacks than benefits.

A student production can't possibly compete with the visual effects common on TV and film. Live theatre offers what these flashier forms cannot: living breathing actors supported by their audience's limitless imagination. The design should interfere as little as possible with the connection between performers and audience.

Audience seating

The improved view of the stage provided by a raised audience is a tremendous benefit. For a multipurpose room, this requires moveable seating that can be retracted when the room is used for other purposes. The folding bleachers used in gymnasiums are perfect for this use.

Figure 3 shows a computer model of a scheme for renovating a multi-purpose gymnasium using a portable riser for the audience, and a simple platform at one end. Note also the sound-reflecting panels on the sides of this model (discussed below).

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com



Figure 3

Reverberation control

Reverberation is the persistence of sound in a room after the source of sound has ceased. Larger rooms have more reverberation. Sound-absorbing surfaces—such as chairs, people, and specifically designed sound-absorbing panels—reduce reverberation. Reverberation is neither good nor bad; it can be appropriate or inappropriate. A room with a lot of reverberation may be called “live;” a room with little reverberation may be called “dry,” or even “dead.”

The typical multi-purpose room is a simple rectangular box, with a wooden or tile floor, concrete walls, and steel deck roof. If left as is, such a space will be very live—clap your hands and the sound goes on forever. If noise has been eliminated as discussed above, this might not necessarily be a bad thing—depending on what you want to hear in the space. It could be very nice for a string orchestra, or choir (though there are ways to make it even better). However, for most requirements—drama, lecture, amplified music, eating, gym class—this live acoustics will be a problem, even if background noise is minimal.

For most uses, a multi-purpose room requires sufficient sound-absorbing material in the audience area to reduce reverberation. This will help speech intelligibility, and will control the din when the space is used as a cafeteria or gym.

Why do multi-purpose rooms have terrible acoustics
And what to do about it.

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com

There are a number of approaches to controlling reverberation, ranging from sound-absorbing construction materials like acoustical decking and sound-absorbing block, to hanging sound-absorbing panels. A very interesting approach is to use curtains that can be expanded to absorb sound, and retracted to allow the room to reverberate. For most rooms, built-in, immobile, sound absorption is appropriate, because it is the most cost-effective approach. But adjustable-reverberation provides some real benefits, discussed below.

Useful sound reflections

For an auditorium, it isn't enough to just absorb sound. Both performers and audience need useful sound reflections, too. We can think of these useful sound reflections in two ways (there is some overlap): early sound reflections and diffuse sound reflections.

Early sound reflections are sound reflections from a surface that is close enough for the sound reflection to arrive at the ears soon after the sound from the sound source itself. Early sound reflections may come from a nearby wall, or floor—or from a surface intentionally designed to provide early sound reflections. Early sound reflections give strength and clarity to the sound of the performer.

Diffuse sound reflections are sound reflections that come from myriad directions. Diffuse reflections provide a pleasant quality to the sound, help mask distracting echoes, and help musicians play together. Complex surfaces, like trusses and ducts, provide diffuse sound reflections, even if they are not designed to do so. Flat walls often need additional sound reflectors to diffuse sound and avoid echoes.

In auditoriums, “clouds” are often hung to provide useful sound reflections, both early and diffuse.

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com



Figure 4

The High School auditorium in Figure 4 illustrates the use of sound reflectors both overhead and on the walls.

Music vs. Speech

Speech and music have different acoustical requirements. To risk a gross oversimplification: music requires reverberation, but reverberation is bad for understanding speech.

Reverberation is particularly hard on speech intelligibility for people with impaired hearing. Reverberation enhances all sound, wanted and unwanted: a singing choir, as well as a noisy HVAC system. A noisy, reverberant space is a disaster, but a quiet, reverberant space can be heavenly for listening to an instrumental ensemble or choir

So how do you reconcile these conflicting requirements? For a multi-purpose room, there are two choices:

Why do multi-purpose rooms have terrible acoustics
And what to do about it.

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com

- 1) Design a room with low reverberation, more suitable for speech clarity, and make provisions such as sound reflecting surfaces to enhance music in the space. In such a space it is particularly important that musical performers be located out in the room with the audience, rather than being cooped up in a curtain-filled stagehouse, as discussed above.
- 2) Or, provide adjustable reverberation.

Adjustable Reverberation

Adjustable reverberation is provided by hanging large areas of heavy curtains. When the curtains are folded into storage boxes, the room is live, with acoustics appropriate for choir, or string ensemble. When the curtains are extended, the room is “dry,” with acoustics appropriate for speech clarity.

