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CLASSROOM AMPLIFICATION: THE NECESSITY OF SOUND-AMPLIFICATION IN THE CLASSROOM

by

Kalley Ellis

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Classroom Amplification:

The Necessity of Sound-Amplification in the Classroom

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In a classroom, the optimal signal-to-noise ratio, as is recommended by the American Nation Standards Institute (ANSI), is 35 dBA, with the reverberation reaching a maximum of 0.6s (Lewis, 2008); yet, in classrooms today, the typical signal-to-noise ratio ranges from 40-73 dBA (Lewis, 2008). With at least 75% of the school day being spent in listening activities (e.g. reading, instructions, lecture, etc.), this noise level in the classroom has great impact on what a child hears and, thus, learns (Blazer, 2008). Unfortunately, with each new year, classroom sizes are increasing and creating an even more detrimental noise level and signal-to-noise ratio. As of October 2013, 14.9% of children ages 6-19 have been diagnosed with a hearing impairment, ultimately meaning that these children are unable to hear as well as the child sitting next to them in the classroom, and the further away the child sits from the teacher, the less of the teacher he/she will hear (Hearing Loss in Children, 2013). For instance, word recognition was shown to decrease from 95% correct at 6 feet when 24 feet from the teacher, to 75% correct at 12 feet from the teacher, and results are even further decreased to 60% correct when the child is 24 feet away from the teacher. Thus, it is not surprising that hard-of-hearing children are typically 3 years behind their peers academically.

There are many devices that have been developed to increase or amplify what a child with hearing loss is able to hear and, thus, decrease the amount of information lost between speaker and listener. Amplification is defined as "the increase in strength of an electrical signal by means of an amplifier" (Amplification, 2014). Amplifiers provide means whereby the signal-to-noise ratio is increased, allowing for a child to hear more of what the teacher says in the classroom. Amplifiers have been developing throughout the centuries, taking forms in theaters, chairs, and even small instruments. Through this evolution, there are amplifiers today that have been created specifically for the classroom. These devices not only aid children with hearing
loss, they also provide needed assistance to teachers and students learning English as their second Language, as well as increase attention in other students in the classroom. Through the use of classroom amplification, children who struggle with hearing impairments, as well as other students in the classroom, are provided the necessary tools to succeed in the classroom.

**An Historical Perspective**

In order to fully comprehend the present and future significance of classroom amplification, it is essential to be immersed in the history of the topic. Further stated, in order to move into the future, one needs to understand his/her past, which allow him/her to learn from mistakes. In the case of classroom amplification, learning the history of the topic allows the development of such aids to better in quality, avoiding the pitfalls that presented themselves in the early years of development, while also utilizing forms of amplification that have proven quintessential for effective amplification aids (see Table 1).

**Epidaurus**

Beginning in 240 BCE, plays, and their corresponding theaters, began their initiation into the world, an activity of the arts that would ultimately spread throughout the world. Rome was the leading country in the initiation of plays, performing in venues as large as two thousand feet long and six hundred feet wide. By 55 BCE, permanent theaters had begun to take precedence over temporary theaters. In simple terms, theaters which, in nature had the ability to be built and deconstructed within the same day (temporary theaters), were placed in the shadows

![Epidaurus Theater](http://www.keytours.gr/)
by the completion of theaters that were stationary in structure, not meant to be packed up and moved (permanent theaters). The first permanent theater built was the Theater of Pompey in Rome which spanned three hundred feet in length and five hundred feet in diameter. The theater was designed in an open arena, with no roofing present. By the second century CE, the addition of a roof was found on newly constructed permanent theaters and was thought to increase the amplification of sound (Brockett, Mitchell, & Hardberger, 2010). One theater known as Epidaurus (Figure 1) amplified sound in such a way that it has become a studied piece of architecture. According to S.E.E. Lakovidis, a professor of archaeology, “The smallest sound—a deep breath or tearing of a piece of paper—can be heard clearly as high up as the last row of seats.” (Greece, 2000). The structure of Epidaurus is such that the positioning of the seats provides diffraction of sound throughout the theater. As a consequence of the apparent diffraction, sound is found to backscatter throughout the entire theater, expanding and increasing the amplitude, ultimately allowing the audience to hear well from any place in the theater (Declercq & Dekeyser, 2007).

