Hearing, Technology and Education

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Abstract

This chapter explores the relationship between hearing, education and technology. I was interested in how a hearing loss affects learning, what strategies can be utilized to help Hard-of-Hearing and Deaf individuals excel and what technology is available to improve their lives.

Introduction

Hearing is a very important sense. It is one sense that we use, without really realizing it, throughout our day. We usually wake up to alarms, listen to the sound of radio, talk to our spouses, friends and family members, listen for vehicles as we cross the road, listen to music, radio shows or books on tape as we head to school or work. We are constantly bombarded with sounds throughout our day, some which we choose and others which we are surrounded by. From a young age we begin to discriminate and discern sounds that our important to us. We also tend to take our hearing for granted.

Now take a moment to imagine the start of the day for teachers. They get to school early and when they arrive in the class they are the only ones in the room. They quietly prepare for the day, getting out school supplies, photocopies and other materials. They conference with neighboring teachers and administration about their day and then they prepare for the arrival of those students they teach for a day of learning. The arrival of students to the classroom is a fun and noisy time, where teachers greet students, ask questions and help them prepare for the day. Getting the class settled and on task can be a challenge some days and noise levels tend to get carried away. A typical classroom day may sound like this.

As you can discern from this example, at times it can be quite hard to hear the teacher in the classroom. The amount of background noise really affects how well a student can hear.

Now imagine that you are a student in that classroom and your ability to hear is impaired. Things sound a little softer. Sometimes the teacher says something but you didn't catch the whole sentence. How hard is it to follow what is being said in the class? How would you feel?

Now let's shift our imaginations back to the role of the teacher of this student. Do you as a teacher really know how much your students are hearing? Are there ways to improve the classroom environment? How can you help a student who may have a hearing loss?

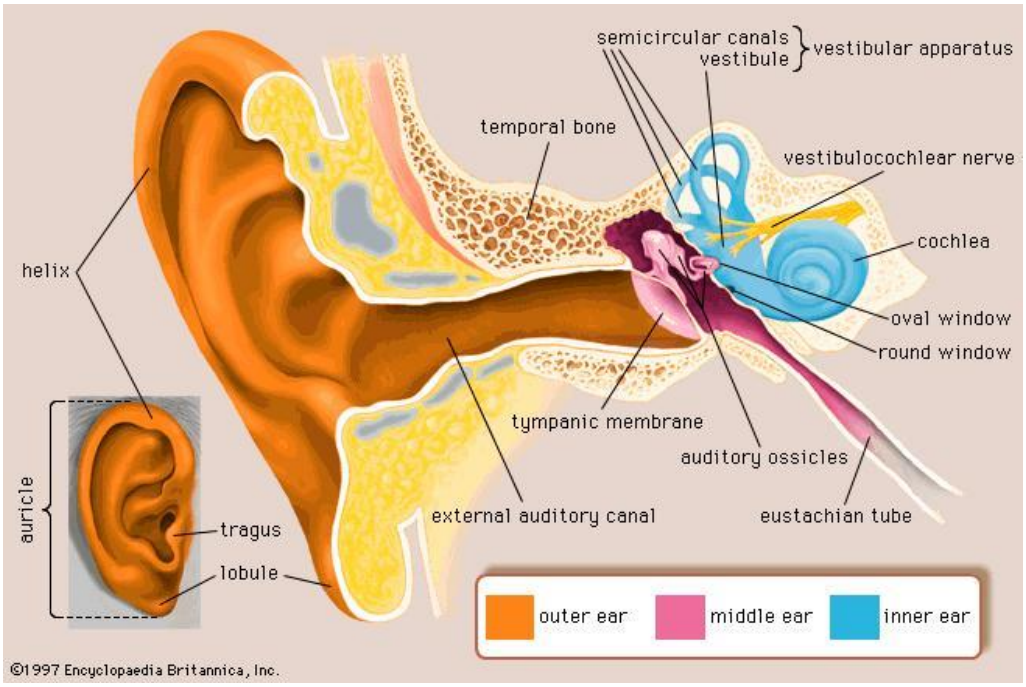
In my personal experience I have been on both sides of the desk. I have been the hard-of-hearing student within the classroom and, on the flip side, I have recently had the opportunity to teach a hard-of hearing student in my classroom. This situation presented a unique challenge as a teacher. While I understood intimately the struggles this student had and adaptations he may require, I was constantly wondering what techniques, teaching practices and environments would best assist this individual. Was I meeting his needs on a regular basis? Was he being provided with the same opportunities to learn and excel as his peers?

The purpose of this chapter is to address these questions and help teachers, educators and the general public better understand what being hard-of-hearing or deaf is. We will look at the

following questions: What is hearing? What is hearing loss and deafness? How does hearing loss affect learning? What technologies and strategies are available that can assist deaf and hard-of-hearing students with achieving success within the classroom? Where are we at for assistive technology for the hearing impaired and what could the future look like for these learners within the classroom?

The Anatomy of Human Hearing

The human ear is one of the five major human senses and is a remarkable development in human evolution. The shape and positioning of the ear allows us to discern sounds from a variety of directions. According to the Encyclopedia Britannica "the human ear is an organ of hearing and equilibrium that detects and analyzes noises by transduction (or the conversion of sound waves into electrochemical impulses) and maintains the sense of balance (equilibrium)" (Hawkins, 2015). While we can see the outer portion of the ear, the ear itself is broken into three distinct areas: The outer ear, the middle ear and the inner ear.