I don't know of any cafeteriums or gymnasium/auditoriums that use adjustable reverberation, but is very common in performing arts centers that have to provide for a wide variety of performers. Curtains are expensive, and subject to damage, but adjustable reverberation really increases the possibilities of an auditorium.

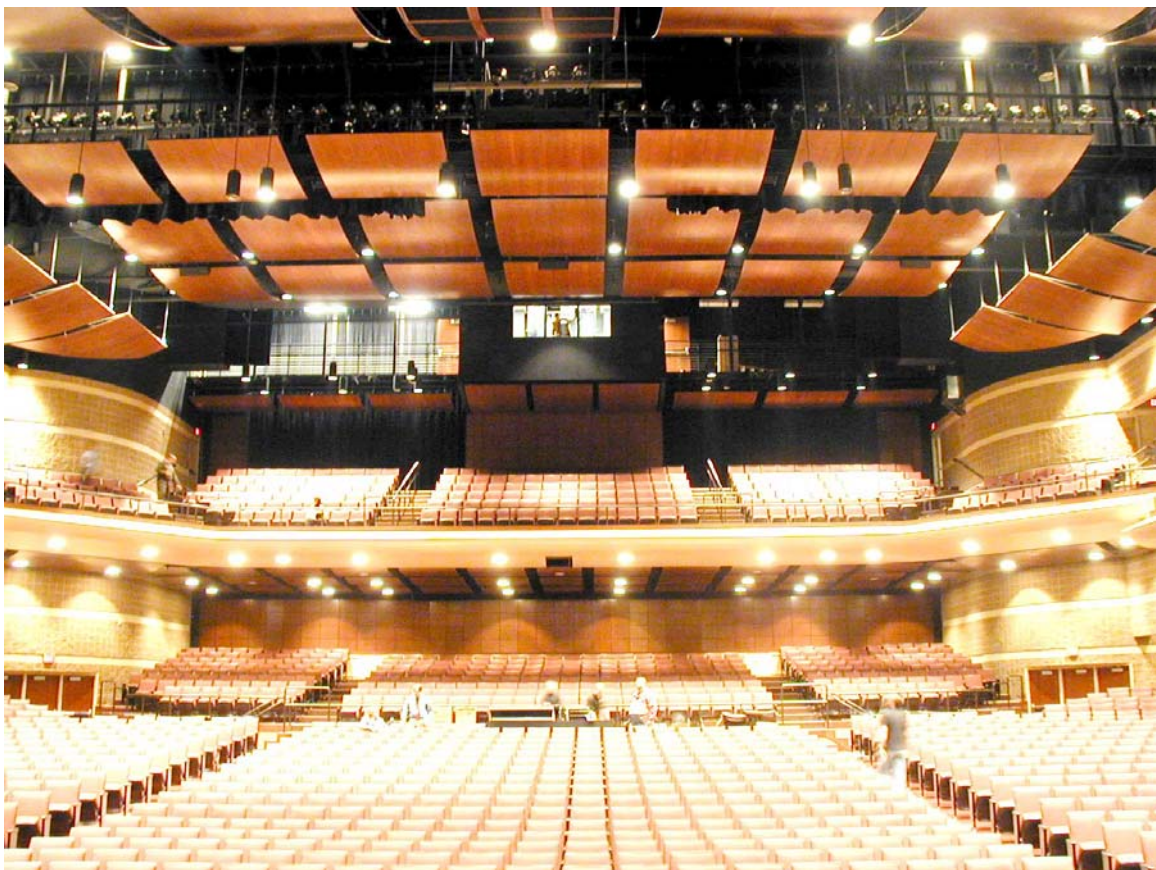


Figure 5

Why do multi-purpose rooms have terrible acoustics
And what to do about it.

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com

Figure 5 shows the rear wall of an auditorium with an extensive collection of sound-absorbing curtains. You can see that the lower wall curtain is stored, and the upper rear wall curtain is extended to absorb sound.

What Does a Sound System Do?

Conventional wisdom dictates that every room should have a sound system. But, what exactly does a sound system do?

