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A comparison of the effects of soundfield amplification on acoustical characteristics and word recognition performance in relocatable and permanent classrooms

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A COMPARISON OF THE EFFECTS OF SOUNDFIELD AMPLIFICATION ON ACOUSTICAL CHARACTERISTICS AND WORD RECOGNITION PERFORMANCE IN RELOCATABLE AND PERMANENT CLASSROOMS

by

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ABSTRACT

There are three acoustical characteristics that should be addressed when developing a good classroom listening environment: signal-to-noise ratio (SNR), reverberation time (RT), and levels of background noise. Previous research has shown that soundfield (SF) amplification systems help to improve these three characteristics, thus improving the classroom listening environment. In the present study, two seventh-grade classrooms were used: one relocatable classroom and one permanent classroom. Acoustical characteristics and speech levels were measured in both classrooms under two amplification conditions (unamplified and amplified). Word recognition abilities of 37 students were also measured under the two amplification conditions in both classrooms. Results showed neither classroom met the standards for optimal acoustics; however, SNRs were increased in both classrooms with the use of soundfield amplification. Additionally, the word recognition scores (WRS) of the children in the relocatable classroom were significantly worse under both amplification conditions than in the permanent classroom; WRS, however, increased when amplification was used compared to when it was not used. The results revealed the benefits of utilizing soundfield amplification systems in both classrooms, especially relocatable classrooms. Clinical implications are also discussed.

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DEDICATION

I would like to dedicate this dissertation to several people. First, I would like to dedicate this dissertation to my mother, Cindy Jenkins, who has been my rock throughout this endeavor. Without her unconditional love, support, and encouragement, I would not be where I am today. Secondly, I dedicate this dissertation to my father, Wayne Babin, who has always taught the importance of setting my goals high and continuous perseverance until they are achieved. Without his guidance and support, I would not have been able to accomplish all the things that I have thus far. Last, but certainly not least, my advisory committee: Dr. Melinda Bryan, Dr. Sheryl Shoemaker, and Dr. Mathew Bryan. They saw my true potential, and they endlessly supported and encouraged me until I reached it. I cannot express my gratitude enough for their time, patience, understanding, and expertise, not only through the dissertation process, but also through my graduate school career. Although I'm sure there are times when they may have wanted to, they never gave up on me, and for that, I am truly thankful.

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CHAPTER I

INTRODUCTION

Improving classroom technology has been a significant focus of the education system (Cornwell & Evans, 2001). Teachers and school administrations are continuously working towards achieving a better learning environment by providing updated textbooks, computers, learning software, etc. Although enhancing the quality of education for students has been a main priority among school officials, the classroom listening environment, a factor that plays a fundamental role in improving the quality of education, is often not addressed (Cornwell & Evans, 2001). The classroom listening environment is an important factor for traditional, permanent classrooms; likewise, it is important for portable, relocatable classrooms as such classrooms are increasing in use and can become more "permanent" solutions.

There are three basic acoustical characteristics that determine the quality of the listening environment in classrooms. The first is the level of background noise present in the room. According to the recommendations for optimal acoustics in permanent classrooms set forth by the American National Standards Institute (ANSI, 2010), the amount of background noise present in an unoccupied classroom should not exceed 35 dBA. Likewise, the recommendations set forth by the American Speech-Language Hearing Association (ASHA, 2005) state that the level of background noise in a permanent, unoccupied classroom should not exceed 30 dBA. It should be noted that many permanent classrooms do not meet either of these standards, and it has been reported that background noise levels for permanent, unoccupied classrooms typically range from 30 to 47 dBA (Knecht, Nelson, Whitelaw, & Feth, 2002). Additionally, ANSI (2009) provides recommendations for optimal acoustics in relocatable classrooms; it states that such classrooms should not consist of background noise levels exceeding 35 dBA. There are, however, currently no known studies that verify if commonly used relocatable classrooms typically meet these standards.

The second basic acoustical characteristic is reverberation time (RT). Reverberation time has been defined as "the time in seconds that it takes for sound in a room to decrease in energy 60 dB after sudden termination" (Iglehart, 2004, p. 62). According to the ANSI (2010) recommendations, RT for a small classroom (i.e., a room smaller than 10,000 ft^3) should not exceed 0.6 s, nor should it exceed 0.7 s for a larger classroom (i.e., a room bigger than 10,000 ft^3); the standards set by ASHA (2005) recommend that RT should not exceed 0.4 s. However, as the case with background noise levels, many permanent classrooms rarely meet either of these standards as it has been reported that typical reverberation times in permanent, unoccupied classrooms generally range between 0.3 s and 1.5 s (Crandell & Bess, 1986). When looking at the RT in relocatable classrooms, ANSI (2009) recommends that the RT in a small classroom should not exceed 0.5 s while the RT in a larger classroom should not exceed 0.6 s.

Signal-to-noise ratio (SNR) is the third acoustical characteristic that determines quality of listening. SNR is the difference between the background noise level and the intended stimulus being presented. The standards provided by both ANSI (2010) and ASHA (2005) recommend at least a +15 dB SNR in classrooms. Because the level of background noise in most classrooms today exceeds the ANSI recommendation of 35 dBA and the ASHA recommendation of 30 dBA, the SNRs in many classrooms do not meet the minimum requirement. Specifically, average SNRs found in typical classrooms usually range from -7 dB to +5 dB (Howard, Munro, & Plack, 2010). These conditions can cause the student to have difficulty focusing and hearing classroom instruction, which can ultimately lead to academic difficulties (Cornwell & Evans, 2001).

SNR is the one factor of the previously three acoustical characteristics discussed that can be easily addressed and controlled for in previously constructed classrooms in order to meet the recommended standards by ANSI and ASHA. Specifically, SNR can be improved through the use of classroom amplification or frequency modulated (FM) technology. This technology has been utilized and tested in traditional classroom environments and has been consistently associated with improved student performance, both in listeners with normal hearing and those with hearing impairment (Cornwell & Evans, 2001; Iglehart, 2004; Ryan, 2009; Rosenburg et al., 1999). The literature does not, however, report how this technology improves the listening environment of a relocatable classroom. Therefore, the purpose of this study was to compare the performance of normal hearing students in a traditional, permanent classroom and a temporary, relocatable classroom using a word identification task. The following specific research questions were addressed:

1. What were the unoccupied noise levels for both the permanent and relocatable classrooms?
2. What were the occupied noise levels for both the permanent and relocatable classrooms?

3. What were the speech levels at various locations in both classrooms under the unamplified and amplified conditions? This information aided in the determination of SNR in each classroom under each amplification condition, thus allowing the two classrooms to be compared.
4. What were the word recognition scores of children in both classrooms under the unamplified and amplified conditions?

CHAPTER II

REVIEW OF LITERATURE

Acoustical Characteristics of Classrooms

As previously stated, there are recommendations for optimal acoustics for both permanent and relocatable classrooms set forth by ANSI (2010) and ASHA (2005); additionally, there are also recommendations for relocatable classrooms set forth by ANSI (2009). For permanent classrooms, ANSI (2010) recommends that background noise levels, defined as any noise that is not the intended stimulus, should not exceed 35 dBA. Additionally, ANSI (2010) recommends that reverberation time (RT) should not exceed 0.6 s for small classrooms or 0.7 s for large classrooms. ASHA (2005) recommendations for background noise levels and RT are more conservative than the recommendations set by ANSI (2010). ASHA (2005) recommends that background noise levels should not exceed 30 dBA; likewise, ASHA recommends RT for small classrooms should not exceed 0.5 s, while the RT for large classrooms should not exceed 0.6 s. Additionally, ASHA (2009) set forth recommendations for background noise levels in relocatable classrooms stating levels should not exceed 35 dBA. The signal-to-noise ratio (SNR), defined as the difference between the background noise level of a room and the intended stimulus being presented, is an important factor for an ideal listening environment and good academic performance. Both ANSI (2010) and ASHA (2005) standards recommend that the SNR in classrooms be at least +15 dBA.

The researchers of the following studies described the acoustical characteristics (i.e., background noise levels, RT, and SNR) among traditional, permanent classrooms. First, Knecht, Nelson, Whitelaw, and Feth (2002) sought to determine the acoustical characteristics of 32 unoccupied classrooms that were randomly selected from Ohio elementary schools. The authors measured the volume, height, length, width, and acoustical characteristics (i.e., RTs and background noise levels) of all the classrooms. To determine the acoustical characteristics of the classrooms, the authors obtained unoccupied noise measurements at five different positions in each room. The authors also recorded the reverberation time for each classroom.

According to Knecht et al. (2002), the levels of noise in each unoccupied classroom were found to be between 34.4 and 65.9 dBA, indicating that all classrooms exceeded the ASHA (1995) recommendation of 30 dBA, and only four classrooms met the ANSI (2002) recommendation of 35 dBA. Furthermore, the RT recordings showed that only six of the 32 classrooms met the criteria of 0.4 s recommended by ASHA (1995), and 19 classrooms met the 0.6 s recommendation set by ANSI (2002). Furthermore, RT was directly related to the size of the classroom. Specifically, the rooms with the lowest ceilings (10 ft or less) were reported to have RTs that met both the ASHA and ANSI standards.

The authors also found that none of the rooms with the heating, ventilation, and air conditioning (HVAC) system turned on met the recommended level of noise set by either ASHA (1995) or ANSI (2002). The noise levels of classrooms that had a HVAC unit on while the measurements were being recorded averaged 49.7 dBA while the noise levels of the classrooms that did not have the HVAC unit turned on averaged 39.8 dBA.

Furthermore, the classrooms that were in the newer schools had the lowest levels of noise and better RTs, while the older classrooms exceeded both criteria. Not surprisingly, these results indicated that larger rooms have substandard RTs, HVAC units introduce noise levels that exceed noise standards, and newer classrooms are more likely than older classrooms to meet minimum noise standards.

Additionally, Choi and McPherson (2005) sought to determine the noise levels and speech measurements of 47 occupied classrooms in 11 different Hong Kong primary schools. Both noise and speech measurements were obtained when class was in session. Noise levels were recorded for 30 minutes from the center of each classroom while neither the teachers nor the students were talking. Speech measurements were obtained by placing a microphone 2 meters away from the teacher's mouth and recording three different measurements during a teaching session (i.e., the beginning, middle, and end of each session); these measurements were then averaged together for each classroom. The investigators also obtained measurements of vocal intensity of two students from each classroom by placing a microphone 2 meters away from their mouths and asking them to read aloud to the class.

The results of the study showed that the noise levels of the occupied classrooms were between 55 and 70 dBA, which the researchers determined to be significantly high levels based on previous research. When the investigators looked at the differences between the speech and noise levels in each classroom, they determined that the average SNR of the teachers' voice was +13.53 dB, with only nine teachers reaching the ANSI (2010) and ASHA (2005) recommendations of +15 dB. However, the Choi and Mcpherson (2005) study showed that the average SNRs of the students' voices were

+4.55 dB (males) and +3.71 dB (females), indicating that none of the SNRs of the students reached the recommended SNR of +15 dB.

