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Qualitative evaluation of a classroom redesign

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ABSTRACT

Shevlin Hall is home to the University of Minnesota's Speech-Language-Hearing Sciences department. Besides the typical needs of any educational space, some of the rooms have additional requirements to meet the needs of a hearing-impaired population. In a previous study, we presented the results of a renovation of classroom 110 that addressed the room acoustics and electro-acoustics redesign, to achieve adequate speech intelligibility. This study presents the results of a qualitative study of the impressions of the building users before and after the renovation of classroom 110.

Keywords: Classroom, Speech, Intelligibility

1. INTRODUCTION

Classrooms are one of the environments with the highest need for good speech intelligibility. In general, classrooms (re)designed during the last couple of decades in the United States, include an absorptive ceiling, which provides an appropriate, if not necessarily ideal, acoustic environment. However, classrooms continue to often use noisy mechanical systems and are rarely under the ambient noise level recommended by the current ANSI 12.60 standard [1,3].

In a typical classroom there are 3 communication paths: Teacher to student, student to teacher and student to student. The third path is rarely considered. Communication between the students is the cause of incidental learning. This is critical especially for those with hearing impairment as it leaves them out from the questioning and opinions of their peers. In order to reinforce all three paths of communication, is important to first address the room acoustics, including reverberation time and ambient noise. Secondly, a voice reinforcement system should be added where necessary.

2. SHEVLIN HALL RENOVATION

The department of Speech-Language-Hearing Sciences of the University of Minnesota is located in a historic building. Shevlin Hall has changed uses and finishes throughout the years, and in 2013, it was necessary to undergo a renovation of classroom 110, formerly the main lounge of the building, now often used as a multipurpose space for activities including classes, poster sessions and social receptions.

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Figure 1. Shevlin Hall (before renovation)

The renovation included adding absorptive panels to meet the standard's recommendation for reverberation time (0.8 s for a large classroom), and adding a new sound system to achieve good speech intelligibility. As the space is often occupied by people with a range of hearing deficiencies, good speech intelligibility was critical for the functioning of the space.

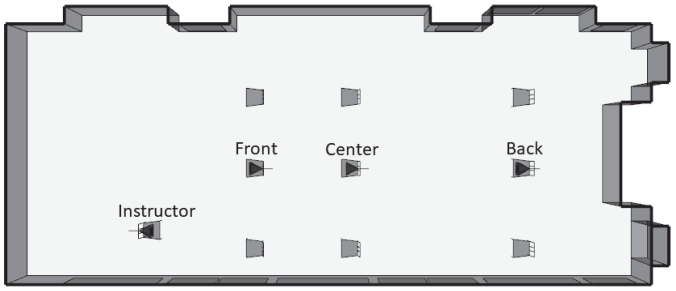

Figure 2. Source and receiver locations for testing.

2.1 Ambient Noise

The cooling of the classroom during the summer is done by 2 large window units. The update of the cooling system was not part of the renovation so the units continue to be functioning in the space resulting in a high ambient noise of NC56-62. Only one of the 2 units was operating during our measurements.

2.2 Reverberation Time

The room had a few absorptive panels but these were not enough for its use as a classroom and the high reverberation time made it hard to achieve good speech intelligibility.

With the addition of 35 absorptive panels, the reverberation time was brought down to the desired range [4]. Figure 3 shows the RT measured at 3 locations in the room (see Figure 2) before (black) and after (grey) the renovation. Optimal RT for a classroom of its size was achieved with the added absorption.

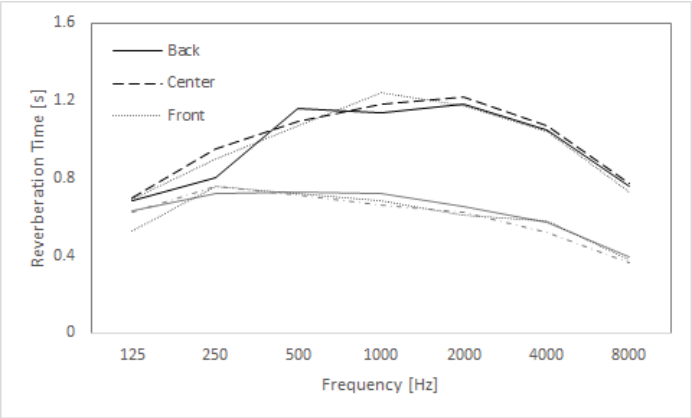

Figure 3. Measured RT at 3 locations

2.3 Speech Intelligibility

Speech Transmission Index was measured in the room at the same 3 locations and it showed values of 0.56-0.58 without the AC units running. With the lower RT and the new sound system, STIs of 0.68-0.76 were achieved.