Proper Function of a Sound System

The *proper* function of a sound system is to provide sound, or an aspect of sound that would not otherwise be available in the space. Sound systems are used:

- To provide sound from another time, or from other location: for example recording or broadcast.
- For people with impaired hearing. (for these people, a separate system is best. In other words, you don't *have* to amplify for everyone just because the assisted hearing system is on.)
- In a space that is too large for a speaker or music to be heard without some help: like in large arenas.
- Where acoustics for one function (say, organ music, which requires maximum reverberation) directly conflicts with speech clarity.
- **And the most usual: as a Band-Aid in a space where no one bothered to think about the acoustics.**

Drawbacks of a Sound System

On the other hand, sound systems can be a real impediment to communication:

For the listener

Sound systems freeze the location of the sound source in space (in the loudspeakers, instead of the performer). Often, one hears no clearly defined source location at all. This distortion of localization creates an unnatural sound, and eliminates a focal point of attention for the listener. And sound systems are often (usually, almost always) TOO LOUD. These two factors discourage active listening.

For the speaker

Sound systems discourage people from talking directly to their listeners. Instead, many people mumble into the microphone. If a speaker is behind a podium, an entire realm of communication (gesture) is virtually eliminated. (This problem is partially addressed by the use of lavalier or headset microphones.)

Why do multi-purpose rooms have terrible acoustics
And what to do about it.

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com

Our built-in communications system (hearing, seeing, speaking, gesturing) was designed long before sound systems. The best, most immediate, communication occurs without a sound system.

Sound system in a Multi-purpose Auditorium

With proper design, a sound system should not be necessary for performers in a modest-sized multi-purpose room. One may be desired for background music for dramatic productions, or for the occasional lecturer who does not know how to support his voice with his diaphragm. But for most performances—drama, lecture, plays, choir, orchestra, other musical ensembles—a sound system is an unnecessary encumbrance.

The key to sound system design in these spaces is simplicity. Such a sound system requires:

- A single loudspeaker, appropriately located and integrated into the room's acoustics (see the CAD drawing for details),
- One microphone on a stand,
- An amplifier,
- Perhaps a CD player and/or cassette deck..

A room with well-designed acoustics will work better for the sound system as well. But sound systems should not be a *substitute* for acoustical design.

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com

Simpler is Better



Figure 6

Figure 6 is the Clemens Theatre at Christopher Dock Mennonite H.S. This is the simplest rooms you can imagine: a simple stage platform, no wings, no proscenium, audience on a steep rake, cmu walls, steel deck ceiling, and silent mechanical system. Music sounds beautiful, speech is absolutely clear. The very first performance that I attended was an opera: Gian Carlo Menotti's *Ahmal and the Night Visitors*. No amplification was used. The sets were simple. But the *sound* was wonderful. The simplicity and directness of the space added greatly to the impact of the performance.

I believe that the approach outlined here will support the music and theatre requirements of an elementary, middle or high school with high quality, and limited cost. Not everyone will be happy with this approach, but the results will be far superior to the vast majority of auditoriums.

With early planning and intent, it is possible to design and build even a sizable room that will provide excellent intelligibility for unassisted speech. To accomplish this, every aspect of acoustical design has to be considered from the very beginning.

So what is the secret?

Keep it simple, and keep it quiet.

Why do multi-purpose rooms have terrible acoustics
And what to do about it.

Christopher Brooks, Orpheus Acoustics

t: 717-291-9123,

f: 717-291-5453,

cnb@orpheus-acoustics.com

*Christopher Brooks is principal consultant and owner of **Orpheus Acoustics** in Lancaster, PA. He is also the author of the book **Architectural Acoustics** (published by McFarland). He is available at (717)-291-9123 or cnb@orpheus-acoustics.com. Web page: www.orpheus-acoustics.com.*

Illustrations

All illustrations by Christopher Brooks.

Figure 1: stagehouse of an un-named school. Architect: (there was an architect?).

Figure 2: same stagehouse other side (actually, I know the architect, but I'm not going to embarrass him.).

Figure 3: computer model, Christopher Brooks, Orpheus Acoustics.

Figure 4: Jim Thorpe H.S. Auditorium, Jim Thorpe, PA; Architect: Hayes Large, Acoustical Consultant, Orpheus Acoustics.

Figure 5: Cumberland Valley H.S. Auditorium, Mechanicsburg, PA; Architect: Thomas Marcinkowski; Acoustical Consultant, Orpheus Acoustics.

Figure 6: Clemens Theatre, Christopher Dock Mennonite H.S., Lansdale, PA; Architect: Greenfield Architects; Acoustical Consultant, Orpheus Acoustics.