Effects of Soundfield Amplification on Classroom Noise and Student Behavior

The investigators of the following research studies described the effects of soundfield amplification on SNRs in classrooms, as well as their effects on the behaviors of the students in the classrooms. First, Larsen and Blair (2008) examined four unoccupied and occupied fourth-grade classrooms for background noise and RT, and their effect on SNR. Secondly, the authors sought to determine the differences between SNRs in the classrooms when soundfield amplification systems were used compared to when they were not used. All the classrooms were 10 or fewer years old, and they contained 24 to 26 students each when occupied. The initial measurements of the unoccupied classrooms for noise and RT revealed that they all met the ANSI (2002) noise and RT standards. The researchers then installed a soundfield amplification system that consisted of four speakers placed at ceiling height in the classrooms. All experimental measurements were recorded for a 10-minute period at nine designated student desk areas in the classrooms. One examiner monitored the instrumentation used during the recordings, and a second examiner monitored and made notes of specific acoustic events that randomly occurred (e.g., sneezing and coughing).

Without the use of the amplification system, the SNRs averaged between +1 and +6 dB SPL. While using the amplification system, the SNRs increased to +13 dB SPL. These increases were observed while the teacher spoke, as well as when the students were speaking to the class. Larsen and Blair (2008) postulated that, although word discrimination scores were not measured, it is reasonable to expect that discrimination would improve with such a significant increase in SNR.

Furthermore, studies have been conducted that observed the effects of amplification systems on the listening and behavioral skills of children, as well as on academic performance (Cornwell & Evans, 2001; Rosenburg et al., 1999; Ryan, 2009). First, Ryan (2009) sought to record the amount of time between when the students received instruction and when they performed physical activity (i.e., managerial time) with and without the use of the amplification system. Two physical education teachers who taught sixth, seventh, and eighth grade were evaluated. Each class was held outside, lasted for 50 minutes, and was comprised of approximately 25 to 37 students.

The soundfield amplification system consisted of a portable speaker that was worn around the waist and a boom microphone positioned 1 inch from the teachers' mouths. The teachers were asked to carry out the daily activities for each class as normal, while an observer recorded the time between when the bell rang until what was referred to as the ALT-PE started. The author defined ALT-PE as "the time when more than 50% of the students became motor engaged in purposeful movement" (Ryan, 2009, p.133). When the ALT-PE began, the observer stopped the timer and recorded the elapsed time. This procedure was completed with and without the use of a soundfield system. Throughout a 20 minute period, the researchers recorded the ALT-PE, as well as the amount of time students remained on-task, under both amplified and unamplified conditions. The results revealed that the average amount of time it took for the students to engage in ALT-PE time decreased in all classes (i.e., the students followed the instructions that were given to them faster) when the amplification systems were in use (ALT-PE = 13 min 58 s) versus when they were not (ALT-PE = 17 min 59 s).

Likewise, Cornwell and Evans (2001) sought to observe the effects of soundfield amplification systems on the listening and behavioral skills of 15 students (ages 8 to 11 years old) in three public school classrooms. Twelve of the participants were picked by their teachers to be a part of this study due to having expressed difficulty with their listening skills, and the other three participants were chosen by their teachers because they were reported to have good listening skills. The authors also asked all of the teachers and students who were in the classrooms with the amplification systems to fill out surveys, and a total of 72 students and five teachers participated in these questionnaires.

Cornwell and Evans (2001) equipped two classrooms with different amplification systems. One of the classrooms was equipped with a soundfield amplification system using a four speaker array, with one speaker placed in each of the four corners of the room, and the teacher used a boom microphone. In the second classroom, the teacher wore a lavaliere microphone and only one speaker which was hung from the ceiling in the center of the classroom was used.

Each child was observed for 60 minutes prior to the use of the amplification system while participating in normal everyday classroom activities, and then in the amplified condition in order to observe how long the students remained on-task in both conditions. After all of the children were observed under both conditions, the authors asked all of the students and teachers that used the amplification systems to complete questionnaires. The questionnaires that were administered asked about the students' and teachers' thoughts and experiences in regards to the use of the amplification system in the classrooms. Results of the surveys that were completed by the students showed that most of the students (86%) felt the amplification systems helped them perform better academically. In the surveys completed by the teachers, 100% indicated that it benefitted the children.

After comparing data from when the soundfield amplification system was in use versus when it was not, the investigators found that the average amount of time that the group of children with attending-behavior difficulties spent on-task under unamplified conditions was around 12 min 25 s. This time increased to 15 min 41 s under amplified conditions. The overall average percent that this group of children spent on-task under unamplified conditions was 61%, and this percentage increased to 77% while under amplified conditions. The overall percentage of time the group of three students who were reported to have good listening skills was observed to stay on-task increased slightly from 92% under unamplified conditions to 95% under amplified conditions.

The results from this study indicated that children who had poor attending behaviors and listening skills benefited from the use of soundfield amplification in the classroom. The children who had good listening skills were reported to have slight benefit from the use of it as well. Additionally, the results of the surveys indicated that, overall, the teachers and students reported on their surveys that they thought the use of the amplification system was beneficial as well (Cornwell & Evans, 2001).

Rosenburg et al. (1999) also conducted a study that sought to examine the effects of amplification systems on the listening and behavioral skills of children; they included two phases over a three year period. In Phase One, the researchers used 1,319 children in

60 kindergarten, first, and second grade classrooms from 14 different primary Florida schools. Half of the classrooms that were used in this phase of the study contained soundfield amplification systems while the other half did not. In Phase Two of the study, the authors used 735 children in 34 kindergarten, first, and second grade classrooms from 19 Florida schools; all of the classrooms in this phase were equipped with a soundfield amplification system. Hearing screenings were performed on the children that participated in Phase One of the study, but not in Phase Two due to lack of availability of staff and variability among existing guidelines for hearing screenings for the district.

Teachers were asked to complete the *ICA Classroom Description Worksheet* (Florida Department of Education, 1999), which assessed and recorded the acoustical characteristics of their classrooms by "providing information about the classroom setting, acoustical treatments, noise measurements, classroom design, noise sources, and other pertinent information about the classroom environment" (Rosenburg et al., 1999, p. 12). A sound level meter was used to measure the ambient noise levels in the classrooms when they were both unoccupied and occupied by taking measurements at five places in the room and averaging the recordings together for each room. The sound level meter was also used to measure and record the intensity level of the teachers' voices by placing it 6 in. from each teacher's mouth while he or she was talking. The soundfield amplification systems were placed in the specified classrooms for both phases, and each system was equipped with four speakers, a transmitter, receiver, and either a lapel or boom microphone.

Rosenburg et al. (1999) used two types of instruments when observing the students: the *Listening and Learning Observation* (LLO; Florida Department of

Education, 1995) and the *Evaluation of Classroom Listening Behaviors* (ECLB; VanDyke, 1985). The teachers for every classroom in both phases were instructed to complete these two surveys in order to provide general information about each student, such as overall health history, number of absences, listening behaviors, and academic skills. In Phase One, the authors had the teachers complete the LLO for each one of their students, and 10 students were randomly picked from each classroom for the ECLB; however, in Phase Two, the authors had the teachers complete both forms for every student that participated in the study. The teachers completed these forms at specified times throughout the school year before (pre-treatment) and after the amplification system was in place (post-treatment).

In both phases, Rosenburg et al. (1999) found the average level of noise in the unoccupied classrooms to be approximately 47.48 dBA, and the average level of noise in the occupied classroom to be approximately 62.63 dBA. In Phase One, the average of the teachers' voice levels increased by +6.94 dBA when using the amplification systems. Based on this measurement, the authors believed the average SNR to be +3.31 dBA when the amplification systems were used. The authors determined this level by subtracting the average SNR when the amplification systems were not used (i.e., -3.63 dBA) from the average level the teachers' voices increased when the amplification systems were used (i.e., +6.94 dBA). The results further showed that the average scores from the LLO and the ECLB increased in both phases of the study when amplification was used versus when it was not. These data allowed the investigators to determine that the rooms equipped with the amplification system showed statistically significant improvements in SNR, as well as improved behavior and listening skills of the students in the classrooms.

Additionally, the authors stated that the systems increased the intensity level of the teachers' voices, thus allowing the children to focus better and stay on task.

A fourth study that observed the effects of amplification systems on the listening and behavioral skills of children was conducted in cross-cultural classrooms by Massie and Dillon (2006). They observed 242 participants from 12 second grade classrooms. Approximately half of these children did not speak English as their primary language. Each classroom was equipped with a soundfield system with fours speakers placed in each of the rooms' four corners at ceiling height. Each amplification system was also equipped with two lapel microphones; one microphone for the teacher to use to speak to the class and one microphone the students could use to pass around and speak to the class. Noise and RTs were recorded to establish the acoustical characteristics in each of the 12 classrooms.

Prior the study, Massie and Dillon (2006) provided in-service training to all the teachers that participated to discuss acoustical characteristics of the rooms and to instruct them on how to properly use and maintain their amplification systems. Hearing screenings were also administered to all children; average hearing thresholds of the children were within normal limits.

Massie and Dillon (2006) used a within-subject crossover design. Specifically, the 12 classrooms were divided into one set of eight (Set One) and then another set of four (Set Two). In four of the classrooms from Set One, students began the school year using the amplification system. In two of those four classrooms, the teacher only used one microphone; and in the other two classrooms, the two microphone condition was used. The second set of four classrooms in Set One began the school year without using the amplification systems. In the middle of the school year, the classrooms were counterbalanced (i.e., the first set of four switched to not using the amplification system, and the second set of four switched to the previous set of four's equipment set up [two classrooms used one microphone and two classrooms used two microphones]). Set Two (classes 9-12) of this study used the amplification system the entire duration of the study and alternated between using one microphone and two microphones. All classes in Set Two used one microphone for half the year, and then switched to using two microphones the second half of the year. The authors collected data on the effects of the amplification systems on the reading, writing, and mathematics skills of the children.

Massie and Dillon (2006) found the amplification systems produced an average of +6 dB of gain for the level of the teachers' voices in the classroom. They further discovered that the average number of acquired skills in the areas of reading, writing, and mathematics for the first eight classrooms was 4.1 out of 10 when amplification was not used, and this average number increased to5.8 out of 10 when amplification was used. Results from the second set of classrooms (9 through 12) showed that the number of microphones did not create a significant difference in the acquisition of skills; however, the use of an amplification system in general did significantly increase the acquisition of behavioral and learning skills. The authors concluded that the use of amplification in the classroom improved the listening and behavior skills of the children as opposed to when they did not use the amplification system.

Finally, McSporran and Butterworth (1997) observed the effects of soundfield amplification on the listening performance of children whose first language was English and whose first language was not English. The authors used two different classrooms for the participants in this five-month study. The first classroom was composed of 35 children (ages seven and eight years) whose first language was English; this classroom was chosen due to its high RT of 1.60 s. The second classroom consisted of 30 children (ages of seven and eight years); however, for 12 of these children, English was their second language. From these two classrooms, the authors chose target groups. The target groups, formed using the *Screening Instrument for Targeting Educational Risk* (SIFTER; Anderson, 1989), were made up of children who were found to be at risk for poor academic performance. Target Group A was composed of 10 children from Classroom One; all 10 children spoke English as a first language. Target Group B was composed of 8 children from Classroom Two that spoke English as a first language, and 7 children that spoke English as a second language (15 children total).

McSporran and Butterworth (1997) identified the listening performance of both groups using the *Children's Auditory Processing Performance Scale* (CHAPPS; Smoski, Brunt, & Tannahill, 1998). According to the authors, "response choices ranged between the child having 'less difficulty' than others (+1 response) to 'cannot function at all' (-5 response)" (McSporran & Butterworth, 1997, p. 86). A soundfield amplification system with four speakers was placed in both classrooms. Furthermore, the authors requested that all of the teachers and students who used the soundfield amplification system complete two questionnaires about their perception of the system at the end of this study.

