Sound Ideas for Better Learning

Studies show how higher education institutions can improve classroom instructional and listening environments with teacher audio enhancement. The result can improve student attention and understanding, and has the potential of increasing student achievement as well as increasing instructional performance.

by Paul McCarty, Ed.D., and John Ribera, Ph.D.

Imagine for a moment that you are a college student. On the first day of class, you find yourself in a large classroom of more than100 students. You choose to sit two-thirds of the way toward the back of the room. There is the usual talking, rustling of papers, people trying to find a seat, etc. The instructor enters and, after a brief introduction, begins to lecture on a subject with which you are unfamiliar — for instance, otoacoustic emissions. The teacher speaks at a conversational level with little vocal inflection. Because you are at a distance of more than 20 ft. from the instructor, you are hearing the lecture at half the intensity of those seated 10 ft. closer. You find yourself straining to hear what is being said. Imagine how well you would be able to focus on the spoken word of the professor if your primary language were not English. You do pick up key words here and there, and need to ask a fellow student to repeat what was said (that's if you have enough courage to do so).

This scenario may seem contrived and unrealistic, but in reality, it is not too far removed from what takes place in many classrooms on campuses throughout this country. The optimum academic learning environment (classroom) must include not only adequate lighting, but also a favorable acoustic setting. This is true whether the classroom is designed for K-12 or for college students.

Students in today's colleges and classrooms are unable to understand 25 to 30 percent of the spoken word of their instructors. Unfortunately, students who can't focus on what is being said because of excessive noise or reverberation not only lose the desire, but also the physical ability to learn. Studies from Cornell University (2001) and University of London (2005) suggest that classroom noise not only interferes with the student's ability to hear, but it can contribute to a state of learned helplessness. All students in the classroom or lecture hall must be able to hear their professors' voices clearly to learn. Adults can usually fill in the missing blanks of words missed because of lifelong language experiences under difficult listening conditions. But if the subject matter is unfamiliar or the competing background noises are too loud and distracting, the typical college student is not going to be able to listen and focus on what is being said. Limited English proficiency students are particularly at risk. In this situation, our college student feels powerless over the classroom environment and gives up trying to learn. And what happens to the professor's throat who attempts to project his or her voice above the confusing din?

Research has found that a student's ability to learn and academic performance are negatively affected when the professor's ability to verbally communicate is blocked or muddled by overwhelming background noises. The classroom instructor is forced to compete with background noise by raising his/her voice. This can lead to an increase in the stress level in the classroom and, ultimately, can put a tremendous strain on an instructor's voice, increasing physical fatigue.

It is crucial for students to hear what the instructor is saying in order for effective learning to take place. The inability to listen or to hear the teacher suggests that students will tend to tune out the lecture, and their desire or ability to learn may diminish.

You have a vested interest in ensuring that the learning and listening environment is optimized for all post-secondary students. You are in a position to make a difference in the classroom listening environment. Following are some facts regarding classroom acoustics that may be of value and that may influence your decisions.

- There is considerable research literature on the effects of classroom acoustics on the learning of K-12 children.
- In 2002, the American National Standards Institute (ANSI) established "acoustical performance criteria, design requirements and guidelines for schools." ANSI standards include:
  - an ambient noise level not to exceed 35 dBA,
  - a reverberation time not to exceed 0.6 to 0.7 seconds and
  - a signal-to-noise ratio (SNR) of at least +15 dB.
- Noise, signal-to-noise ratios and reverberation values that exceed ANSI standards can have a negative effect on learning, reading, memory, math and other skills.
- Research shows that English language learners need a greater SNR than those whose native language is English.
- There is evidence to suggest that there is a synergistic effect when elevated noise levels are combined with elevated reverberation times.
- A recent study at a midwestern university revealed that the acoustics of post-secondary classrooms were found more often than not to exceed the maximum values allowed by the ANSI standard.
- Noise levels can also have a deleterious health effect on teachers/instructors, resulting in vocal fatigue and increased absenteeism.
- Noise can be generated from outside the building (i.e., traffic), inside the building (students in hallways) and/or inside the classroom (heating ventilation and air conditioning systems). This combination of noise sources increases the level of noise reaching each listener's ears and can interfere with the learning process.

It would seem logical that the best solution for overcoming the adverse effects of noise would be to attenuate it at its source. The problem decision-makers are faced with is that it is not always fiscally feasible

to retrofit/remodel every classroom with solutions designed to engineer out troubling noise. When financial constraints limit what can be done in an existing classroom to maximize the acoustical environment, a viable alternative is classroom sound enhancement. This can be accomplished at a reasonable cost (about $1,500 per classroom) through the use of frequency modulated (FM) or infrared sound field amplification systems. Instructors wear a lightweight microphone. The speech signal is transmitted via wireless transduction to an amplifier that feeds the enhanced signal through ceiling-mounted speakers placed so as to ensure that no matter where in the classroom a student sits, he/she can hear what is being said.

Evidence Supporting Audio-Enhanced Classrooms

In a yet-to-be published study conducted at Utah State University, Ribera, Vega & Larsen found evidence to support the use of classroom audio enhancement in the college classroom. Two college classrooms were selected for this study. Classroom 1 met the ANSI S12.60 – 2002 standards, while Classroom 2 was considered a poor acoustic environment. Classroom 1 had an enclosed volume below 283m^3, one-hour average noise level of 34 dBA, and a reverberation time of 0.53 seconds for 500, 1000 and 2000 Hz. Classroom 2 had a similar volume, a background noise level of 44 dBA and a reverberation time of 0.76 seconds. The noise in Classroom 2 was generated by a heating, ventilation and air conditioning (HVAC) system.

Fifty-three college-age students, ages 18 to 40 (mean age 23 years), were selected as subjects for this experiment. Student desks were positioned in an orderly fashion throughout each classroom. Participants were tasked to write down each word presented under two classroom conditions: unamplified and amplified.

For the unamplified condition, a CD player was placed on a table in the front of each classroom and served as the speaker source. The presentation level was set at 65 dBA, recorded at a distance of six in. from the CD player. In the amplified condition, an audio enhancement infrared system was used to broadcast the speech signal via ceiling-mounted speakers. The output averaged 65 dBA, measured at six in. from each speaker.

The results suggest that even sophisticated adult listeners have difficulty understanding what is said in a classroom with poor acoustics. The average word recognition score in Classroom 1 (unamplified) was 44 percent (SD = 17 percent). When amplification was added to Classroom 1, the mean score increased to 81 percent (SD = six percent). Although performance was improved with amplification, the scores still demonstrated some students had problems understanding. The mean score in the unamplified condition for Classroom 2 was 82 percent with a range of (SD = eight percent), while the amplified mean scores improved to 93 percent (SD = four percent).

This research was conducted using very conservative levels to illustrate the worst-case scenario, but the principles remain the same. If the signal-to-noise ratio is insufficient, whether listeners are children or adults, they miss much of the message. When the cost of retrofitting a classroom with noise controls is unrealistic, the solution to the problem of inadequate classroom acoustics seems simple and straightforward; namely, improve the signal-to-noise ratio using a ceiling-mounted audio enhancement system. When planning a new facility, in addition to engineering sound control into the classroom, amplification systems should be included in the design, thus affording all students ready access to acoustical input (speech) necessary to receive verbal information in the academic setting. CPM

Paul McCarty (<paul.mccarty@byu.edu>) is an adjunct professor of Environmental Psychology and Human Development at Brigham Young University. John Ribera (<jribera@cc.usu.edu>) is director of the Audiology Department at Utah State University.