The current standard recommends values above 0.64 for spaces that require very high speech intelligibility, but 0.60 is considered acceptable [2].

In Figure 4 we see the results of STI measurements with (black) and without (grey) the sound system on, at locations across the room with the source at the instructor and back locations. The light grey baseline shows the highest level measured before the renovation, so we can appreciate the improvement in STI given by the added absorption, and then the improvement given by the new sound system.

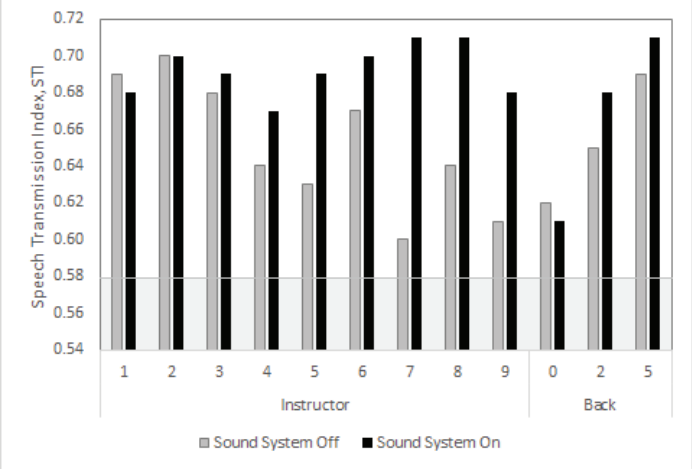

Figure 4. Measured STI with and without Sound System, after the renovation.

3. SUBJECT TESTING

Intelligibility subject-based tests were performed in the room, to compare with the speech intelligibility predicted through STI. These tests were performed using IEEE sentences, played back through a single speaker at the front.

3.1 Speech Intelligibility

For speech played in quiet conditions, 4 tests were done using 3 receiver locations (instructor, front and back) and 2 source locations (instructor and back).

Table 1 shows the results of this test.

Table 1. Results of intelligibility test in quiet condition

Test	Receiver Location	Source location	Results (Average %)
1	Front	Instructor	78
2	Back	Instructor	79
3	Front	Back	80
4	Instructor	Back	68

In quiet conditions, all subjects were able to get more than 68% of the spoken sentences. The path from the instructor in the front corner to the receiver in the center back of the room was the poorest. This condition would be highly improved by the use of the sound system.

The second test compared speech intelligibility in quiet and noisy conditions. For the noisy condition, the window AC units were running (~52 dBA).

Table 2 shows the results of this test.

Table 2. Results of intelligibility test in quiet vs noisy conditions

Test	Condition	Receiver Location	Source location	Results (Average %)
1	Quiet	Front	Back	94
	Noisy			6
2	Quiet	Instructor	Back	94
	Noisy			2

The comparison between noisy and quiet conditions is clear. The high noise levels make the room unusable without the aid of the sound system.

3.2 Survey

In order to get a subjective impression of the users of the classroom, 2 open-ended questions were distributed after a poster-session, inquiring about the ease of communication. During the session, there were 4 posters being presented simultaneously.

How easy is it to understand the presenters?

Easy | 6 OK | 6 Difficult | 0

How easy is it to understand the poster discussion?

Easy | 7 OK | 5 Difficult | 0

The results from the survey show that it was fairly easy for people to understand an individual poster presenter and discussion around it, even in the presence of distracting activity noise around them. Additional survey results from long-standing faculty indicated great improvement in speech understanding and vocal effort following the renovation. The achieved RT helps provide an environment in which this type of activity can be done successfully.

4. FINAL REMARKS

Shevlin Hall 110 started as a historic room with a high reverberation time and very high background noise levels where typical classroom activities could not be done. After the renovation of the room, the historical character was maintained but the reverberation time was lowered to the recommended levels. An addition of an appropriate sound system completed the renovation to achieve very high speech intelligibility. Even though the noisy AC units continue to exist in the room, it is only a small portion of the year where their use is required (due to its location in the colder Minnesota climate). Future renovations of the building hope to address this need. Subject-based testing as well as an open-ended

survey helped compare the predicted and measured room acoustics and the actual user experience of the room. All users found the room to be appropriate for its use as a classroom as well as other activities. Further investigations into the comparison between subject-based testing and speech intelligibility predictions using STI are needed.

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