The CHAPPS questionnaire was administered to the teachers of both target groups before the soundfield amplification system was installed and then again five months after it had been installed. The investigators discovered that, among both groups, a statistically significant number of children (19 children) had an increase in post-treatment CHAPPS scores compared to pre-treatment scores. Additionally, the investigators determined that, in target Group B, the children who spoke English as a second language had a greater increase in scores between pre-treatment and post-treatment (6 out of 7 children) than children who spoke English as a first language (4 out of 8 children). These results indicated that most of the children showed an improvement in listening performance among both of the groups after the installation of the amplification system. The results also demonstrated that the amplification systems were beneficial to all of the children but significantly more to those whose first language was not English (McSporran & Butterworth, 1997).

The Effects of Amplification on Word Recognition Ability

Researchers have examined the effects of classroom amplification systems on the speech perception abilities of normal developing children as well as for children with developmental disabilities. One such study was conducted by Eriks-Brophy and Ayukawa (2000); they observed three classrooms over a three month period using soundfield amplification. The students ranged from 7 to 17 years old and were in the second or third grade, and a high school classroom, with at least one student in every class reported to have some type of hearing loss. Twenty students (10 with normal hearing and 10 with bilateral hearing loss) were selected to complete the speech intelligibility testing portion of this study. Furthermore, seven children out of the classrooms were selected to complete the behavioral observation portion of this study.

Eriks-Brophy and Ayukawa (2000) equipped all three classrooms with soundfield amplification systems consisting of four loudspeakers that were each placed in the corners of the rooms. To obtain speech intelligibility measurements, recorded lists of 42 syllables were presented to the 20 selected children. These lists were presented both with and without the amplification system. Specifically, each student was independently presented a list of syllables (Auditec recording) when the amplification system was both in use and not in use. Furthermore, Eriks-Brophy and Ayukawa (2000) observed the seven students that participated in the behavioral observation part of the study before installation of the soundfield amplification system and three months after. The students were observed separately for 15 minutes. A list of specific attending behaviors was used to assign scores to the students for this part of the study. The investigators also conducted interviews of the participating students and teachers at the end of the study. Specifically, the teachers were asked their opinions on the level of their students' performances throughout the study, and all of the students were asked to comment on their thoughts about having the amplification systems in the classrooms.

The results showed SNRs between +1.2 and +4.8 dB without the use of the amplification systems and SNRs between +2.8 and +10.2 dB when the amplification systems were used. These results indicated that there was an increase in SNR when the amplification system was in use. In addition, an improvement in speech intelligibility was shown when the amplification system was used as opposed to when the amplification system was not used. Specifically, there were 16.2 and 9.7 fewer errors on the speech intelligibility test when the amplification system was in use versus when it was not in use in children with and without hearing loss, respectively. Additionally, the specific attending behaviors improved (i.e., talking, body orientation, and movement in the classroom) when the amplification system was used as opposed to when it was not used. Lastly, all of the teachers and students reported they liked the amplification system in the classroom, and the teachers reported an improvement in the academics and behaviors of their students (Eriks-Brophy & Ayukawa, 2000).

Larsen, Vega, and Ribera (2008) measured the benefits of classroom amplification on speech perception abilities in two Utah State University classrooms. The acoustical characteristics of one of the classrooms met the standards recommended by ANSI (2002; i.e., ambient noise level of 34 dBA and a RT of 0.53 s), and the other did not (i.e., ambient noise level of 44 dBA and a RT of 0.76 s). The authors of this study selected 53 adult students at Utah State University to participate. All participants had normal hearing sensitivity, and all were believed to be healthy at the time of the study.

Larsen et al. (2008) equipped both classrooms with a soundfield amplification system consisting of four speakers that were each mounted in the four corners of both rooms. A SNR was obtained in both classrooms by taking measurements at every row of desks while the amplification system was in use and not in use. The SNR in the classroom that did not meet ANSI standards averaged +3 dB when the amplification system was not in use and +14 dB when the amplification system was in use. In the classroom that did meet ANSI standards, the SNR averaged +12 dB when the amplification system was not in use and +24 dB when the amplification system was in use. Furthermore, for speech intelligibility testing, the students were asked to write down 50 words that were presented from a CD under both unamplified and amplified conditions in both of the classrooms.

Larsen et al. (2008) found that the average word recognition score for the students in the room that met ANSI standards was 82% when the amplification system was not used and 93% when the amplification system was used. The average word recognition scores for the room that did not meet ANSI specifications was 44% when the amplification system was not used and 81% when the amplification system was used. Thus, both groups of students showed improvement under amplified conditions; however, the improvement of the room that did not meet ANSI standards was significantly better than the improvement of the room that did. Even though the substandard room had a bigger improvement of word recognition ability, the word recognition abilities of the students in the room that did meet ANSI standards still increased with the use of an amplification system. These results suggest that having an amplification system in a substandard room resulted in significantly better word recognition abilities as opposed to not using one. Additionally, the authors found that the use of an amplification system resulted in better word recognition abilities even in a room that already had adequate acoustical characteristics before the use of an amplification system.

A third study that measured the benefits of classroom amplification on speech perception abilities was performed by Mendel, Roberts, and Walton (2003) and used six kindergarten classrooms, consisting of approximately 20 children in each class. One hundred and twenty eight total students (all believed to have normal speech, language, and hearing skills) participated in this study. Three of the kindergarten classrooms were equipped with soundfield amplification systems (treatment group) while the other three were not (control group). Furthermore, when the children moved to first grade, they remained in the same groups and were placed into eight classrooms, four equipped with soundfield amplification systems and four without amplification systems. This study began with 128 students but was completed by only 95 students.

Mendel et al. (2003) equipped each of the treatment classrooms (i.e., three kindergarten classrooms and four first grade classrooms) with one soundfield amplification system and four loudspeakers. In order to measure the speech perception abilities of the children, the authors used two types of tests: the *Phonetically Balanced Kindergarten* (PB-K; Haskins, 1949) word lists and the *Word Intelligibility by Picture Identification* (WIPI; Ross & Lerman, 1971). The authors presented both tests through a CD (Auditec of St. Louis), and the word lists were presented in combination with background noise that was obtained through recording randomized classroom noise in each classroom at various times throughout the day. The authors obtained speech perception ability measurements in two ways. In the first way, the authors used two audiometers and routed the PB-K word lists at 56 dBA and background noise at a +6 dB SNR to the students individually through supra-aural headphones. For the second way the authors presented WIPI word lists at 70 dBA and background noise at a +6 dB SNR through speakers in order to test the students as a group. In the classrooms with soundfield amplification systems, the WIPI word lists were also presented through soundfield speakers. Over the period of the study, the authors tested these children in the fall of their first year of school (kindergarten), that spring, and then in the spring of their second year of school (first grade).

The results showed that the SNRs of the classrooms that had soundfield amplification systems were between +6 and +10 dB. Furthermore, speech perception testing showed an improvement of five or more words correct when the amplification system was in use for the WIPI word lists. Specifically, with all semesters combined, the treatment group scored 86.07% versus the control group which scored 82.46%. The results demonstrated that the use of an amplification system increased the SNR of the classrooms that used the system and also improved the speech intelligibility of the children who were tested while using the system.

A fourth study that measured the benefits of classroom amplification on speech perception abilities used four children from the Down Syndrome Association of New Zealand and was conducted by Bennetts and Flynn (2002). The children were all diagnosed with Down syndrome and were all between the ages of five and seven years. All children had mild to no hearing loss. All children were tested using the Kendall Toy test (KT; Kendall, 1962) in both amplified and unamplified conditions using a soundfield amplification system with a four speaker array. The examiner spoke into a microphone at 60 dBA connected to the soundfield amplification system. The soundfield amplification system provided the level of the speaker's voice with +10 dB of gain, so when the system was in use, the speech stimuli was being presented at 70 dBA. Before every test session, the authors used a sound level meter to measure the level of background noise as well as the level of the speaker. Furthermore, while the speech perception test was taking place, cafeteria noise was presented from a tape recorder at the levels of 50, 55, and 60 dBA.

When the amplification system was not in use, the averages of the number of words the children were able to correctly identify (out of 10) were 8.5 in the presence of 50 dBA of background noise, 5.25 in the presence of 55 dBA of background noise, and 2.75 in the presence of 60dBA of background noise. When the amplification system was in use, the averages of the number of words correctly identified by the children were 9.5 in the presence of 50 dBA of background noise, 10 in the presence of 55 dBA of background noise, and 9.5 in the presence of 60dBA of background noise. These data provided evidence that, even among high levels of background noise, the speech perception abilities of the children were greatly improved with the use of the SF amplification system, even when the children have Down's syndrome.

A fifth study that observed the effects of classroom amplification on speech perception was completed by Flexer, Millin, and Brown (1990) and used nine children with developmental disabilities. All children had an IQ of 80 or lower and were between the ages of four and six. Six of the nine children were also reported to have fluctuating hearing loss; however, none of the children used hearing aids. The classroom was a primary/normal level class with the only exception being that it was used for developmentally handicapped children.

Flexer et al. (1990) placed a soundfield amplification system with two loudspeakers, a microphone, and a receiver in the classroom. The two loudspeakers were placed 12 ft from each other along one wall on shelves that were 6 ft high. The authors used a sound level meter that was placed on a tripod to record the sound pressure level produced by the soundfield amplification system and the acoustical characteristics of the room. The authors also used the sound level meter to measure the noise levels of the room and the intensity levels of the teacher's voice by taking measurements at five specific positions around the room. The measurements were taken close to the nearest desk that was at each of the five positions, and the tripod was positioned at ear height of the student seated in the desks. In order to measure the speech perception abilities of the children, the authors used the WIPI (Ross & Lerman, 1971).

Using live voice, the teacher presented one WIPI word list to four of the students while not using amplification, and then she presented another word list to the same set of students while amplification was used. The teacher then presented a WIPI word list to the other five students while the soundfield amplification system was in use, and then she proceeded to present another word list to the same set of students while amplification was not in use. All of the students were seated at individual tables that were placed in the area of the room where the SNR was found to be the poorest. An adult who was seated with the child at each table marked the responses of the child on a picture worksheet that corresponded to the WIPI word lists.

Flexer et al. (1990) found that the level of background noise to be approximately 42 to 43 dBA. Furthermore, the SNR of the teacher's voice in unamplified conditions ranged from +3 to +11 dB. Despite the differences between the SNR, the use of the soundfield amplification system increased the SNR of the teacher's voice at all positions. The authors reported that the average increase of the level of the teacher's voice at all positions was +10 dB when the amplification system was in use. Additionally, the authors found that the correct number of responses improved when the soundfield amplification system was used; the mean improvement of correct responses when the soundfield amplification system was used was 2.4 words. These results suggest that the use of a soundfield amplification system improved the speech intelligibility of children who were developmentally disabled, and the soundfield systems also improved the SNR of the teacher's voice.

Iglehart (2004) further investigated the effects of soundfield amplification systems on speech perception abilities in children with cochlear implants. The children were chosen based on three criteria: they were experienced cochlear implant users; they were efficient at concentrating on tasks that were auditory-only for long periods of time;

and they demonstrated language skills that were consistent with normal developing children. The children in this study were between the ages of 6 and 16 years old, and the average number of years the children had worn cochlear implants was 4.6 years.