**Hearing Aids**

In contrast to an expansive space such as the Greek theater of Epidaurus, more individualized hearing amplification devices have been developed within the last century. Constructed individual petite amplifiers, hearing aids are an electroacoustic device designed to amplify sounds. Today, hearing aids are composed of a microphone, processor, amplifier, receiver, volume control, and battery (Parts of a Hearing Aid, 2014). These amplification devices have the ability to fit behind the ear, inside the ear, or anchored on the bone. However, the first hearing aids were far from what was is typical of the amplification device common in today’s society. The hand cupped behind the ear, as well as animal horns and seashells, are thought to be
the first hearing aids. However, no demonstrative evidence has been gathered to establish the existence of the initial hearing aid. Rather, the device’s first presence is more inference based. Sound collectors, however, are known as the true first amplification devices. The common type of sound collectors were speaking and hearing trumpets. Speaking trumpets (hearing trumpets reversed) were first developed in 1670 by Sir Samuel Moreland and later began manufacture in the 1800s by F.C. Rein. By 1808, a German named Mälzel had begun developing hearing trumpets, many of which were used by Beethoven. These instruments were hallow cornucopia shaped and typically developed from either tortoise shell or thin metal (Berger, 1980). As shown in Figure 2, the pointed end of the instrument was placed inward to the ear, the purpose being to collect and amplify sound as it enters into the external ear. Interestingly, sea captains were known to use such devices in order to communicate with individuals on shore or on other residing ships. It was not until after hearing trumpets had be utilized in these forms that their use in aiding hearing impaired individuals was realized (Berger, 1980).

In the year of 1819, hearing amplification technology had reached a literal sitting position. The acoustic throne, as it is known, was developed by F.C. Rein, a man whose legacy is built on the production of commercial hearing aid devices, typically ones which were nonelectric (e.g., the hearing trumpet). The throne was initially built for the Portugal king,
King Goa, and included a chair with hollowed arm rests carved in the shape of lions heads which lead to a resonator located in the seat of the chair. Sound would travel through the armrests into the resonator and would subsequently be sent up and heard through a hearing tube visibly attached to the chair, as is illustrated in Figure 3. Rein developed other hidden hearing amplification devices, such as aids which were hidden by an individual’s beard or a hat (Berger, 1980).

Bone conductors are another early developed hearing aid instrument. In contrast to sound amplifiers, bone conductors are typically developed from strips of wood or iron and have the ability to transfer sound propagation through to the inner ear by vibration of bone. A forerunner in the development of bone conductors was Giovanni Paladine. Paladine is known for his creation of the Fonifero—originally developed in 1876—in which sound is propagated through a rod. With the curving end of the rod held to the speaker and the opposite and straight end held against the mastoid process, teeth, or forehead of the listener, the vibration created as the speaker speaks is transferred through the rod until it reaches the body process it is touching on the receiver’s body. The vibration is then sent through the bone which transfers the sound propagation directly through to the inner ear (Berger, 1980). Such a device is shown in Figure 4, illustrating the placement on the teeth and mastoid process.
Body aids were the ensuing hearing aid devices and were the main form of amplification before the development of the smaller hearing aids used in present day. Unlike the typical hearing aids today, the body aid was worn around the user’s neck or on a piece of his/her clothing. The individual would have a receiver located at the ear, with a wire traveling from the receiver to the aid in order to amplify sound, as illustrated in Figure 5 (Pollack, 1980). In the 1960s, the predecessors of the aids worn today began to take precedence over body aids. These devices, commonly referred to as ear-level aids, were located behind the ear, attaching to the receiver in the ear by a small section of material. As the years progressed, the power level ability of the ear level aids increased, resulting in a greater popularity and usage of the devices, while body aid usage decreased.

Statistically speaking, in 1963, the percentage of body aids sold was 20, with ear level aids totaling 43.4% sold. By 1978, body aids had decreased to a decumbent 4.1% sold, while ear-level aids increased to 56.3% (Pollack, 1980).

Today, there are several different types of hearing aids available to the public, including behind the ear (see Figure 5), completely in the canal (see Figure 6), and bone conduction (see Figure 7). Usually, hearing aids contain a microphone, receiver/sound output, program button, volume control, and an ear mold (Larsen J., Introduction to Hearing Aids, 2014). According to Dr. Jeffery Larson, sound is received by the microphone and is changed into an electrical signal. The signal is then processed by the amplifier and thus, the intensity is increased. The signal is then changed to an acoustic signal once more by the receiver and then transferred to the ear.
Each step is completed as a result of the battery which powers the hearing aid; depending on the size of the battery, the lifespan varies. For instance, of the 4 available sizes (10, 312, 13, 675), the size 10 has to be changed every 3-4 days, while the size 675 should be changed every 3 weeks (Larsen J., Introduction to Hearing Aids, 2014).