The Outer Ear

The function of the outer ear is to collect sound waves and guide them to the tympanic membrane (Hawkins, 2015). The placement of our ears on the opposite sides of our head assists us with being able to locate where a sound is coming from.

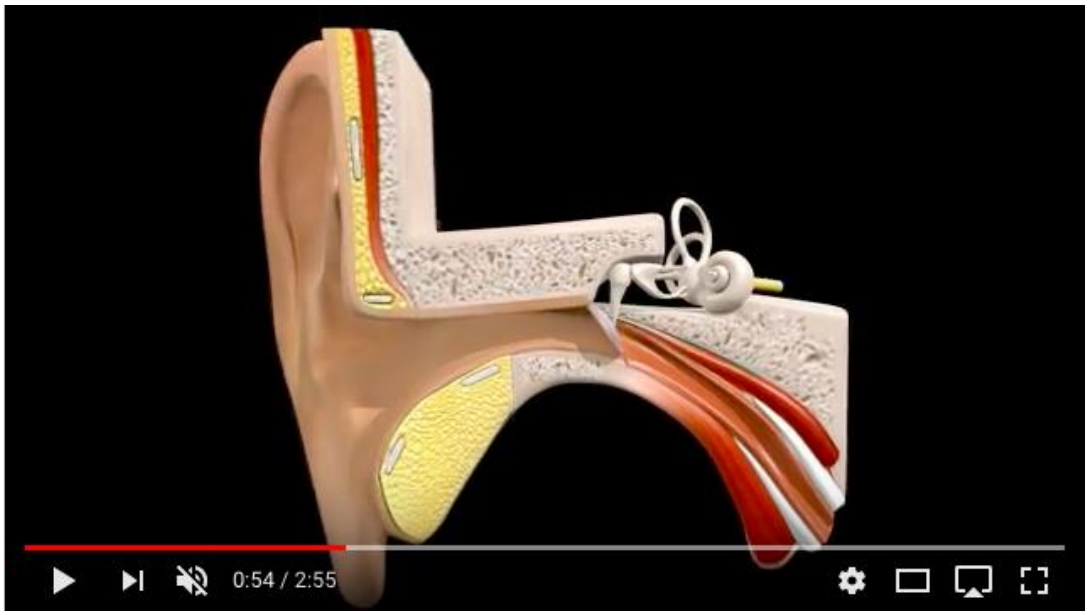
The Middle Ear

The middle ear is a narrow, air-filled cavity in the temporal bone. It is spanned by a chain of three tiny bones—the malleus (hammer), incus (anvil), and stapes (stirrup), collectively called the auditory ossicles. This ossicular chain conducts sound from the tympanic membrane to the inner ear. (Hawkins, 2015)

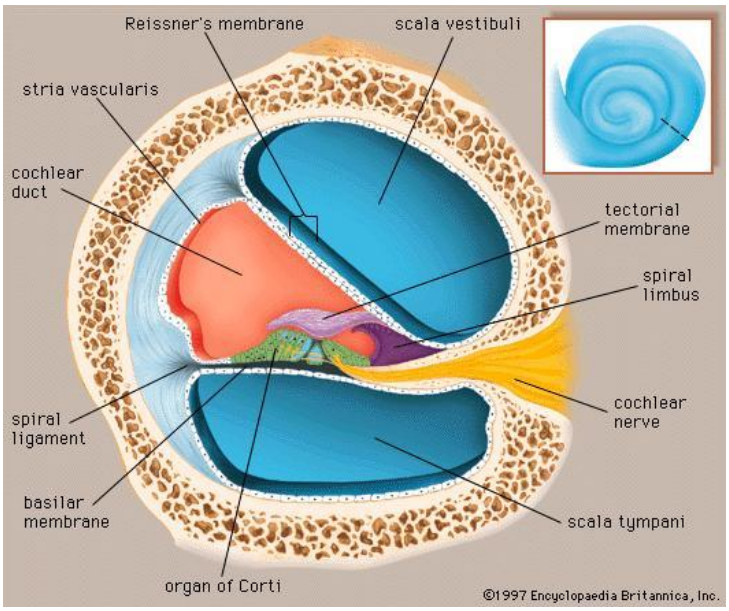
The Inner Ear

The inner ear has two distinct parts that have two important functions. It is responsible for our ability to balance and our sense of hearing. One part is known as the vestibular apparatus and the other is known as the cochlea. The vestibular apparatus is what senses a person balance. It is a common misperception that a person who is hard of hearing or deaf also has poor balance. While it is possible for both the vestibular apparatus and the cochlea to be damaged, they are in fact two separate systems that have two separate nerve pathways. The cochlea is the area where actual sound waves are converted into electrical impulses.