Iglehart (2004) used two different types of classrooms for this study; one of the classrooms was reported to have ideal classroom acoustics while the other classroom's acoustics were reported to be substandard. The acoustical characteristics of the rooms were recorded in each classroom, and the children were tested under three different testing conditions in each room: no amplification system in use; an amplification system that consisted of four speakers that were each mounted on the wall; and an amplification system with a single speaker placed on the desk. To test the speech perception abilities of the students, the investigator used a CD recording of consonant-vowel-consonant (CVC) words. Forty words were given to each of the students under each testing condition.

In the classroom that was reported to have ideal acoustical characteristics, Iglehart (2004) found no significant difference between the speech recognition score when the wall-mounted amplification system was used (50.3%) versus when the amplification system on the desktop was used (48.2%); however, these scores were better compared to when no soundfield system was used (40.5%). In the classroom with substandard acoustical characteristics, the author found that the use of the amplification system on the desktop provided more benefit (38.0%) than the amplification system that was mounted on the wall (25.2%); however, both scores were found to be better compared to when soundfield amplification was not used (12.8%). The average speech recognition score when any type of amplification was used in the room that had poor acoustics was 31.6%, and the average speech recognition score when any type of amplification was used in the room that had good acoustics was 49.3%; the authors believed this to be due to listening fatigue of the students in the substandard room compared to the fatigue for those in the ideal classroom. However, in both of the classrooms, the author found that the use of either amplification system benefited the speech perception abilities of the children more than when the amplification system was not used.

Lastly, Leung and McPherson (2006) compared two types of soundfield amplification systems in eight classrooms in four government-funded primary/elementary schools that were constructed with concrete within the last 30 years. The four schools were randomly selected from 48 schools in Hong Kong, all of which were in highly populated areas and close to roads with heavy traffic. Each classroom used was a randomly selected special education room for children with developmental disabilities. No acoustic alterations were made to any of the classrooms, and each classroom averaged between seven to 10 students. Acoustical measurements were taken when the classrooms were unoccupied.

First, unoccupied acoustical characteristics including levels of noise, RT, and levels of speech were recorded. In all eight classrooms, the authors then installed the soundfield system and placed the loudspeaker stands in all four corners of each classroom. They also installed a PA system by placing the speaker in the front center of the room. The microphones for both the soundfield and PA systems were positioned at a distance of 5 cm from the mini-disk (MD) speaker that produced the recorded speech.

Leung and McPherson (2006) found that none of the classrooms met the 35 dBA ANSI (2002) recommendation for unoccupied noise levels. Furthermore, the average level of speech for the classrooms when neither the soundfield nor the PA amplification system was used was 58 dBA. When the soundfield system was used, the average level of speech was 68 dBA; in comparison, the PA system produced speech at 64 dBA. The investigators further showed that when using soundfield amplification the average SNR was found to be +24 dB and when using PA amplification the average SNR was +20 dB. While the averages of the rooms met the +15 dB SNR recommended by ANSI (2002) for optimal acoustics, the soundfield amplification system provided a greater SNR. Therefore, the use of either type of amplification system in a classroom was beneficial in improving the SNR, compared to the classrooms that did not use an amplification system; however, the soundfield amplification system provided a greater amount of gain than the PA system did.

Rationale for Current Study

While there are many studies that have provided evidence that amplification systems in the classrooms are beneficial to the listening environments, there are currently no known studies on the acoustical characteristics of a relocatable classroom (i.e., a stand-alone, portable classroom that is not in, or connected to, another structure or building) or the effects soundfield amplification systems have on the SNR and speech perception abilities of the children in them. In other words, there is no evidence to indicate if relocatable classrooms, while convenient, actually provide a disadvantage to learning.

Without proper study of the acoustical characteristics of these buildings and their effect on the listening environment of the children in them, we are not able to determine how they compare to standard classrooms. Therefore, the goal of the present study was to examine background noise levels and the SNR of a relocatable classroom and compare it to a traditional classroom in both an amplified (soundfield amplification system) and unamplified condition, as well as with them occupied and unoccupied. Additionally, word discrimination abilities were compared between the two settings in both an amplified and unamplified condition.

CHAPTER III

METHODS

Participants

Two junior high school classrooms were chosen for this study. The classrooms consisted of one relocatable classroom and one permanent classroom from a Lincoln Parish school. The relocatable classroom was a building the school used for a classroom. Standing apart from the school, it was portable, and it measured 32 (length) by 23 (width) ft. The permanent classroom was a classroom inside the main school building and measured 36 ½ (length) by 23 (width) ft. The classrooms were selected based on availability and the principal's recommendation.

The inclusion criteria into this study required: (1) children signed an assent form; (2) their guardians signed an informed consent form; and (3) children passed a hearing screening at 20 dB HL at 1000, 2000, and 4000 Hz in the left and right ears. Any children that did not meet all three of the inclusion criteria were allowed to participate in the study; however, their data were not used in the results. In the permanent classroom, 21 out of 22 students returned permission forms; therefore, 95% of the students from this classroom participated in the study. In the relocatable classroom, 16 out of 18 students returned permission forms, and one student failed the hearing screening; therefore, 83% of the students from this classroom participated in the study.

Instrumentation

All of the children that participated in this study had their hearing screened with a portable audiometer (GSI 17) using supra-aural headphones. Two soundfield amplification systems (Easy Listener by Phonic Ear), each equipped with a four-speaker array (AT 578-S, Phonic Ear), a FM transmitter (PE300T, Phonic Ear), and a microphone (AT0291-L, Phonic Ear) were used in this study. In order to obtain word recognition measurements, a CD player (Memorex) was used to produce word lists using an Auditec recording of the *Northwestern University Auditory Test No.6* (NU-6, Tillman and Carhart, 1966; see Appendix A for the word lists). Adobe Audition was used to remove the spaces between the speech for word lists 1A and 2A. The NU-6 word lists were chosen due to the fact that the children were likely to have heard these words on a daily basis; this allowed the test to be a test of speech perception ability and not a test of vocabulary. A sound level meter (Bruel & Kjaer type 2235) connected to a microphone (Bruel & Kjaer type 4176) was used to record the levels of noise in each classroom, to determine the intensity levels of the CD player, and to measure the SNR of the amplified and unamplified classrooms.

Procedures

Following approval by the Human Use Committee at Louisiana Tech University (see Appendix B for IRB Approval Memo), a letter was sent to the principal of the school in order to seek permission to carry out the study (see Appendix C). After approval from the principal of the school, permission forms were sent to the guardians of the children participating in this study (see Appendix D). On the day word recognition abilities were tested, students were asked to sign an assent from to confirm that they agreed to participate in the study (see Appendix E for child assent form). The students who did not return consent forms, pass the hearing screening, or confirm they agreed to participate in the study on the assent form were allowed to participate in this study; however, their data were not used in the results.

The researcher provided hearing screenings for the children who participated in the study. Hearing screenings were administered to both groups of children on the same day at a time that was convenient for the classroom teachers and school administration. The researcher set up the portable audiometers in a separate room located inside of the school building and screened the participants individually at 20 dB HL at 1000, 2000, and 4000 Hz in both ears using supra-aural headphones.

Five tables in the permanent classroom were rearranged into a square that measured 15 (length) by 15 (width) ft with two tables in the front, one table in the center, and two tables in the back (see Appendix F for classroom layouts). Five tables were rearranged in the same arrangement in the temporary classroom, which measured 12 (length) by 19 (width) ft (see Appendix F for classroom layouts). Markers were placed at specific locations on the floors in both classrooms to ensure that measurements were obtained at the same locations for unoccupied and occupied measurements under both amplification conditions. Unoccupied noise level measurements were then obtained in both classrooms. The noise levels in the unoccupied classrooms were taken during school hours so that there were people in and around the buildings to help ensure that test conditions were consistent with everyday classroom environments. Please note all unoccupied noise level measurements were made with permanent systems turned on (i.e., lights, HVAC, etc.) and all temporary systems were turned off (i.e., computers, projectors, etc.). The following protocol was followed in order to obtain unoccupied noise level measurements in both classrooms:

1. The sound level meter was placed 1.5 m off the ground next to the table to the far right in the front row, and an average sound pressure level was recorded.
2. The sound level meter was placed 1.5 m off the ground next to the table to the far left in the front row, and an average sound pressure level was recorded.
3. The sound level meter was placed 1.5 m off the ground next to the table to the far right in the back row, and an average sound pressure level was recorded.
4. The sound level meter was placed 1.5 m off the ground next to the table to the far left in the back row, and an average sound pressure level was recorded.
5. The sound level meter was placed 1.5 m off the ground next to the table directly in the center, and an average sound pressure level was recorded.

After school was dismissed, the researcher assembled the soundfield amplification system, placing the loudspeakers around the square of tables at the corners (see Appendix F for classroom layouts). The speakers were positioned facing towards the center of the classroom, and the soundfield amplification system was arranged using the directions for set-up which were provided with the system. This was done to simulate typical set-up for these systems. Specifically, both of the soundfield systems were set to a volume level of 4 ½ because this was the highest level the relocatable classroom could tolerate before experiencing feedback.

Occupied classroom noise level measurements were completed for both classrooms using the exact same procedure used when obtaining the unoccupied classroom noise levels. To collect these data, all permanent and temporary systems were turned on (i.e., lights, HVAC, projectors, computers, etc.). There were students inside the classroom sitting at the tables working on an assignment, and neither the students nor teachers were talking at this time. The following protocol was followed in order to obtain occupied noise level measurements in both classrooms:

1. The sound level meter was placed 1.5 m off the ground next to the table to the far right in the front row, and an average sound pressure level was recorded.
2. The sound level meter was placed 1.5 m off the ground next to the table to the far left in the front row, and an average sound pressure level was recorded.
3. The sound level meter was placed 1.5 m off the ground next to the table to the far right in the back row, and an average sound pressure level was recorded.
4. The sound level meter was placed 1.5 m off the ground next to the table to the far left in the back row, and an average sound pressure level was recorded.
5. The sound level meter was placed 1.5 m off the ground next to the table directly in the center, and an average sound pressure level was recorded.

Speech level measurements of the unoccupied classrooms were obtained under both unamplified and amplified conditions. While collecting these data, all permanent systems were turned on (i.e., lights, HVAC, etc.) but all temporary systems were left off (i.e., projectors, computers, etc.). The following protocol was used to collect the data for the unoccupied speech level measurements under unamplified and amplified conditions:

1. Protocol for Obtaining Unamplified Speech Level Measurements
   a. The researcher placed the CD player that presented the NU-6 word lists on a stand 6 ft in front of the first row of tables, in the center.

b. NU-6 word lists 1A and 2A were presented at a constant intensity of 65 dBA (see Appendix A for word lists). The sound level meter was used to ensure the intensity level of 65 dBA was achieved 1 m front of the CD player. The word lists that were presented here were for unoccupied room speech intensity measurements only. They were not the same word lists that were presented to the classrooms during the speech perception testing.

c. The sound level meter was placed 1.5 m off the ground next to the table to the far right in the front row, and an average sound pressure level was recorded.

d. The sound level meter was placed 1.5 m off the ground next to the table to the far left in the front row, and an average sound pressure level was recorded.

e. The sound level meter was placed 1.5 m off the ground next to the table to the far right in the back row, and an average sound pressure level was recorded.

f. The sound level meter was placed 1.5 m off the ground next to the table to the far left in the back row, and an average sound pressure level was recorded.

g. The sound level meter was placed 1.5 m off the ground next to the table directly in the center, and an average sound pressure level was recorded.