Behind the ear (BTE) hearing aids first began production in the 1950s, and they are the most commonly used hearing aid. These hearing aids sit behind the ear (Figure 6), hence the name, with a tube that is attached to the hearing aid at one end connects to a custom-fit earmold on the opposite end (Mayo Clinic Staff, 2014). Such hearing aids provide a higher level of amplification than other hearing aids (e.g., in-the-ear hearing aids), but they are generally more visible as a consequence (Vonlanthen & Arndt, 2007). For children, BTE hearing aids are an optimal choice, because they are not as difficult to fit as other types of hearing aids are, they are more capable of attaching devices in such a way as to prevent children from removing the device, and they require a low level of maintenance (Larsen J., Introduction to Hearing Aids, 2014). Typically, BTE hearing aids are equipped with an ear mold and need to be replaced every 3-5 years (Ross M., 2013).

In-the-ear hearing aids were first developed in 1955 and are best used for mild to severe hearing impairments. Further, these instruments rest inside of the ear, as shown in Figure 7 (NIDCD Fact Sheet: Hearing Aids, 2008 & Deafness in Disguise, 2009). Additional features may be added
to an ITE, such as a telecoil; a small magnetic coil, a telecoil allows the user to, instead of obtaining sound through the microphone of the hearing aid, receive sound via the hearing aid circuitry. Through use of a telecoil, the user has the ability to connect to and use an induction loop system, a type of sound-field amplification (NIDCD Fact Sheet: Hearing Aids, 2008). Just as with any other hearing aid, ITE hearing aids need to be replaced every 3-5 years (Ross M., 2013).

Bone anchored hearing aids (BAHA), as shown in Figure 8, are unlike other hearing aids. These devices are placed on the mastoid process behind the ear; sound vibrates the mastoid process which sends the signal directly into the cochlea of the inner ear (Hearing Aids, 2014 & Mastoid Process, 2014). There are three distinct components of a BAHA: a small titanium screw that is surgically implanted into the bone, a cone-shaped external abutment which connects to the screw, and a sound processor that connects to the abutment. Due to the fact that the sound travels directly to the inner ear, surpassing the damaged outer and middle ear when using a BAHA, there are candidates who are best suited for the device: individuals who have issues stemming from the outer ear, such as congenital ear malformation, individuals who are deaf in one ear, as well as individuals who have mixed and conductive hearing loss and deal with chronic ear infections. Further, unlike traditional hearing aids, BAHAs do not suffer from whistling of feedback due to the sounds direct transfer from the outer ear to the inner ear (Bone Anchored Hearing Aid, n.d.). Some individuals may not be able to undergo the surgery necessary to implant the screw of a BAHA, so other methods such as a softband may be used. A softband acts as a headband, fitting
around the individual’s head, and includes a snap connect which sits on the bone behind the ear and is the place of attachment for the sound processor (Softband, 2014).

**Cochlear Implants**

By the 1950’s, hearing amplification had advanced to being implanted underneath the skull and into the inner ear, as is shown in Figure 9. The beginnings of cochlear implants were in the 1950s and were later introduced in the United States at the William House. Each implant contains external and internal components. The internal parts sit directly underneath the skin of the cranium and consist of a magnet, antenna, receiver, stimulator, and electrode array. The external components consist of a microphone, sound processor, cords, external transmitter, power source, and magnet, as illustrated in Figure 10. Through the magnetization of the internal and external magnets, the external components are firmly attached to the cranium (Larsen J., 2014). The microphone of the cochlear implant picks up the sound signal which is then converted into digital signals. These signals are then sent to the internal receiver via the processor-where the signals are transferred into electrical energy. The energy is then sent into the cochlea through electrode arrays which stimulate the VIII nerve, allowing the brain to perceive the signals as sound (Larsen J., 2014).
Cochlear implants cost around $40,000 (Cochlear Implant Frequently Asked Questions, 2014), and the changeable parts of the implant (battery charger kit, cochlear auxiliary cable adapter, belt clip, harness extension adapter, microphone cover, and pouch) need to be changed every 1-3 years, depending on the part (Cochlear Implant Frequently Asked Questions, 2014 & Cochlear Implants, n.d.). An individual may receive a cochlear implant as young as 12 months, and the younger a child is at the time of implantation, the more advantageous the outcome. There are several color varieties available to match an individual’s skin tone, and hair can cover the implant, but static electricity and water are to be avoided so as to prevent static discharge or malfunction (Larsen J., Introduction to Cochlear Implant Technology, 2014 & Cochlear Implants, 2014).