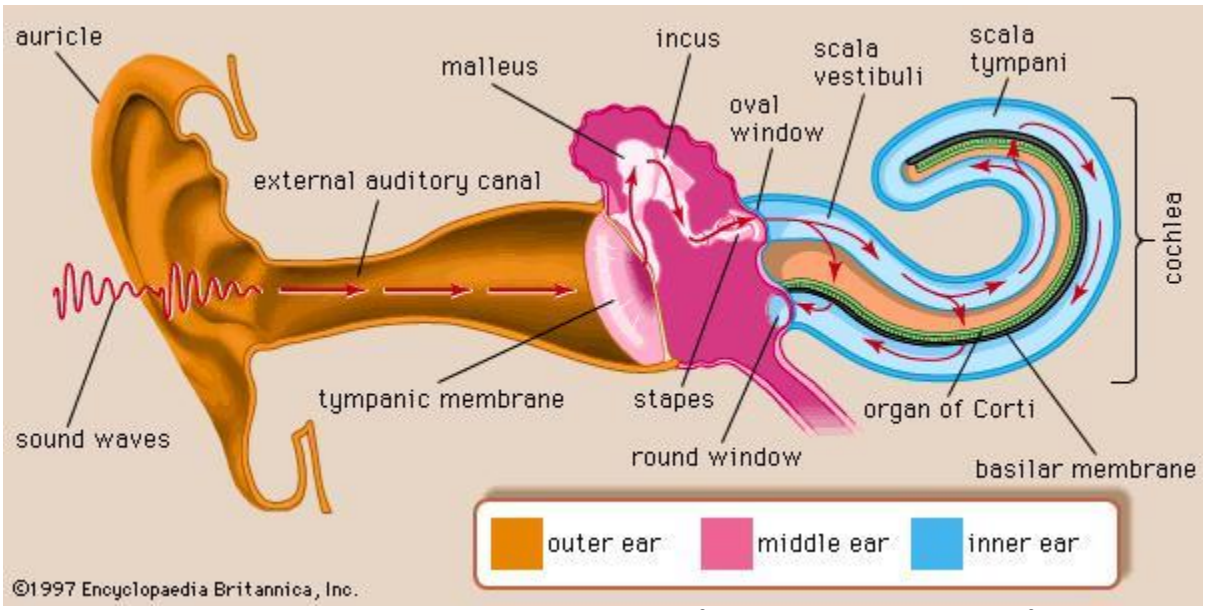
The cochlea is filled with tiny hair like structures, known as the Organs of Corti that move when sound waves hit them. The structure of the cochlea resembles a sea shell and this design actually allows us to sense different sounds at different pitches or frequencies. The following video gives a good overview of the structure and the function of the ear.



It is at the cochlea where sound is converted into electrical impulses. The cochlea's shape plays an important role in determining the range of sounds the human ear can hear.

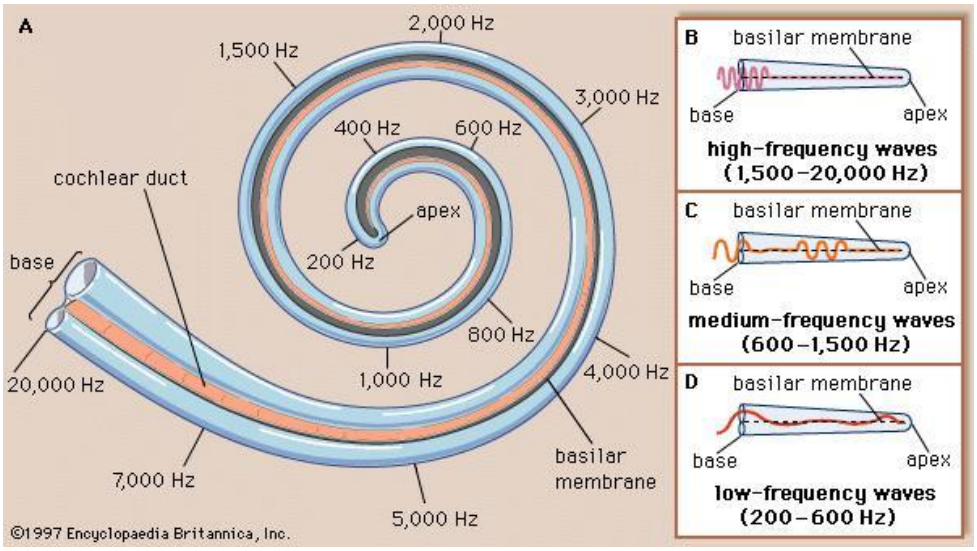


Inside the cochlea is a tiny structure known as the organ of Corti. The organ of Corti is a collection of specialized cells that resemble tiny hairs. Each of these organ of Corti are connected to a nerve fibre of the cochlear nerve, the main nerve that transmits electrical sound impulses to the brain. When sound is transmitted to the cochlea by the auditory ossicles the sound waves travel through the cochlea certain distances and cause these tiny hairs to move at certain frequencies.



The middle and Inner ear showing the transduction of sound waves and path of travel within the cochlea

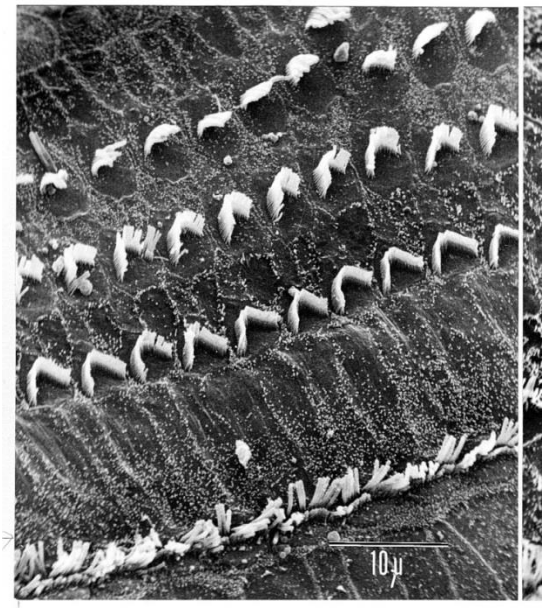
(note the middle and inner ear are not to scale)