2. Protocol for Obtaining Amplified Speech Level Measurements

a. With the NU-6 word lists 1A and 2A presenting at a constant intensity of 65 dBA (see Appendix A for word lists), the microphone of the FM system was placed on a stand 6 in. away from the CD player, and the soundfield amplification was turned on.

b. The sound level meter was placed 1.5 m off the ground next to the table to the far right in the front row, and an average sound pressure level was recorded.

c. The sound level meter was placed 1.5 m off the ground next to the table to the far left in the front row, and an average sound pressure level was recorded.

d. The sound level meter was placed 1.5 m off the ground next to the table to the far right in the back row, and an average sound pressure level was recorded.

e. The sound level meter was placed 1.5 m off the ground next to the table to the far left in the back row, and an average sound pressure level was recorded.

f. The sound level meter was placed 1.5 m off the ground next to the table directly in the center, and an average sound pressure level was recorded.

The researcher also conducted speech testing in both classrooms under both unamplified and amplified conditions for the children who returned signed consent forms, signed the assent form, and passed the hearing screening The following protocol was used to obtain the speech perception abilities of the participants in both classrooms:

1. Protocol for Obtaining Unamplified Speech Perception Abilities

   a. The researcher placed the CD player that presented the NU-6 word list on a stand 6 ft in front of the first row of tables, in the center. The CD presented 50 words at a level of 65 dBA.

   b. The soundfield amplification was turned off.

   c. Pieces of paper with the numbers 1-50 were placed on the tables in front of each of the children. The children were given verbal instructions that they were going to hear 50 words and that they were to write down what they heard on the numbered paper in front of them. They were told that even if they were not sure what they had heard, they were to take a guess and to try to write something down anyway.

d. NU-6 word list 3A or 4A was presented at a constant intensity level of 65 dBA (see Appendix A for word list).

e. The children wrote down the 50 words that they heard to the best of their abilities.

2. Protocol for Obtaining Amplified Speech Perception Abilities

a. The microphone of the FM system was placed on a stand 6 in. away from the CD player.

b. Pieces of paper with the numbers 1-50 were placed on the tables in front of each of the children. The children were given verbal instructions that they were going to hear 50 words and that they were to write down what they heard on the numbered paper in front of them. They were told that even if they were not sure what they had heard, they were to take a guess and to try to write something down anyway.

c. The microphone of the FM system was turned on.

d. The NU-6 word list 3A or 4A was presented (see Appendix A for word list).

e. The children wrote down the 50 words that they heard to the best of their abilities.

f. The microphone of the FM system was then turned off.

When speech testing was completed, the researcher counterbalanced the soundfield conditions between the two classrooms. The entire experiment from the hearing screenings through the completion of speech testing for both classrooms was completed in two weeks.

CHAPTER IV

RESULTS

The overall purposes of this study were to compare the acoustical characteristics of a temporary, relocatable classroom and a traditional, permanent classroom as well as to compare the word recognition abilities of students with normal hearing with and without soundfield amplification. The two selected classrooms were determined by the principal's recommendation and availability. The permanent classroom measured 36 ½ (length) by 23 (width) ft, and the relocatable classroom measured 32 (length) by 23 (width) ft.

Noise Levels in the Classroom

The first purpose of this study was to determine the unoccupied noise levels for both the permanent and relocatable classrooms. In order to determine this, five measurements in each unoccupied classroom (permanent and relocatable) were taken at five specific locations around the room; one measurement was taken on each of the four outside corners of the square of tables , and one measurement was taken in the center of the square of tables (see Appendix F for classroom layouts). The noise levels were determined by taking an average sound pressure level measurement at each location. During the time of the measurements, there were students in and around the building in order to simulate an average class day; however, both rooms were unoccupied at the time of the measurements. The data for the unoccupied noise levels taken at each position in both classrooms are displayed in Table 1.

Table 1

Unoccupied Noise Levels for the Permanent and Relocatable Classrooms

Position	Permanent (dBA)	Relocatable (dBA)
1	39.5	53.6
2	39.2	52.6
3	37.6	59.0
4	39.2	55.7
5	37.0	54.2

A one-way repeated measure analysis of variance (ANOVA) was conducted to determine the effect of classroom on unoccupied noise levels. The dependent variable was unoccupied noise measurements. The grouping variable was classroom with two levels (permanent and relocatable). The results showed a significant effect for classroom ($F[1,9] = 182.6$, $p < 0.001$). These results indicated that the noise was louder in the relocatable classroom ($M = 55.0$) compared to the permanent classroom ($M = 38.5$).

The second purpose of this study was to determine the occupied noise levels for both the permanent and relocatable classrooms. In order to determine this, measurements were taken in the same five locations as the unoccupied noise measurements with the only differences being that both of the rooms were occupied (i.e., children were sitting at the tables working quietly on an assignment) and the temporary systems (i.e., computers, projectors, etc.) in the room were turned on (see Appendix F for classroom layouts). The noise levels were determined by taking an average at each location. The data for the occupied noise levels taken at each position in both classrooms are displayed in Table 2.

Table 2
Occupied Noise Levels for the Permanent and Relocatable Classrooms

Position	Permanent (dBA)	Relocatable (dBA)
1	47.5	54.6
2	45.5	53.4
3	43.0	60.4
4	45.1	56.2
5	43.1	56.5

A one-way repeated measures ANOVA was conducted to determine the effect of the classroom on occupied noise levels. The dependent variable was occupied noise measurements. The grouping variable was classroom with two levels (permanent and relocatable). The results showed a significant effect for classroom ($F[1,9] = 61.5, p < 0.001$). These results indicated that the noise was louder in the relocatable classroom ($M = 56.2$) vs. the permanent classroom ($M = 44.8$) when both classrooms were occupied with children sitting at the tables working on an assignment.

Speech Levels in the Classroom

The third purpose of this study was to determine the speech levels at various locations in both classrooms under unamplified and amplified conditions. In order to answer this, Auditec recordings of two NU-6 word lists, with the spaces between the speech removed, were presented from a CD player while the classrooms were unoccupied (i.e., no students were present but permanent systems were turned on). The word lists were presented under both unamplified and amplified conditions. Measurements of the speech levels were taken at the same five locations in each room as the unoccupied and occupied noise measurements (see Appendix F). The speech levels were determined by taking an average at each location. The data for the unoccupied speech measurements taken at each position in both classrooms under unamplified and amplified conditions are displayed in Table 3

Table 3

Unamplified and Amplified Speech Levels in Both Classrooms

Position	Condition	Permanent (dBA)	Relocatable (dBA)
1	Unamplified	61.8	64.0
	Amplified	65.6	66.3
2	Unamplified	60.0	62.3
	Amplified	65.9	66.6
3	Unamplified	54.6	64.6
	Amplified	62.0	66.4
4	Unamplified	55.2	62.1
	Amplified	61.9	65.4
5	Unamplified	58.6	63.7
	Amplified	60.8	67.3

The unoccupied noise levels and unoccupied speech levels from both classrooms were used to determine the SNR of both classrooms under unamplified and amplified conditions. For example, these SNRs were determined by subtracting the unamplified noise level from the unamplified speech level at each of the five positions as displayed in Table 3; this procedure was completed for both amplification conditions for each classroom. A two-way repeated measure ANOVA was conducted to determine the effect of type of classroom and amplification condition on SNRs in the unoccupied classrooms. The within subject variable was amplification condition with two levels (unamplified and amplified). The between subject variable was classroom with two levels (permanent and relocatable). The data for the SNRs in both classrooms under both unamplified and amplified conditions are displayed in Figure 1.

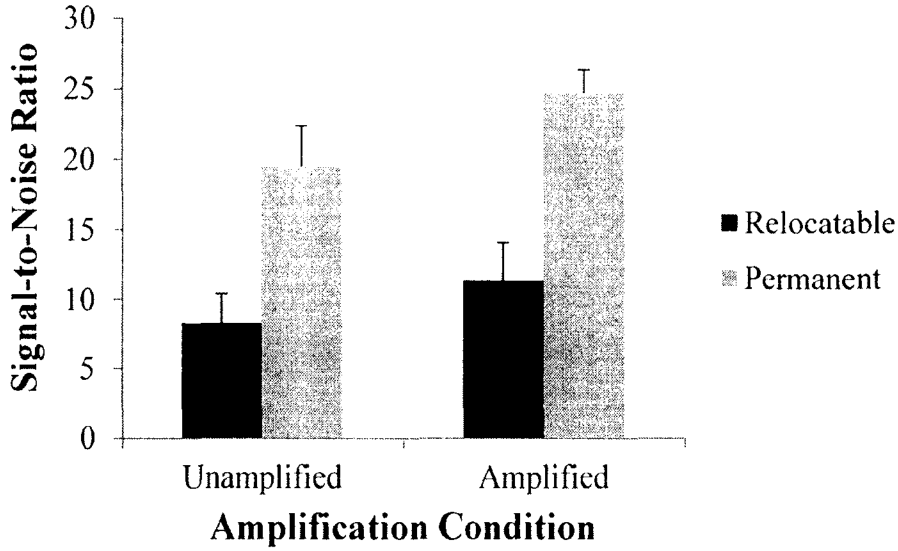


Figure 1. SNRs for both classrooms under unamplified and amplified conditions

The results showed a significant main effect for amplification condition ($F[1,8] = 60.4, p < 0.001$) and type of classroom ($F[1,8] = 74.7, p < 0.001$). The amplification condition by type of classroom interaction was not significant ($F[1,8] = 4.1$, p = .079). These results indicated that, overall, SNRs were improved in the amplified condition as opposed to the unamplified condition in both classrooms. The results also indicated that the SNRs were greater in the permanent classroom under both conditions compared to the SNRs in the relocatable classroom.

Word Recognition Performance

The fourth purpose of this study was to determine the word recognition scores (WRS) of children in both classrooms under unamplified and amplified conditions. The children in both classrooms were seated in seats predetermined by the examiner at each of the five tables in the rooms (see Appendix F for classroom layouts). Two different NU-6 word lists (unamplified and amplified) were presented to the children using a CD player, and they were asked to write down the words that they heard. The examiner assigned a percent correct for each child in each amplification condition. All of the children's scores were then averaged per classroom and amplification condition. Mean data for the percentage of words correct in both classrooms under both unamplified and amplified conditions is displayed in Figure 2.

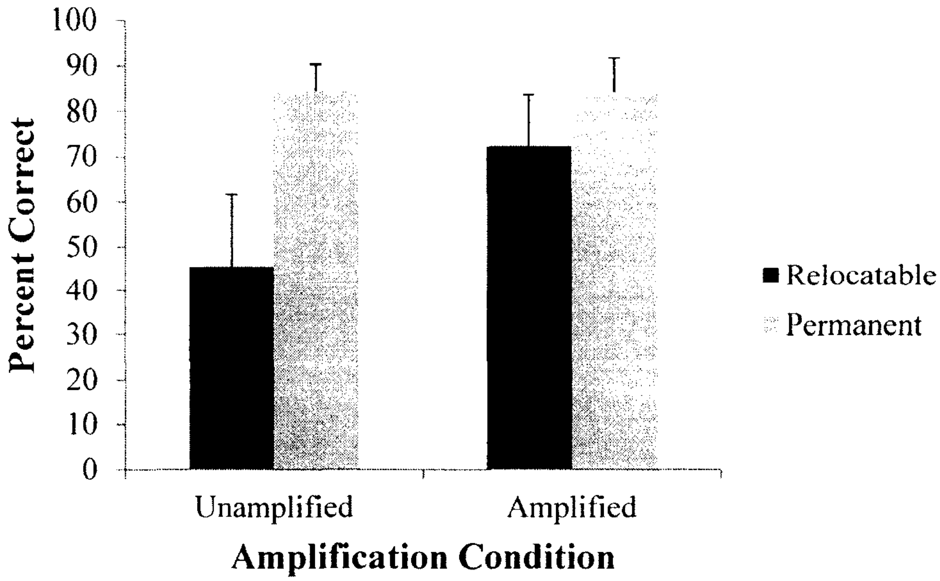


Figure 2. Percent of words correct under unamplified and amplified conditions for relocatable and permanent classrooms

A two-way repeated measures ANOVA was conducted to determine the effect of classroom type and amplification condition on word recognition ability. The within subject variable was amplification condition with two levels (unamplified and amplified). The between subject variable was classroom with two levels (relocatable and permanent). The results showed: (1) a significant main effect for amplification condition (F[1,34] =

109.6, $p < 0.001$), (2) a significant main effect for classroom condition ($F[1,34] = 60.6$, $p < 0.001$), and (3) a significant amplification condition by classroom interaction ($F[1,34] = 114.4$, $p < 0.001$). These results indicated that, overall, WRS improved in both classrooms when amplification was used ($M = 78.2\%$) compared to no use of soundfield systems ($M = 65.1\%$). These results also indicated word recognition ability in the relocatable classroom ($M = 59.0\%$) was significantly worse than word recognition ability in the permanent classroom ($M = 84.2\%$), most likely due to high background noise levels in the relocatable classroom.