Classroom Amplification

Classroom amplification, unlike hearing aids and cochlear implants, has the capability to aid several individuals at once. Such systems include FM, infrared, radio, hardwire, looping, two-way loudspeaker, and distributed mode loudspeaker systems. Each system provides different ways of amplifying sound, along with strengths and weaknesses.

Sound-amplification systems transmit signals through two types of wave forms: infrared and radio. To send signals between the microphone and receiver, infrared classroom amplification systems use infrared light. In contrast, Radio sound-amplification systems utilize radio bands to send signals. Radio amplification systems can provide little assistance, however, when there are multiple waves from these systems running into one another, because this will cause interference. Interference is no issue for infrared sound-amplification systems, but because such systems function only when in line of sight, more systems are necessary in order for the signal from the microphone to reach the receiver in all portions of the classroom (Blazer, 2008).
FM systems function via radio waves and are composed of a receiver and a transmitter. The listener wears the receiver (a hearing aid) while the speaker (a parent or teacher) wears the transmitter and speaks through the microphone, as is illustrated in Figure 11 (FM Systems, 2014). The first miniaturized FM receiver was introduced in 1996 (The history of FM, n.d.). These amplification devices allow for a more consistent exposure to sound, thus providing a greater level of opportunity to learn and understand speech and language. Further, FM systems are portable and may be used both inside and outside. Outside interference (police band, pagers, and construction walkie talkies) is prone to occur, however, and the receiver and transmitter must be on the same channel to function (Larsen J., Assistive Listening Devices, 2014).

Hardwire systems have two separate devices that coordinate to amplify sound. One device is looped around the neck of the teacher, containing an FM microphone. The second of the two devices is a stationary electronic box which is placed on the desk of the student. A set of headphones is plugged in to the electronic system, allowing for the voice of the teacher to be sent through to the electronic system, and, thus, the headphones, amplifying the sound. Hardwire systems may be used for personal use as well, including television watching, as is illustrated in...
Figure 12. As a result of minimal signal loss, these systems provide respectable sound quality, but due to the direct connection between the headphones and stationary electronic system, the listener’s mobility is minimal (Assistive Devices, n.d.).

Electromagnetic/Induction looping systems, which were first developed by Joseph Poliakoff in 1937, are transmission systems that connect with telecoil found on hearing aids (Traynor, 2014 & Larsen J., Assistive Listening Devices, 2014). Looping can be set up around the classroom and is invisible to the naked eye; no additional equipment is necessary, only a telecoil hearing aid or cochlear implant is needed. Looping takes gathered sound from the classroom, filters the background noise, then sends the signal directly to the hearing devices (Figure 13), and unlike hardwire systems, looping systems allow the children in the classroom to easily move throughout the classroom.

Further, these systems are compatible with any loop system, and they have a life-long expectancy (Larsen J., Assistive Listening Devices, 2014).