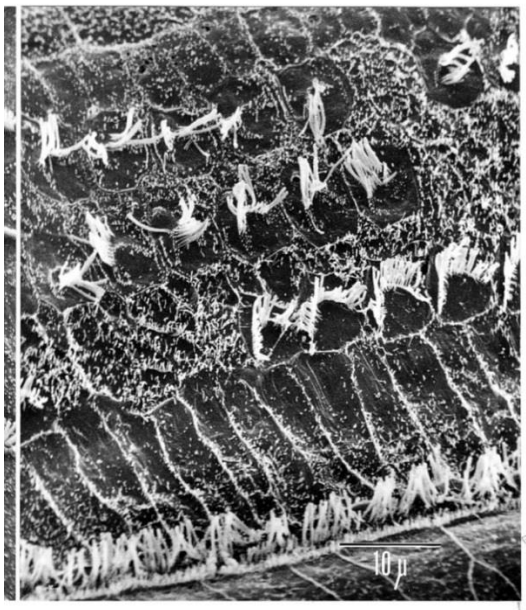


The cochlea can detect frequencies from as low as 200 Hz (known as low frequency waves) to as high as 20,000 hz (high frequency waves).

In a healthy person the organs of Corti line the inside of the cochlea in neat rows as shown below.

In a cochlea of a hard of hearing individual the organ of Corti do not have the same symmetry as shown below.





Portion of a noise-damaged organ of Corti from a guinea pig exposed to sound at a 120-decibel level, similar to that experienced at a heavy metal rock concert, showing "scars" that have replaced many of the outer hair cells and showing the remaining stereocilia in disarray. Hearing is permanently damaged because lost hair cells will not be replaced, and injured cells may be dying.

What is Hard-of-Hearing?

Many people assume that when encountering someone who is deaf or hard of hearing that they simply need to speak louder. This is not the case. It's a lot more complex. Being Deaf and Hard-of-Hearing are two very different classifications and the range of hearing loss in each means that there can be quite a wide spectrum of Deaf and hard-of-hearing individuals. Each hard-of-hearing and Deaf person is unique.

Over 5% of the world's population – 360 million people – has a disabling hearing loss (328 million adults and 32 million children) (World Health Organization, 2015). A disabling hearing loss refers to a hearing loss greater than 40 decibels (dB) in the better hearing ear in adults and a hearing loss greater than 30 dB in the better hearing ear in children. The majority of people with disabling hearing loss live in low- and middle-income countries. (World Health Organization, 2015). While hearing loss is commonly associated with older adults and seniors due to age related hearing loss, a noteworthy percentage of young people within the school system have a disabling hearing loss that affects their learning. Unfortunately being hard-of-hearing is an invisible disability that often goes unnoticed and misinterpreted and understanding exactly how it affects them can be hard to discern.

What is it like for a hard of hearing person in a regular school environment? The following video provides a good example of what a hard-of-hearing student may perceive in a regular classroom.

Youtube

As this video shows hard-of hearing students can miss certain words or misinterpret word in speech and have to mentally work harder to discern what is being said. It can lead to lack of interest in the class, confusion and missed learning opportunities that can hurt a hard-of-hearing student's education.

So what are the chances of a student who is hard-of-hearing arriving in your classroom? While there are limited accurate statistics that identify how many students are hard-of-hearing or deaf within the Canadian school system, it is possible to extrapolate a statistic based on the World

Health Organization's numbers. Given that around 32 million children have a disabling hearing loss in a world population is approximately 7 billion, this translates to around 0.5% prevalence. If we extrapolate this probability to an educational setting in this translates to around 1 / 2000 likelihood that a student has a hearing loss.

If we look at the average classroom size that a teacher has as being around 30 students a year (typical elementary class size) and that a teacher in their career will on average teach for 30 years you find that the average teacher will teach around 900 students. Given this number is closing on 1000 students it means, there could be 1000 /2000 chance. If my math is correct, this works out to a 50% statistical chance that a teacher may teach a student with a hearing loss within their careers. Therefor it is important that all teachers have an understanding of what hearing loss and deafness is and how it impacts students in today's educational environment.

Canadian Statistics

A number of studies have been done in Canada on hard-of-hearing and deaf students to try to get an accurate picture of its prevalence. According to Statistics Canada, 13.1 percent of children under the age of 14 were identified as having hearing losses (Statistic Canada, 2001). While these are the identified children the reality is that many other students who suffer from a range of hearing loss may go undetected. In a study done by Edwards and Crocker (2008) in the United Kingdom, they suggested that in a class of average elementary school students, there will emerge a child in every two to three years that will have a hearing loss that requires intensive intervention.

Types of Hearing Loss

Hearing loss can be classified into two main types: conductive loss or sensory neural loss.