As noted, there was a significant interaction between amplification condition and classroom type. As shown in Figure 3, WRS in the relocatable classroom improved from 45.7% when no amplification was used to 72.3% when amplification was used. On the other hand, permanent classroom results for the two amplification conditions remained constant (i.e., 84.4% in the unamplified condition and 84.1% in the amplified condition). The WRS of the children in the relocatable classroom were significantly poorer than the WRS of the children in the permanent classroom under both amplification conditions. However, the WRS of the children in the relocatable classroom significantly improved when the amplification system was used, indicating the children greatly benefited from the use of the soundfield amplification systems.

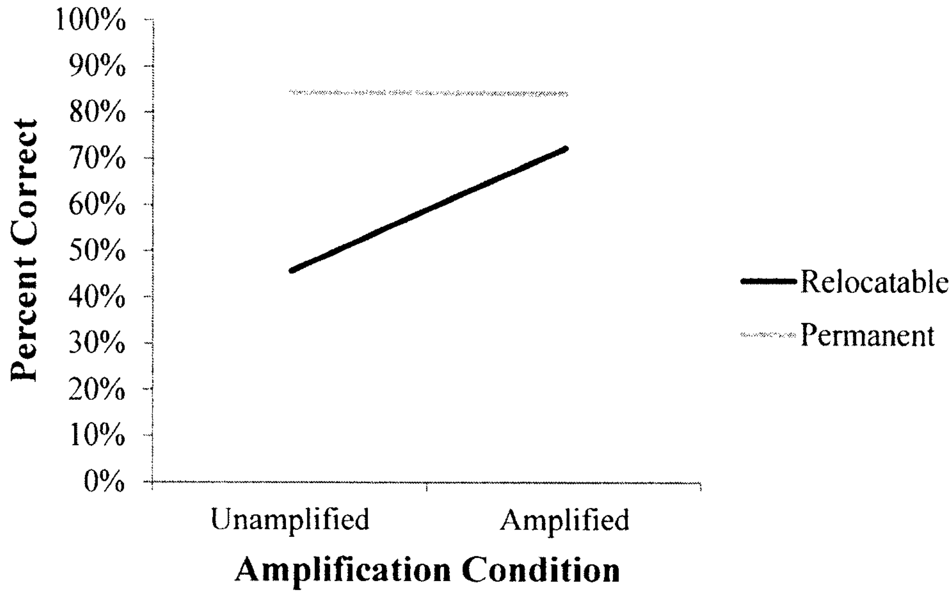


Figure 3. WRS for both classrooms under unamplified and amplified conditions

CHAPTER V

DISCUSSION

Noise Levels in the Classroom

The first purpose of this study was to determine the unoccupied noise levels in the permanent and relocatable classrooms. This was completed by taking measurements in each unoccupied classroom (permanent and relocatable) at five specific locations around the room (see Appendix F). The noise levels were determined by taking an average sound pressure level measurement at each location. According to the recommendations for optimal acoustics in classrooms set forth by ANSI (2009; i.e., relocatable classroom standards) and ANSI (2010; i.e., permanent classroom standards), the amount of background noise present in unoccupied permanent and relocatable classrooms should not exceed 35 dBA. Results of the present study revealed that neither of the classrooms met this 35 dBA recommendation of ambient noise levels. The noise levels in the permanent classroom, however, were close to meeting this standard (M = 38.5 dBA) while the noise levels in the relocatable classroom (M = 55.0 dBA) were found to be significantly greater at each of the five positions than the noise levels in the permanent classroom.

These results indicated that the relocatable classroom was louder at every position compared to the permanent classroom. Specifically, the noise levels inside the unoccupied permanent classroom never exceeded a level of 39.5 dBA at any of the measured locations, even though high noise level events were occurring at the same time measurements were taken (i.e., children were eating lunch down the hall as well as practicing band). On the other hand, the relocatable classroom had no measured noise levels lower than 52.6 dBA despite the fact that these measurements were taken with little to no activity occurring just outside the building. It should also be noted that the permanent classroom was relatively close to meeting ANSI (2010) standards regardless of the fact that it was constructed in 1985 (i.e., 28 years ago); however, the relocatable classroom, was marginally newer (constructed approximately 25 years ago) and still had significantly poorer acoustical characteristics.

Although there is currently no known research on the noise levels of relocatable classrooms, the results from the present study on unoccupied permanent classroom noise levels were expected and agreed with previous research. Specifically, Knecht et al. (2002) obtained unoccupied noise levels in 32 classrooms and found that levels of noise in unoccupied classrooms were found to be between 34.4 and 65.9 dBA; in fact, only four of the 32 classrooms that were used met the ANSI recommendation of 35 dBA. Likewise, Rosenburg et al. (1999) obtained unoccupied noise levels in 94 classrooms and found the average level of noise in the unoccupied classrooms to be 47.5 dBA, much higher than the ASHA (1995) recommendation of 35 dBA. Results of the present study agreed with the results from the previous research, showing that many permanent classrooms typically do not meet the ANSI (2010) or ASHA (2005) recommendations for background noise levels.

The second purpose of this study was to determine the occupied noise levels for both the permanent and relocatable classrooms. In order to determine this, measurements were taken in the same five locations as the unoccupied noise measurements with the only differences being that both of the rooms were occupied (i.e., children were sitting at the tables working on an assignment) and the temporary systems (i.e., computers, projectors, etc.) in the room were turned on. The results revealed that the occupied noise levels in both classrooms were high, with the levels in the permanent classroom averaging 44.8 dBA, and levels in the relocatable classroom averaging 56.2 dBA. Additionally, it was noted that even though the occupied noise levels in both classrooms were high, the levels in the relocatable classroom were significantly higher at each position compared to the levels in the permanent classroom.

As previously stated, there is currently no known research on relocatable classrooms, however, the results from the present study on occupied permanent classroom noise levels were expected and agreed with previous research. Specifically, one study that looked at occupied noise levels of permanent classrooms was conducted by Choi and McPherson (2005); these results showed that the noise levels of the classrooms were between 55 and 70 dBA, which agreed with the results from the current study, showing that occupied noise levels in classrooms are generally high.

Speech Levels in the Classroom

The third purpose of this study was to determine the speech levels at various locations in both unoccupied classrooms under unamplified and amplified conditions by taking speech level measurements at the five locations in each room (see Appendix F). The results revealed that the speech levels increased by appropriately 3-5 dB in the permanent classroom when the soundfield amplification system was used; likewise, the results revealed that the speech levels increased by approximately the same degree in the relocatable classroom when the amplification system was used. Based on these results, the investigator determined that the use of soundfield amplification increased the levels of speech in both classrooms at each position.

The primary purpose for obtaining unoccupied speech levels under both amplification conditions was for the determination of SNR. Specifically, SNR was determined by subtracting the unoccupied noise level measurements from the unoccupied speech level measurements in each classroom in each amplification condition (e.g., Speech – Noise = SNR). The results revealed that the average SNR in the permanent classroom in the unamplified condition was +19.5, and it increased to +24.7 in the amplified condition. For the relocatable classroom, the results revealed that the average SNR in in the unamplified condition was +8.3, and it increased to +11.3 in the amplified condition. According to the standards provided by both ANSI (2010) and ASHA (2005), a +15 SNR in permanent classrooms is recommended; there are currently no known SNR standards for relocatable classrooms. The investigator found that the results obtained in the current study indicated that, overall, the average SNR in the permanent classroom met the +15 recommendation when amplification was not used, and the SNR improved when amplification was used. The results also supported that while the average SNR in the relocatable classroom did not meet the +15 recommendation under either amplification condition, the SNR still significantly improved when amplification was used.

The results from the present study on SNR levels were expected and agreed with previous research. Specifically, Larsen and Blair (2008) looked at the SNR of four fourth-grade classrooms when amplification systems were used versus when they were not used. The researchers discovered that without the use of the amplification system, the

SNRs averaged between +1 and +6 dB SPL and increased to +13 dB SPL when amplification systems were in use. The results from previous research, as well as from the current study, revealed that an increase in SNR can be expected when amplification systems are used compared to when they are not used (Larson & Blair, 2008; McSporran & Butterworth, 1997; Mendel et al., 2003).

Word Recognition Performance

The fourth purpose of this study was to determine the WRS of children in both classrooms under unamplified and amplified conditions. The results revealed that the WRS in the relocatable classroom improved when amplification was used; however, permanent classroom results for the two amplification conditions remained constant, most likely because the permanent classroom generally met the recommended acoustical characteristics. These results further revealed that the WRS of the children in the relocatable classroom were significantly poorer than the WRS of the children in the permanent classroom under both amplification conditions. However, the WRS of the children in the relocatable classroom significantly improved when the amplification system was used, indicating the children greatly benefited from the use of the soundfield amplification systems in this room.

The results from the present study were expected and agreed with previous research. Specifically, Larsen et al. (2008) looked at the word recognition abilities of children in two different classrooms: one classroom that met ANSI recommendations for optimal acoustics, and one classroom that did not meet ANSI standards. Larsen et al. (2008) found that the average WRS for the students in the room that met ANSI standards was 82% when the amplification system was not used and 93% when the amplification system was used (i.e., an increase of 11%). The average word recognition scores for the room that did not meet ANSI specifications was 44% when the amplification system was not used and 81% when the amplification system was used (i.e., an increase of 37%). The results from the study conducted by Larsen et al. (2008) revealed that both types of classrooms benefited from the use of soundfield amplification systems, with the room that did not meet the standards benefiting more. Similar results were displayed in the current study.

In summary, the investigator found that although the permanent classroom was close, neither of the classrooms that were used (permanent or relocatable) met the ANSI (2010) or the ANSI (2009) standards for optimal acoustics. However, the unoccupied and occupied noise level measurements taken in the relocatable classroom were significantly greater at all five of the positions compared to the permanent classroom, indicating that the relocatable classroom was considerably louder than the permanent classroom. The average SNR in the permanent classroom met the recommended +15 under both amplification conditions and was significantly greater than the SNR in the relocatable classroom, most likely due to the high noise levels measured in the unoccupied relocatable classroom. Although the average SNR of the relocatable classroom did not meet the recommended +15 dBA under either amplification condition, it was significantly improved when the amplification system was used compared to when it was not used.