However, due to a microphone cord needed for the amplifier, the teacher is unable to move freely throughout the classroom. Also, just as with hardwire systems, problems arise that result in a less than optimal outcome; there is a likelihood of dead spots in the loop and electrical interference is found to take place. Further, those who wish to use the looping system must have a T-coil, and the cost of installation may be high (Larsen J., Assistive Listening Devices, 2014).
Systems that are functional for every student and not just students with hearing aids or cochlear implants are loudspeakers. There are different types of loudspeakers, as well as different set-up positions in the classroom. Two-way (TW) loudspeakers, first created in 1931 by Bell Labs, are a conventional loudspeaker (Loudspeaker HIstory, 2014). Such devices contain loudspeakers with a woofer and tweeter, with the woofer having the ability to produce low frequency signals, while the tweeter produces high-frequency signals (Curtis, n.d.). Typically, conventional loudspeakers utilize a rigid diaphragm to move the air and produce sound. If rigidity is lost, the speaker will begin to flex and result in sound-quality disturbance such as resonance. Further, after frequency has rose to the level at which “the wavelength in the air is comparable with the dimension of the diaphragm,” the signal begins to transmit unidirectional rather than throughout the entire room (Harward, 2013). An additional 2 or more drive units may be placed in the loudspeakers (large, low-frequency driver intended for bass sounds, and small, high frequency driver for treble sounds), but even with these drive units, frequency distribution issues are still present. As a result, listeners using a conventional or TW loudspeaker have to be in an “acoustic sweet spot”, which ultimately prevents free movement throughout the room, as is shown in Figure 14 (Harward, 2013).
Distributed mode (DM) loudspeakers were first introduced in 1996 by a company based in Britain named The Verity Group (Loudspeaker History, 2014). These loudspeakers are a type of bend-wave technology and do not contain a tweeter and woofer as a Two-Way loudspeaker does (Curtis, n.d.). A flat, motile, and single diaphragm is used, which is the location point of excitation points, producing sound, as is shown in Figure 15 (Curtis, n.d.). This structure of DM loudspeakers allows the modal to encompass a wide bandwidth rather than the unidirectional transmitting of a conventional, or TW, loudspeaker (Harward, 2013).

In 2010, a study was conducted on the difference between two way (TW) loudspeakers and distributed mode (DM) loudspeakers (Harward, 2013). At the conclusion of the study, “the authors of this study believe that the DM loudspeaker outperforms the TW loudspeaker in terms of frequency response, spread of energy, and therefore most likely speech perception” (Curtis, 2010, as cited in Harward, 2013). Further, in a study conducted by Prendergast (2001), 3rd and 4th grade children’s scores on the California Consonant Test (CCT) were observed on how they were altered when DM and TW loudspeakers were used. When DM loudspeakers were used, the children’s average score was 65.68%, while the average score was 58.06% after the use of TW speakers (Harward, 2013). Such results illustrate the proficient ability of DM loudspeakers over TW loudspeakers.
Table 1:
A Depiction of The Major Evolutionary Advancements in Amplification

<table>
<thead>
<tr>
<th>Name</th>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
</table>
| Epidaurus       | 240 BCE    | - The positioning of the seats provides diffraction of sound throughout the theater  
- Sound backscatters throughout the entire theater, allowing the audience to hear from both the front and back, expanding and increasing the amplitude, |
| Hearing Trumpets| 1670       | - Hallow cornucopia shaped instruments  
- The pointed end of the instrument was placed inward to the ear in order to collect and amplify sound as it enters into the external ear. |
| Acoustic Throne | 1819       | - Developed by F.C. Rein for King Goa.  
- A chair with hollowed arm rests carved in the shape of lions' heads.  
- Sound travels through the armrests into the resonator and is subsequently sent up and heard through a hearing tube visibly attached to the chair. |
| Fonifero        | 1876       | - The curving end of the rod is held to the speaker, and the opposite and straight end are held against the mastoid bone, teeth, or forehead.  
- The vibration created as the speaker speaks is transferred through the rod until it reaches the body process it is
<table>
<thead>
<tr>
<th>Hearing Aid Type</th>
<th>Time Period</th>
<th>Description</th>
</tr>
</thead>
</table>
| Body Aid              | Early 1900s | - Worn around the user’s neck or on a piece of his/her clothing.  
- Receiver placed at the ear, with a wire traveling from the receiver to the aid, amplifying sound.                                                                                                                                                                                                                                                                                                                                                             |
| Behind-the-Ear        | 1950s       | - Most commonly used hearing aid.  
- Sits behind the ear.  
- Provide a greater level of amplification than any other hearing aid.  
- Generally more visible.                                                                                                                                                                                                                                                                                                                                                           |
| In-the-Ear            | 1955        | - Less likely to pick up wind noise,  
- Least noticeable because they sit in the canal of the ear.  
- There are no extra features such as volume control or directional microphones.                                                                                                                                                                                                                                                                                                                                                                       |
| Cochlear Implant | 1950s | - There are external and internal components.  
- The microphone picks up the sound signal which is then converted into digital signals.  
- These signals are sent to the internal receiver via the processor-where the signals are transferred into electrical energy.  
- The energy is then sent into the cochlea through electrode arrays which stimulate the VIII nerve, allowing the brain to perceive the signals as sound is amplified. |
|------------------|-------|---------------------------------|
| FM System        | 1996  | - Composed of two separate parts: a receiver, and a transmitter and microphone.  
- The listener wears the receiver  
- the speaker wears the transmitter and speaks through the microphone |
| Hardwire System  | N/A   | - One device looped around the neck of the teacher, containing an FM microphone.  
- The junction box is placed on the desk of the student.  
- A set of interchangeable headphones is plugged in to the junction box  
- The voice of the teacher is sent through to the junction box and the headphones, amplifying the sound. |
A Closer Look at Classroom Amplification