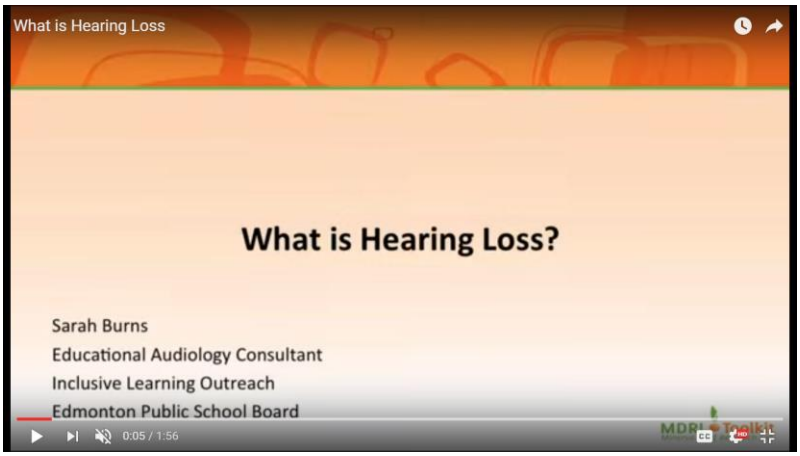
Conductive loss is when the conduction of sound is limited or inhibited. Most people experience a temporary conductive hearing loss at some point in their lives. If you have ever had a severe head cold where you have had pressure or fluid in the middle ear and had trouble hearing, you have experienced a temporary conductive hearing loss. Another example is if you have ever gone swimming and had fluid stuck in your ears and found it hard to hear.

As mentioned, a conductive hearing loss can be temporary in certain cases or permanent. An example of permanent loss could be damage to the ear drum preventing sound from being transmitted to the cochlea. This could be due to injury or repeated exposure to loud noises that causes scarring on the eardrum, causing it to lose its sensitivity to sound. It is also possible that there could be damage to the tiny bones found in the middle ear that prevents transmission of sound to the cochlea. This can happen due to a birth defect or a traumatic injury. In any case the sound waves are not transmitted to the cochlea properly.

Sensory neural hearing loss refers to damage to the cochlea or the cochlear nerve that prevents the transduction of sound waves into electrical impulses. This can be the result of a birth defect causing the cochlea not to be formed properly (congenital) or caused by exposure to excessive noise levels that damage the Organ of Corti within the cochlea later in life.

Congenital abnormalities are becoming the primary cause of hearing loss (Edwards & Crocker, 2008) and they have been found to account for more than half of the hearing losses that are moderate of profound (Arnos & Pandya, 2003).

Further information on what hearing loss is can be found in this online video produced by Sarah Burns, an Educational Audiology Consultant with the Edmonton Public School Board.

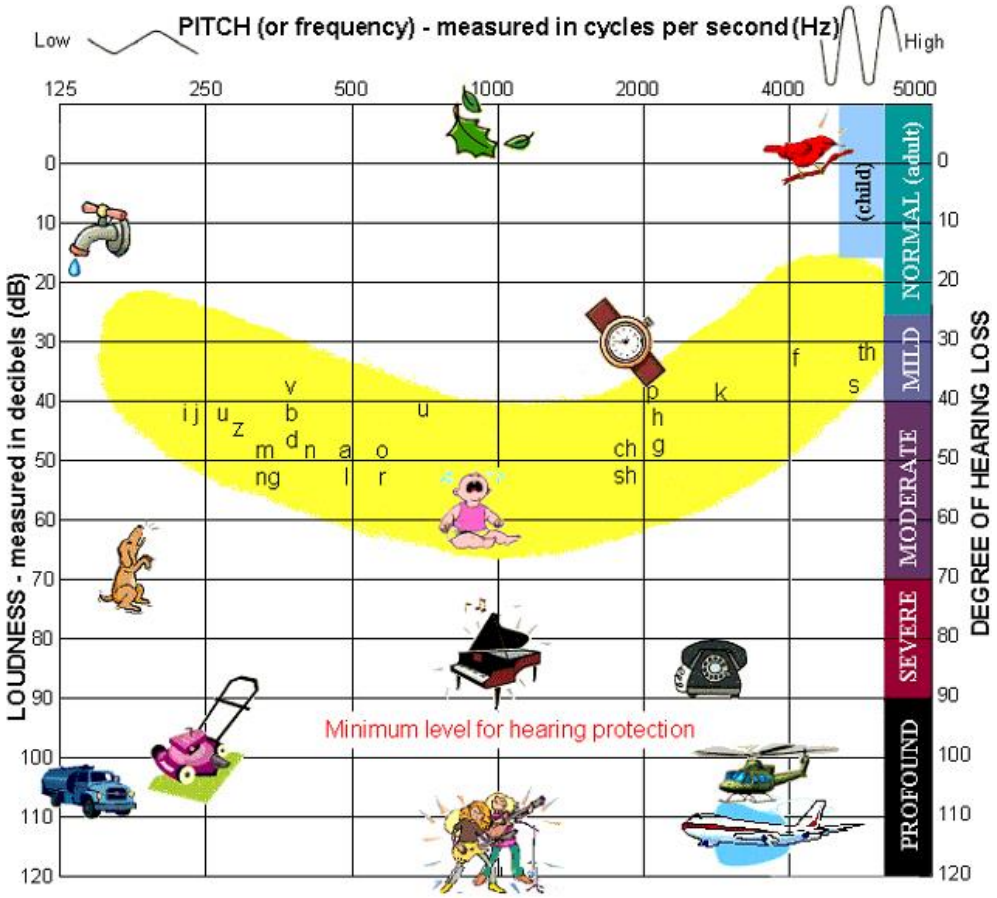


Ranges of Hearing Loss

Hearing loss is usually classified into three general stages: mild, moderate and severe. The following diagram is a typical audiogram that shows the level of hearing loss and the frequencies where it occurs. This is the same graph you would see if you happened to get your hearing tested. The colored areas show the types of hearing loss associated with degree of hearing loss. The loudness of sound is measured in decibels on the vertical side of the graph while the pitch (think of a deep base singer to a whistle) is measured on the horizontal axis. The larger the number on the left side the louder the sound needs to be in order for the person to perceive it.