The results of this study revealed that using an amplification system proved to be beneficial in both classrooms by improving SNR, especially in the relocatable classroom. Although using the amplification system did not allow the relocatable classroom to meet the ANSI recommendations for optimal acoustics, it still significantly improved SNR, thus improving the word recognition abilities of the children in that classroom.

Based on these results, it is reasonable to state that soundfield systems would be beneficial to use in permanent classrooms, but more importantly, soundfield systems should always be used in relocatable classrooms due to the high levels of background noise. The relocatable classroom had significantly higher ambient noise levels compared to the permanent classroom, which greatly affected the word recognition abilities of the children. In fact, the two students who had the poorest WRS in the relocatable classroom were seated next to the two AC wall units inside of the building (seats that are also used during normal class time). When the amplification system was not used, one of the students scored an 8% while the other scored a 16%. These scores significantly increased to 42% and 52%, respectively when the amplification system was used. While the scores increased with soundfield amplification system, they were still considered poor. Also noted in the relocatable classroom, none of the students scored higher than a 60% on the word recognition task under unamplified conditions. When the soundfield system was used, the scores all increased; however, none of the scores were higher than 84% which was the average score in the permanent classroom.

Based on the findings of this study, it is appropriate to state that a relocatable classroom may not be an optimal listening environment compared to a permanent classroom and caution should be taken when making the decision to use a relocatable classroom over a permanent classroom. Many times these "temporary" relocatable classrooms become permanent solutions; therefore, if these types of classrooms are used, school administrators may consider not using these types of buildings for core classes (i.e., math, science, reading, etc) or resource classes (i.e., special education, speech therapy, etc.), even with the use of a soundfield amplification system. Additionally, if these types of classrooms are used, they may be more ideal for elective-type classes (i.e. art, computer, typing, etc.), and a soundfield amplification system should also be used. Due to the investigator's limitation of using only one relocatable classroom in the present study, it may be beneficial for future studies to implement the use of multiple relocatable classrooms with different characteristics (e.g., classrooms constructed with different types of building materials and classrooms of different sizes) in order to obtain a better understanding of how these types of classrooms compare to permanent classrooms.

APPENDIX A

NORTHWESTERN UNIVERSITY AUDITORY NO.6 WORD LISTS

APPENDIX A

Northwestern University Auditory No. 6 Word lists

Northwestern University Auditory No. 6 (NU-6) by Auditec of St. Louis

LIST 1A	LIST 2A	LIST 3A	LIST 4A
1. laud	1. pick	1. base	1. pass
2. boat	2. room	2. pass	2. doll
3. pool	3. nice	3. mess	3. back
4. nag	4. said	4. mop	4. red
5. limb	5. fail	5. good	5. wash
6. shout	6. south	6. luck	6. sour
7. sub	7. white	7. walk	7. bone
8. vine	8. keep	8. youth	8. get
9. dime	9. dead	9. pain	9. wheat
10. goose	10. loaf	10. date	10. thumb
11. whip	11. dab	11. pearl	11. sail
12. tough	12. numb	12. search	12. yearn
13. puff	13. juice	13. ditch	13. wife
14. keen	14. chief	14. talk	14. such
15. death	15. merge	15. ring	15. neat
16. sell	16. wag	16. germ	16. peg
17. take	17. rain	17. life	17. mob
18. fall	18. witch	18. team	18. gas
19. raise	19. soap	19. lid	19. check
20. third	20. young	20. pole	20. join
21. gap	21. ton	21. road	21. lease
22. fat	22. keg	22. shall	22. long
23. met	23. calm	23. late	23. chain
24. jar	24. tool	24. cheek	24. kill
25. door	25. pike	25. beg	25. hole
26. love	26. mill	26. gun	26. lean
27. sure	27. hush	27. jug	27. tape
28. knock	28. shack	28. sheep	28. tire
29. choice	29. read	29. five	29. dip
30. hash	30. rot	30. rush	30. rose
31. lot	31. hate	31. rat	31. came
32. raise	32. live	32. void	32. fit
33. hurl	33. book	33. wire	33. make

34. moon
35. page
36. yes
37. reach
38. king
39. home
40. rag
41. which
42. week
43. size
44. mode
45. bean
46. tip
47. chalk
48. jail
49. burn
50. kite

34. voice
35. gaze
36. pad
37. thought
38. bought
39. turn
40. chair
41. lore
42. bite
43. haze
44. match
45. learn
46. shawl
47. deep
48. gin
49. goal
50. far

34. half
35. note
36. when
37. name
38. thin
39. tell
40. bar
41. mouse
42. hire
43. cab
44. hit
45. chat
46. phone
47. soup
48. dodge
49. seize
50. cool

34. vote
35. judge
36. food
37. ripe
38. have
39. rough
40. kick
41. lose
42. near
43. perch
44. shirt
45. bath
46. time
47. hall
48. mood
49. dog
50. should

APPENDIX B

IRB APPROVAL MEMO

APPENDIX B

IRB Approval Memo

LOUISIANA TECH
UNIVERSITY

Relocatable

MEMORANDUM

OFFICE OF UNIVERSITY RESEARCH

TO: Ms. Sarah Babin and Dr. Melinda Bryan

FROM: Barbara Talbot, University Research

SUBJECT: HUMAN USE COMMITTEE REVIEW

DATE: August 9, 2013

In order to facilitate your project, an EXPEDITED REVIEW has been done for your proposed study entitled:

"A Comparison of the Effects of Soundfield Amplification on Acoustical Characteristics and Word Recognition Performance in Relocatable and Permanent Classrooms"

HUC 1021
Change Title of Study

The proposed study's revised procedures were found to provide reasonable and adequate safeguards against possible risks involving human subjects. The information to be collected may be personal in nature or implication. Therefore, diligent care needs to be taken to protect the privacy of the participants and to assure that the data are kept confidential. Informed consent is a critical part of the research process. The subjects must be informed that their participation is voluntary. It is important that consent materials be presented in a language understandable to every participant. If you have participants in your study whose first language is not English, be sure that informed consent materials are adequately explained or translated. Since your reviewed project appears to do no damage to the participants, the Human Use Committee grants approval of the involvement of human subjects as outlined.

Projects should be renewed annually. ***This approval was finalized on November 7, 2012 and this project will need to receive a continuation review by the IRB if the project, including data analysis, continues beyond November 7, 2013.*** Any discrepancies in procedure or changes that have been made including approved changes should be noted in the review application. Projects involving NIH funds require annual education training to be documented. For more information regarding this, contact the Office of University Research.

You are requested to maintain written records of your procedures, data collected, and subjects involved. These records will need to be available upon request during the conduct of the study and retained by the university for three years after the conclusion of the study. If changes occur in recruiting of subjects, informed consent process or in your research protocol, or if unanticipated problems should arise it is the Researchers responsibility to notify the Office of Research or IRB in writing. The project should be discontinued until modifications can be reviewed and approved.

If you have any questions, please contact Dr. Mary Livingston at 257-2292 or 257-5066.

A MEMBER OF THE UNIVERSITY OF LOUISIANA SYSTEM

P.O. BOX 3092 • RUSTON, LA 71272 • TELEPHONE (318) 257-5075 • FAX (318) 257-5079
AN EQUAL OPPORTUNITY UNIVERSITY

APPENDIX C

LETTER TO THE PRINCIPAL

APPENDIX C

Letter to the Principal

November 15, 2010

Dear Mr. Principal:

My name is Sarah Babin, and I am in the Doctor of Audiology program at Louisiana Tech University. I am currently working on my dissertation titled *A Comparison of Classroom Soundfield Amplification Systems on Word Recognition Performance*, and I am requesting your permission to conduct my research at your school and to contact the teachers of the classrooms eligible to participate in my study.

The purpose of this study is to measure and compare the differences, if any, in the word recognition performance of children and the signal-to-noise ratio in relocatable and permanent classrooms when soundfield amplification is in use.

In order to conduct my research, I am requesting the use of two of your classrooms. One will need to be a stand-alone, relocatable classroom not connected in any way to the school building, and the other will need to be a permanent classroom inside of the school building.

I have provided a list of events that will occur in order to perform my research. I have also attached a more detailed protocol list to give you a better idea of everything that will be taking place. This will be a 3 day study in which I would like to do the following:

- Obtain permission from the teachers who would be participating in this study;
- Send letters of consent to the parents/guardians of the participating students;
- Temporarily equip both participating classrooms with a soundfield amplification system (Easy Listener by phonic Ear);
- Perform hearing screenings on the participants for the study;
- Measure the acoustical characteristics of both rooms; and,
- Conduct word recognition ability testing of both classrooms by presenting the *Northwestern University Auditory No. 6* (NU-6) word lists to the children.

This letter also serves to inform you that anonymity of all participants in this study is guaranteed. All data that is collected will be used only for the purpose of this study and will only be used by the researcher. A completed copy of the results will be sent to you at the completion of this dissertation.

If you have any further questions about my study, I would be happy to answer them for you. I look forward to hearing back from about the participation of your school. Thank you for your consideration.

Sincerely,

Sarah Babin

Day by day protocol that will be used for conducting research in this school:

2 weeks before research begins:

Parent/Guardian consent forms will be issued to the children for their parents to sign and return back. Students who do not have a signed consent form will not be used for this study with no repercussions involved.

Day 1:

- The researcher will provide hearing screenings at your facility for the children who are participating in this study. Both classrooms will be screened on the same day and will take about 30 minutes for each room. These will be performed during the time of day that is the most convenient for the teachers.
- The desks in both classrooms will be rearranged into at least 5 even rows.
- During lunch time, measurements of background noise will be collected in both classrooms.
- After school has ended, the amplification systems will be installed in both classrooms.

Day 2:

- Noise level measurements of the occupied relocatable classroom will be obtained.
- Acoustical measurements of the occupied relocatable classroom under unamplified conditions will be obtained. Children will be seated at their desks while the *Northwestern University Auditory No. 6* (NU-6) word lists from a CD are presented at 65 dBA in order to try to record the intensity level of the stimulus while class is in session. Measurements will be made at each desk around the classroom during the word list presentation. This part will also take 15 minutes.
- Word recognition abilities of the children in the relocatable classroom under unamplified conditions will also be measured. Again, children will be seated at their desks while the *Northwestern University Auditory No. 6* (NU-6) word lists from a CD are presented at 65 dBA in order to try to record the intensity level of the stimulus while class is in session. The children will be asked to write down the words that they hear. The same procedure will be repeated while the amplification system is in use. This part will take about 15 minutes.

Day 3:

- Noise level measurements of the occupied relocatable classroom will be obtained.
- Acoustical measurements of the occupied permanent classroom under unamplified conditions will be obtained. Children will be seated at their desks while the *Northwestern University Auditory No. 6* (NU-6) word lists from a CD are presented at 65 dBA in order to try to record the intensity level of the stimulus while class is in session. Measurements will be made at each desk around the classroom during the word list presentation. This part will also take 15 minutes.

- Word recognition abilities of the children in the permanent classroom under unamplified conditions will also be measured. Again, children will be seated at their desks while the *Northwestern University Auditory No. 6* (NU-6) word lists from a CD are presented at 65 dBA in order to try to record the intensity level of the stimulus while class is in session. The children will be asked to write down the words that they hear. The same procedure will be repeated while the amplification system is in use. This part will take about 15 minutes.