Classroom Amplification was introduced in the form of FM systems in the 1960s by a company known as Electronics Futures Inc. The idea did not obtain the amount of attention and support as was needed to allow the company to flourish, however, resulting in the closing of the company in the 1970s. Phonic Ear Company began in the midst of the loss of the Electronics...
Futures Inc. company in 1967. Through the continual development of classroom amplification devices, the idea of adding amplification throughout the entire room rose in popularity, but years would pass before the idea truly began to take precedence over other means of amplification (Ross M., n.d.).

Students

In a typical classroom, reverberation and/or background noise is present. According to David B. Hawkins, "The presence of reverberation causes elongation of vowels, smearing of transitions, and virtual elimination of silent gaps." In a study conducted by Hawkins and Yacullo (1984) on the effects of reverberation on hearing ability in the hearing impaired, when reverberation levels were raised from 0.3 to 0.6s, the hearing ability of the subjects decreased. To counteract this decrease, the signal-to-noise (SN) ratio had to increase 4 dB. When the reverberation levels increased even further (0.6 to 1.2s), the dB had to increase by 9. To lessen the effect of reverberation, a positive signal-to-noise (SN) ratio needs to be present, meaning, the sound (teacher's voice) needs to be amplified over the noise (reverberation and/or background noise) (Hawkins, 1988). The use of classroom amplification has been shown to increase the sound-to-noise ratio by 8-10 dB (Larsen & Blair, 2008). In a study done by Dr. Jeffery Larsen and Dr. James Blair (2008), noise and reverberation levels were measured in four 4th grade level classrooms that contained 24-26 students each. Some of the classrooms had a sound-amplification system present, while the remainder did not. Results of the study showed that the children in the classrooms that used sound-amplification were able to hear the teacher at 13 dB above the noise floor, while children in the classrooms with no sound-amplification system could only hear the teacher at 2 dB above the noise floor (Larsen & Blair, 2008). Further, according to a study completed by McCarty and Ure (2003), the use of classroom amplification reversed a 2
year downward trend in achievement tests of 4th and 5th grade children, and there was a visible 10-15% increase in the scores of the children in the classroom with sound amplification than was found in the scores of children in classrooms that did not use sound amplification (Blazer, 2008).

In addition, for children whose second language is English, classroom amplification has been found to aid in their advancement in the language. In a study conducted by Nelson et al., speech perception for ESL students and student’s whose native language was English in both quiet and noise was observed. Results showed that both ESL and native English speakers showed decreased performance in speech perception in noise, but ESL students showed a greater decrease than native English speakers (Lewis, 2008). When classroom amplification is introduced, ESL students’ academic abilities increase; in a study by Vincenty-Luyando (2000), bilingual and monolingual children’s phoneme discrimination abilities were compared both with and without sound-field amplification in noise. When noise levels were present with no classroom amplification, the bilingual students’ ability percentage was 63% as compared to their monolingual peers’ 76%. When classroom amplification was presented, even during the highest level of noise, every student’s scores improved a combined 19% (Millett, 2008).

Behavior issues in the classroom have also seen improvement in classrooms that utilize sound-field amplification. Teachers who were part of the American Federation of Teachers were asked about disruptive behavior in the class. 17% of the teachers stated that 4+ hours were lost each school day due to disruptive behavior, and 19% stated that 2-3 hours were lost each school day (Walker, Ramsey, & Gresham, n.d.). Studies have shown that the optimal distance between the child and teacher is 6 feet, and with every increase of 1 foot between the child and teacher, the speech recognition by the child decreases (Blazer, 2008). Crandell and Smaldino (1995) discovered that at 6 feet a child had a 95% correct rate for speech recognition, while at 12 feet
the correct rate was 75%, and at 24 feet, the correct rate was 60% (Blazer, 2008). If a child is continually not understanding what the teacher is stating, he/she may revert to problematic behaviors due to boredom or in order to gain the full attention of the teacher. However, in a study conducted by the Mainstream Amplification Resource Room, when classroom amplification was used, student attention increased, and the need for instruction repetition by the teacher decreased. Similar results were also discovered in 2006, when first grade teachers in amplified classrooms indicated that student attention had increased while the need for instruction repetition decreased in the classroom. Further stated, according to the Florida’s Improving Classroom Acoustics project in 1999, 96% of participating teachers believed that the use of classroom amplification resulted in increased attentiveness and listening behaviors (Blazer, 2008).