Healthy Hearing

The following audio diagram provides a visual representation of hearing pitches and the loudness of the sound.



How to Read an Audiogram

A mild hearing loss is hearing loss in the ranges of 24 – 40 dB of loss.
A moderate hearing loss is from 40 – 55 dB.
A severe hearing loss ranges from 70 – 90 dB hearing loss and
a profound hearing loss is over 90 dB.

The visuals give you an idea of the type of sound heard at different frequencies (pitches) and decibels (loudness). As you can tell soft sounds are leafs falling, a bird singing or a tap dripping. The yellow banana shape in the middle with the different letters shows the range that those sounds are heard. Letter sounds like f, s, and th are in the high frequency area and pronounced at a low decibel level. Hard-of-hearing students, especially those with a high-frequency hearing loss can have a lot of difficulty hearing and discerning these letter sounds in speech. As the degree of hearing loss increases the ability to discern more letter sounds disappears. Individuals with a profound hearing loss can also be classified as deaf.

So what does this mean for children within the classroom? What are they missing out on at the various levels of hearing loss? Hearing Aid maker Seimens provides an interesting table to clarify this.

Degrees of hearing loss	**Hearing threshold**	**Ability to hear speech**
None	0 - 15 dB	Your child experiences no perceptible difficulty.
Minimal hearing loss	16 - 25 dB	Comparable to lightly plugging both ears with your fingers. Your child has difficulty hearing very soft speech or speech from a distance. It is harder to hear when there is background noise, like in an auditorium, classroom, or dining room. Hearing aids might be useful, but this depends on the individual.
Mild hearing loss	26 - 40 dB	Similar to minimal hearing loss, but with effects that are greater in degree. Your child may hear speech, but certain segments, especially short words, word endings and indistinct word sounds, tend to drop out. Background noise in classrooms and in other listening environments makes it even more difficult for the child to hear. Hearing aids are usually recommended.
Moderate hearing loss	41 - 55 dB	Your child may miss over 50% of speech, and even more with the presence of background noise. Hearing aids are necessary to provide amplification. Otherwise, children may have limited vocabulary, produce faint or unclear articulation of speech sounds, and develop limited communication skills. They may also have a flat tone to their voice with only a little inflection or modulation due to their inability to properly monitor their own voice.
Moderate to severe hearing loss	56 - 70 dB	Most sounds are not audible to the child. Speech and language skills may not fully develop without proper and early amplification through hearing aids. The child may also need support from speech and language therapists.
Severe to profound hearing loss	71 dB and above	Most environmental sounds and even speech are almost inaudible. Speech is unlikely to develop without amplification through hearing aids or other interventions. In addition, children might also be referred to programs that offer specialized instruction in various supportive and alternative communication methods such as lip reading, sign language.
Fluctuating hearing loss		Children who frequently have middle ear infections (otitis media) with fluid build-up in the middle ear (effusion) may experience varying degrees of hearing loss. These episodes of temporary hearing loss may last for several months or even longer. Although the hearing loss is mostly temporary and reversible, the child's speech and language skills may still be affected if the reduced hearing ability persists over a certain period of time. The child may hear, but will constantly miss certain fragments of information.
High-frequency hearing loss	1,500 - 8,000 Hz	The child experiences difficulty perceiving consonant sounds. Significant portions of important information may be lost from the speech signal. High levels of background noise will make it even harder to understand speech. This is because background noise contains a lot of low-frequency sounds that are perceived normally by the child, but the high frequencies, which are affected by the hearing loss, carry most of the information necessary for speech intelligibility.

Unilateral hearing loss		One ear has normal hearing, while the other has a hearing loss, which can create an imbalance in hearing. The child may have difficulties locating sound sources and voices. In addition, the child may have difficulty separating soft-spoken speech from background noise, especially if the speech is originating from the side with hearing loss. A hearing aid is sometimes recommended. Ongoing audiological monitoring is very important in case a hearing loss should develop in the ear with normal hearing or if the existing hearing loss worsens.

Best Sound Technology

What is Deafness?

According to the World Health Organization 'Deaf' people mostly have a profound hearing loss (greater than 90dB) which means little or no hearing ability. (WHO, 2017).

What is interesting to note is there are two very distinct groups of people within the spectrum of deafness. One group is considered Deaf with a capital D. This group primarily uses American Sign Language (ASL) rather than auditory or oral communication. They also may refrain from using assistive listening devices like hearing aids. It has also been noted that "this culture includes a unique set of values, norms, arts, social structures, and its own language (ASL)" (Saskatchewan Human Rights Commission, 2016).

On the flip side of the coin, there are people who are labeled as deaf without the capitalization. This group of people are deaf or very hard-of-hearing "but do not identify with the Deaf culture…This group predominantly prescribes the use of hearing aids, cochlear implants and/or lip reading." (Saskatchewan Human Rights Commission, 2016). This group also primarily uses auditory and verbal speech to communicate.