End of study

APPENDIX D

LETTER TO THE PARENTS

APPENDIX D

Letter to the Parents

Parental or Guardian Permission Form for Child Participation in Research

Title of Project: A Comparison of Classroom Soundfield Amplification Systems on Word Recognition Performance

Your permission is being sought to have your child participate in a research study. Please read the following information carefully before you decide whether or not to give your permission.

Purpose of the research: The purpose of this study is to measure and compare the differences, if any, in the word recognition performance of children and the signal-to-noise ratio in portable and permanent classrooms when soundfield amplification systems are used and when they are not used.

Procedures: First, acoustical measurements will be recorded at specific desk locations. For these measurements, your child will only have to sit quietly at their desk. Second, students will be asked to write down the words they hear, which will be presented from a recorded word list with and without soundfield amplification systems being used.

Risks/Alternative Treatments: This study has no known risks that are involved. The participant understands that Louisiana Tech is not able to offer financial compensation nor to absorb the costs of medical treatment should you be injured as a result of participating in this research. All testing procedures will be conducted at normal conversational speech levels and are similar to clinical audiometric measures. Participation is voluntary with informed consent. Your child is free to discontinue participation at any time.

Benefits/Compensation: As a part of the testing, your child will receive the results of a free hearing screening.

Statement of Confidentiality: All records are kept confidential and will be available only to professional researchers and staff. If the results of this study are published, the data will be presented in group form and individual children will not be identified.

Voluntary participation: Participation in this research is strictly voluntary and your child's participation or refusal to participate in this study will not affect his or her relationship with Louisiana Tech University, the Louisiana Tech Speech and Hearing Center, or his/her grades in any way. If at any point during the study you or your child wishes to terminate the session, he/she may withdraw at any time without penalty.

Please sign and return this form by ________. If you do not sign and return this form, the researchers will understand that you do not wish to allow your child to participate.

I, the parent or guardian of ______________________________, **permit** his/her participation in the program of research named above and being conducted.

_________________________________ _____________

Signature of Parent or Guardian Date

CONTACT INFORMATION: The principal experimenter listed below may be reached to answer questions about the research, subject's rights, or related matters.

Melinda F. Bryan, Ph.D., CCC-A; Sarah Babin, B.A.

Department of Speech, (318) 257-2146

Members of the Human Use Committee of Louisiana Tech University may also be contacted if a problem cannot be discussed with the experimenters: Dr. Les Guice (318) 257-4647; Dr. Mary Livingston (318) 257-2292; Nancy Fuller (318) 257-5075

APPENDIX E

CHILD ASSENT FORM

APPENDIX E

Child Assent Form

Louisiana Tech University
Child Assent Form

A Comparison of Classroom Soundfield Amplification Systems on Word Recognition Performance

The following script will be used to secure the child's assent, prior to conducting the study.

Hi, my name is Sarah Babin. I am doing a project in school to try to find out some information about relocatable classrooms. The purpose of this project is to find out how relocatable classrooms compare to permanent classrooms and the effects that classroom amplification systems have on them. You have been asked to be in this study to help me find the answers to how these classrooms affect the word recognition abilities of the students in them. The activity will take place at Ruston Junior High School during class time, and it will take no longer than an hour of your time to complete. On the first day, we will go into a quiet room, and I will do a hearing screening to make sure that your hearing is normal. On the second day, I will take sound measurements at certain desk locations while you are not in the room, and then I will take them while you are sitting at your desk working on an assignment. Then, I want you to participate in a listening activity with me where you listen to words and then write down what you hear. Your mom or dad (or parents or guardians) said that it is okay for you to be in this research study. You do not have to be in this study if you don't want to. You can change your mind at any time by telling your parents or me.

_______No, I do not want to be in the study. _______Yes, I want to be in this study

__________________________________ __________________

Name or Signature of Participant (Optional) Date

__________________________________ __________________

Signature of Person Obtaining Assent Date

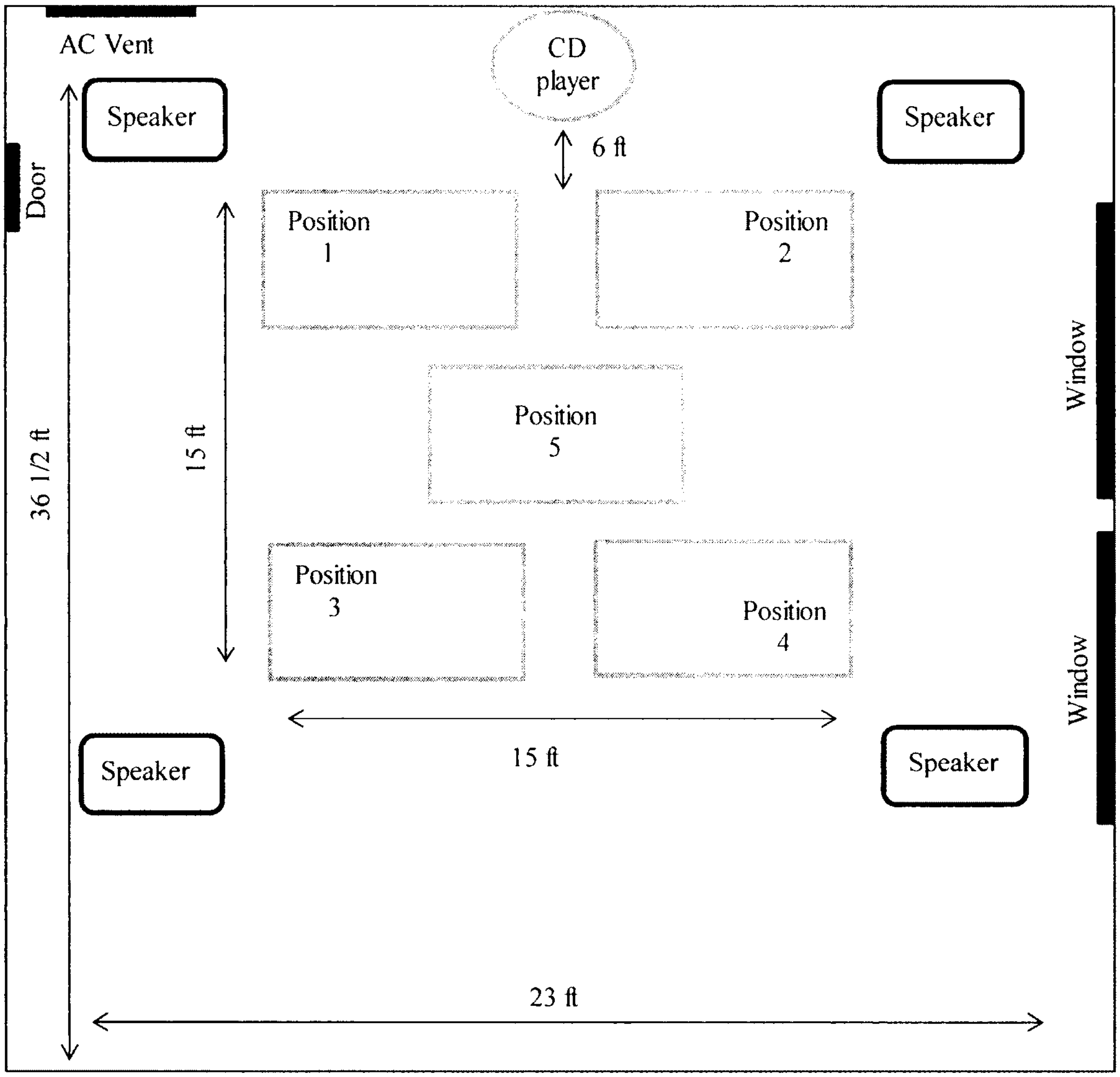
APPENDIX F

CLASSROOM LAYOUTS

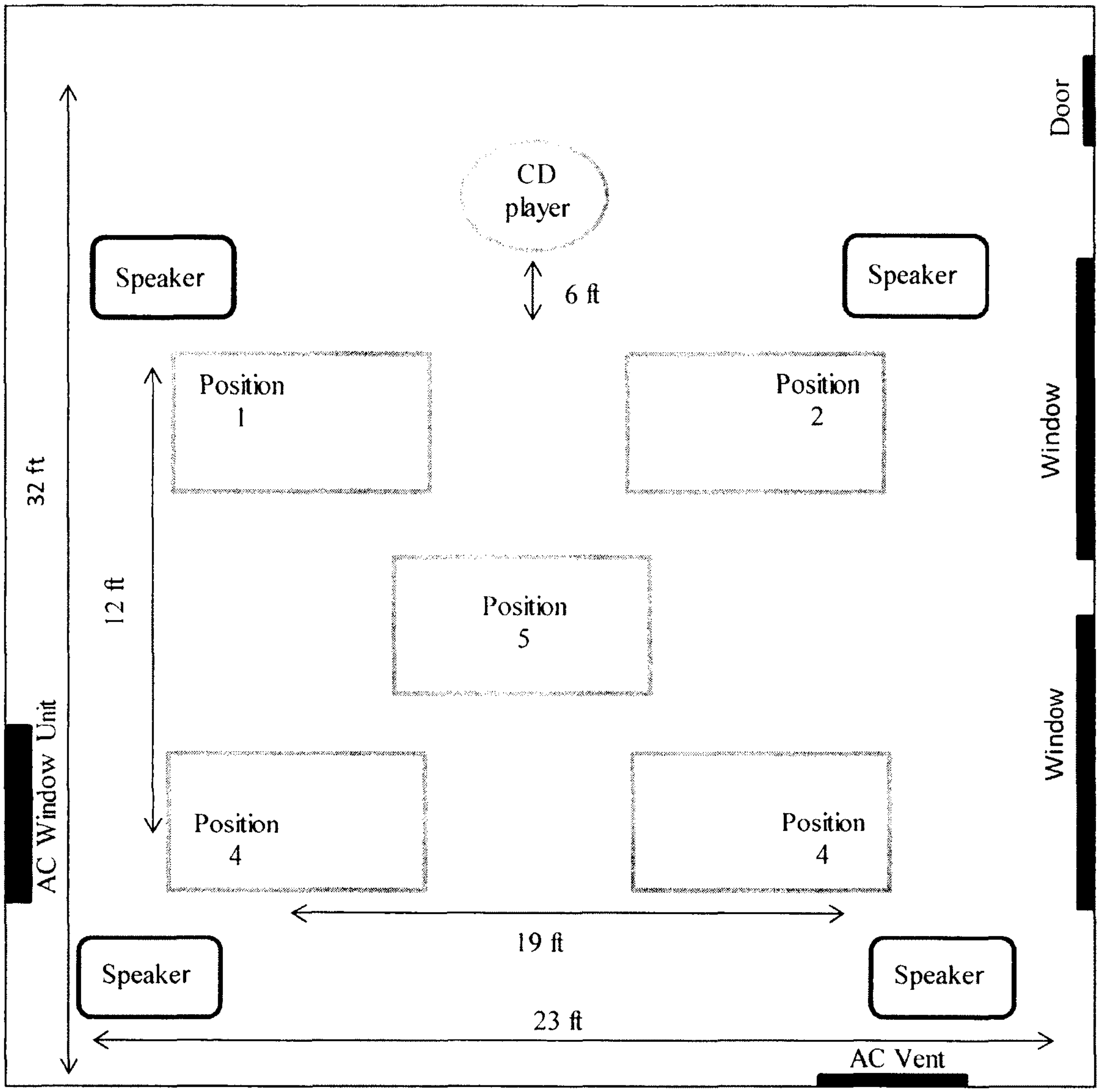
APPENDIX F

Classroom Layouts

Permanent Classroom



Relocatable Classroom



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