**Teachers**

Though the children in the classroom have experienced positive results with the use of classroom amplification, they are not the only ones; teachers have also been found to benefit from classroom amplification. In a typical classroom that does not contain a sound-field amplification system, the teacher does not have assistance in amplifying his/her voice. As such, teachers are straining their voices in order to be heard over the background noise. In a study conducted by Sliwinska-Kowalska, Wiebudek-Bogusz E., Fiszer M., Los-Spychalska T., Kotylo P., Szurowska-Przygocka B., and Modrzewska M. (2006), 425 primary and secondary, full-time, female Polish teachers were observed and compared to 83 females who did not occupy a teaching position. Each of these women took a questionnaire and completed a videostroboscopic, laryngological, and phoniatric exam. The results of the study showed that the female teachers were more likely to develop vocal symptoms (hoarseness and throat dryness) than were the non-teaching females. The study also illustrated that hyperfunction dysphonia was more prevalent in teachers (32.7%), than non-teachers (9.6%). Further, a positive correlation was found between a
teacher with hyperfunction dysphonia and strained phonation, instability of voice, and neck muscle hypertension (M., et al., 2006).

To avoid such outcomes as hoarseness, teachers can use a sound-amplification system which will amplify his/her voice through a microphone and accompanying loudspeakers that are set up strategically throughout the classroom (Lewis, 2008). As such, the teacher may speak in a typical speaking voice without the need to strain his/her voice in order to be heard by the children in the classroom.

According to the Mainstream Amplification Resource Room study (2005), teachers reported hoarseness, fatigue while speaking, temporary loss of voice, and pain, which ultimately resulted in 15% of the recorded absences of teachers. Upon use of classroom amplification, the percentage of teacher absences for voice issues reduced to 2-3% during the year (Blazer, 2008). In Florida, teachers in rooms with sound-field amplification systems stated that they had experienced less fatigue and vocal strain when speaking in class. After a multi-year study of teachers in the Orange County Public School District in Florida, the rate of absenteeism of teachers who taught in amplified classrooms decreased by 25%. Further, because classroom amplification allows for the teacher’s voice to be amplified throughout the classroom, researchers believe teacher mobility has also increased (Blazer, 2008).

Financial Suppliers

As of 2014, there are 899 public schools in the state of Utah, with the student population reaching 491,206. Of those 899 schools, 501 are elementary schools (grades K-12), with an average of 22.16 students per classroom (Public Schools, 2014 & Superintendent's Annual Report, 2010). In a wider form, as of 2011, there were 98,819 schools in the United States, with 160,000 classrooms having sound-field amplification (Fast Fact, n.d. & Boswell, 2006). When
the total number of schools is compared to the total number of classrooms equipped with sound-field amplification systems, the discrepancy is seen; if, theoretically, there was an average of 15 classrooms per school, that would indicate that only about 10,666 schools would have a sound-amplification system in every classroom, a little over \(\frac{1}{10}\)th of the total number of schools. For the schools that do not currently contain classroom amplification, there are different methods of acquiring the financial means whereby to purchase such a sound-field amplification system.

In the United States, as of 2012, 6,401,238 children have an Individual Education Program (IEP), with 71,233 of these children living in Utah (Digest of Education Statistics, 2013). According to section IV of IEP regulations,

"a statement of the special education and related services and supplementary aids and services, based on peer-reviewed research to the extent practicable, to be provided to the child, or on behalf of the child, and a statement of the program modifications or supports for school personnel that will be provided for the child--

(aa) to advance appropriately toward attaining the annual goals;

(bb) to be involved in and make progress in the general education curriculum in accordance with subclause (I) …" (Write, 2004).