Current Canadian statistics

It is hard to get an accurate statistic on how many people are Deaf in Canada. Research into the issue has generated a number of different statistics ranging from as little as 1 in 25 to as high as 1 in 8 prevalence (CAD, 2007; Statistics Canada, 2006) The reason for such wide variability is multifaceted. Some individuals will fail to self-identify in surveys that they are hard-of -hearing or deaf. This may be because they are unaware of their mild hearing loss, they do not want to be identified; they don't think of themselves as having a disability or do not seek or can't afford assistance to help them with their disability. In some cases the wording of the surveys cause confusion and therefore leads to inaccurate data. For this reason the statistics in Canada are only a rough estimate.

According to the Canadian Association of the Deaf "with strong disclaimers as to the dependability and accuracy of any data, there are approximately 357,000 profoundly deaf and deafened Canadians and possibly 3.21 million hard of hearing Canadians" (CAD, 2017).

Deaf and Hard of Hearing in Saskatchewan

The support system for Deaf and hard-of-hearing students within Saskatchewan is limited and unfortunately falls behind other provinces within Canada. According to Nairn Gillies, Executive Director of Saskatchewan Deaf and Hard of Hearing Services, support for people who are deaf and hard-of-hearing is limited at best and that within the Ministry of Education and school divisions across the province there are few qualified supports to assist these students.

The reason for this has to do with the history of supports for Deaf people within the province. Up until 1991, there had been a dedicated School for the Deaf based in Saskatoon. This school had teachers trained in American Sign Language (ASL) who would teach the students of the school who were exclusively Deaf. The benefit of this school was that Deaf students were able to socialize with others like themselves. They received instruction in their primary language (ASL) and the supports were in place to allow them to succeed. Unfortunately in 1991 the school was closed and the Deaf students were placed in the public school system. According to the Saskatchewan Human Rights Commission report on Access and Equality for Deaf, deaf and Hard of Hearing People "since the closure of the School for the Deaf in Saskatoon in 1991, the primary approach to teaching deaf children has been to include them in regular classrooms with the support of educational assistants." This inclusive model has been the framework for schools around the province. Unfortunately "parents and educators alike criticized the lack of formal training for these educational assistants in sign language." (The Saskatchewan Human Rights Commission, 2016).

In discussions with Nairn Gillies, it became apparent that within the Ministry of Education there are no firm guidelines or supports to assist students who are deaf and hard-of-hearing in the school system. In many cases the decision of how to assist deaf and hard-of-hearing students is left to individual school divisions to manage, with each division providing its own version of supports.

How Hearing Loss Affects Learning

Hearing Loss can have a profound effect on what is heard and understood. For individuals who lose their hearing later in life, the loss of hearing can cause them to miss certain words leading to confusion, difficulty in following directions and conversations. These individuals may already have developed strong neural pathways for speech recognition and production but due to their hearing loss they are no longer able to perceive these sounds. Key learning opportunities within the classroom can be missed and unfortunately hard-of-hearing and deaf students can fall behind. This can lead to frustration, embarrassment, social isolation and low self-esteem.

Unfortunately for individuals who are born hard-of-hearing or deaf the situation is compounded. Specific sounds they can't hear means those sounds are not learned (i.e. pronouncing the sound "s" or "f") and mispronunciation can occur. Also since they can't hear the sounds critical language development stages can be compromised.

The development of speech begins at a very young age and is described in 6 stages: The

prelinguistic, the holophrase, two-word sentence, multi-word sentences and the more complex grammatical structures phase stage. (Edublok, 2017) The first stage starts from birth to ten months old. At this time babies are listening to the world and quickly are able to discern the sound of their mother's voice and begin to make associations with sounds. This is a critical time for them as they are rapidly growing and their brain is making many important connections at an accelerated rate. The remaining stages occur over periods of around a year on average and for the next 5 years speech development is rapid and the groundwork for speech is developed. Any impairment that prevents proper hearing of sounds and speech will have a detrimental effect on the speech development of that individual. For this reason early screening for hearing is essential.

"One population that has consistently experienced challenges in acquiring reading proficiency is students who are deaf or hard of hearing, even though most have average or above-average intelligence" (Braden, 1994; Maller & Braden, 2011). In fact it has been found that without specific interventions and adaptations "the average student with a hearing loss graduates from high school with reading comprehension skills at approximately the fourth-grade level." (Luckner, 2013). While this paints a rather bleak picture for people who are hard-of-hearing or deaf, there are many cases where hard-of-hearing and deaf students have achieved high levels of education and success.

A great book to check out on the success stories of hard of hearing and Deaf people is called "Believing... Achieving: Success Stories from Individuals Who Are Deaf and Hard of Hearing", by Tammy Cate and Missey Wright (2005). This showcases 32 individuals from a variety of backgrounds and cultures that have overcome barriers and difficult obstacles to achieve impressive accomplishments.

Strategies to help Deaf Students

How can we best assist deaf students within the classroom? First and foremost, we must understand that they are individuals and each person is unique. As long as they are respected then the doors are open for us to be able to build a foundation of trust. Secondly, it is important to determine the type of communication they are most comfortable with. For some deaf people or those with a severe hearing loss, they may rely on hearing aids to provide a reduced ability to hear sound and may only use auditory language as their primary way to communicate (likely in their native language). It is possible that even in profoundly deaf people they may have a limited ability to communicate.

In a Deaf individual their primary mode of communication is likely sign language. It is likely that they were instructed using sign language at a young age and it is used at home with their families. These students tend to have a stronger sense of identity but will experience frustration with trying to communicate with non-signing peers or others who insist on using auditory means to communicate.