A school district has the legal obligation to provide necessary services that are necessary and present on a child's IEP. As such, if a child's IEP indicates that a sound amplification system is needed in the classroom in order for the child to have an equal opportunity in reaching his/her academic goals as the rest of the students, then the school is inclined to accommodate. However, if a child's IEP does not indicate the direct necessity of a sound amplification system, and the school is lacking in funds, the school may choose not to accommodate such a desire.
If the child’s IEP services does not include classroom amplification, and there are no extra funds available in the school and/or district budget, an education grant may be filed (Fund Opportunities for Educators, 2000). Private grants are typically from hospitals, utility companies, and auto manufacturers and have been found to provide grants to community-based organizations. Community-based grants are different from private grants; upon visiting the www.DonorsChoose.org website, donors view different project ideas and have the opportunity to donate to the cause of their choice (Van Hyfte, 2012).

Fundraisers are another option to raise money for classroom amplification. In an article written by Shannon M. Van Hyfte, Au.D. (2012), fundraisers for trash bags, a fall carnival, a restaurant partnership, and food sales, all aided in providing necessary funds for a sound-field amplification system in the classroom. Such fundraisers typically do not produce all of the profits needed to supply every classroom in the school with a sound-field amplification system at once; each system costs around $1,500 per classroom (Blazer, 2008).

Parental Support

For a young child, his/her best advocate is his/her parent(s). Thus, the parent’s role in the child’s education is vital for the said child’s academic success. For a child with a hearing impairment, the parent’s advocacy is of even greater importance. Before the first day of class, the parent(s) may speak with the teacher and/or school administrator about the current sound-amplification present the classroom. If there is no current sound-amplification, the parent(s) have the opportunity to advocate for the use of such systems. However, one should understand that school budgets may not accommodate the installment of a classroom amplification system. In such a situation, the parent(s) may bring forth the previous presented ideas to raise money; there
is no promise, however, that the school will agree or be willing to install a sound-amplification system.

Depending on the type and degree of hearing loss, hearing aids and cochlear implants may be the only option for the individual child. These devices, unlike classroom amplification, produce an amplification of the sounds for the individual child rather than for the entire classroom. Such devices are unable to reduce the sound-to-noise ratio as classroom amplification can, but when such systems are unobtainable for the classroom, a cochlear implant or hearing aid will provide the child with an ample amount of language. Further, if a child has the knowledge of American Sign Language (ASL), he/she may have the opportunity to receive ASL translator services. Such a service will allow the child to acquire language that was lost in the distance and/or noise between him/her and the teacher. Table 2 provides an in-depth look into the costs of various amplification devices (hearing aids, cochlear implants, and ASL translators). Some hearing amplification devices have a greater ability to decrease the SNR in a classroom for a child, but, regardless of the device, the child should acquire a hearing amplification device; an expansive amount of language will be lost in “translation” if a child with a hearing impairment is left with only his/her hearing capabilities.

Table 2

<table>
<thead>
<tr>
<th>Comparison of Hearing Impairment Services</th>
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<tr>
<td><strong>Hearing Loss (HL)</strong></td>
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<tr>
<td><strong>Adults:</strong> severe to profound HL in both ears (Cochlear Implants, 2014). Children: profound HL in both ears (Cochlear Implants, 2014).</td>
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<tr>
<td>Cost</td>
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</tr>
<tr>
<td>Wear-Ability</td>
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<td>Life</td>
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Illustration
Conclusion

Amplification has seen hundreds of years of evolution, expanding and increasing in abilities and popularity. Through the utilization of classroom amplification, students’ test scores, attention levels, and behavior, have all increased. Further, the vocal strain placed on teachers has been found to reduce when sound-amplification systems are used in the classroom. The cost of each installment of a sound-field amplification system is around $1,500 dollars, but “Over the expected life of the system (an estimated 10 years), classroom amplification costs pennies a day per student.” (Blazer, 2008). A child may require the addition of classroom amplification if his/her IEP condones such services, but funding may be found elsewhere (e.g., fundraisers, grants) if such a circumstance does not exist.

Children spend an average of 943 hours of their year in school, making the ability to hear the language spoken throughout each day in the classroom detrimental (Chalabi, 2014). Classroom amplification has the ability to decrease reverberation and background noise in the classroom, ultimately allowing for students to better hear and understand the teacher. 160,000 classrooms have sound-amplification installed, with a 20% annual increase. With every installation of a sound amplification system, reverberation levels are decreased, the teacher’s voice is increased, and students are able to hear a more expansive amount of language (Boswell, 2006).
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