In both cases it will be important to determine what are the best ways to communicate with

the student that will make them feel the most comfortable and allow them to express themselves.

There are a number of strategies that can be used if you ever encounter a Deaf person. The University of Wolverhampton, in England, has put together a great video that highlights important tips for communicating with Deaf people in a school environment.

Youtube

Strategies that can help Hard of Hearing Students

First and foremost, if a hearing loss is suspected the student should be recommended to have their hearing tested. The earlier a hearing loss is detected the better chance that the student can be provided with supports that will improve their overall education and development. According to the Saskatchewan Human Rights Commission's report on Access and Equality for Deaf, deaf and Hard-of-Hearing People "the need for early detection and support mechanisms for both the deaf / hard-of-hearing child and their family." Within larger suburban centres these services are readily available, but in rural areas these services may be sporadic and families may need to travel in order to be assessed.

Once a hearing loss is detected a number of options are available to the child based on their level of hearing loss. For mild to severe hearing losses a hearing aid may provide enough amplification to assist the students with hearing.

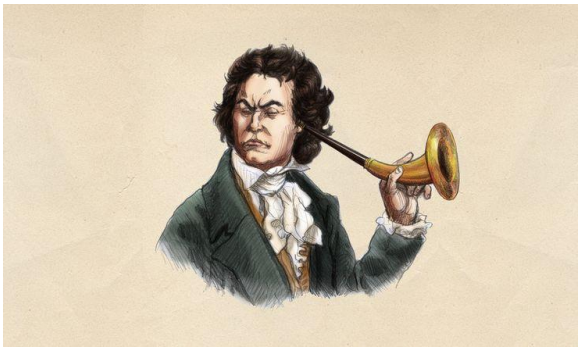
History of Hearing Aid Technology

The following brief history of assistive hearing devices will help us understand how hearing technology has changed over time to where we are today, and allow us to predict where it will be in the future.

Hearing aids have been around for a long time, easily dating back hundreds of years with the

first hearing aids been simple horns that a hard-of-hearing person put up to their ears to help them better catch sound.

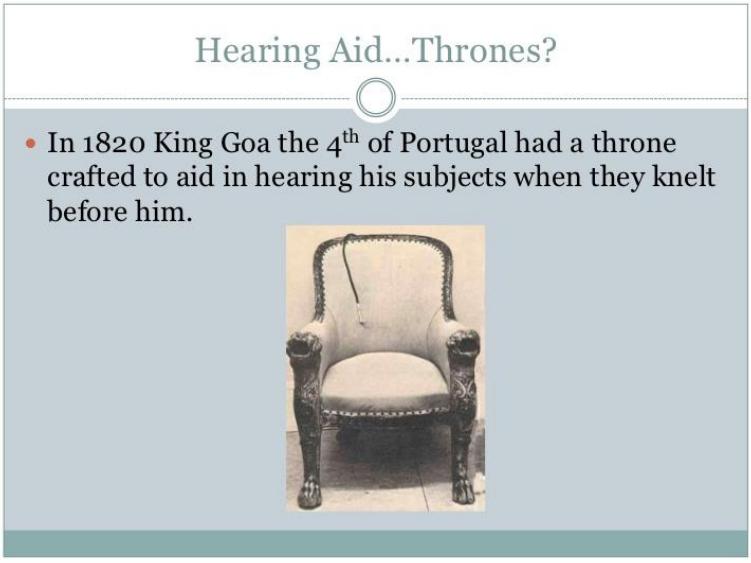
In the 1600s & 1700's hearing aid "trumpets" were popular way to help hard-of-hearing people to hear. They consisted of a wide end at one end to collect sound and a narrow end at the other that was placed against the person's ear. Sound captured at one end was amplified as the tube narrowed. These trumpets allowed for the collection of sound and some amplification but they had no ability to discern the sounds hear and provided only limited amplification. A famous user of the ear trumpets was Beethoven.



Dr. Kay

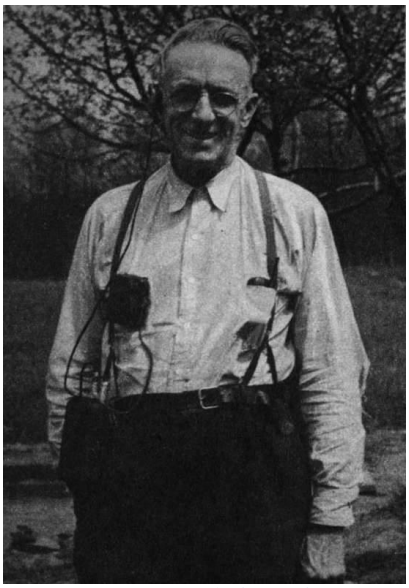
Beethoven-Haus Bonn

In the 1800's efforts to conceal hearing aids were made. While the hearing aids were still large "hearing aids were designed to be decorative accessories, and integrated into collars, head wear, bouffant hairstyles and clothing." (Beltone, 2017). An interesting historical fact is that "Members of royalty had hearing aids built right into their thrones. Special tubes were incorporated into the arm rests to collect the voices coming from visitors kneeling before the throne. The voices were channeled into a special echo chamber and amplified. The sound then emerged from openings near the monarch's head, with no one the wiser." (Beltone 2017).



Leanne Powers via Slideshare

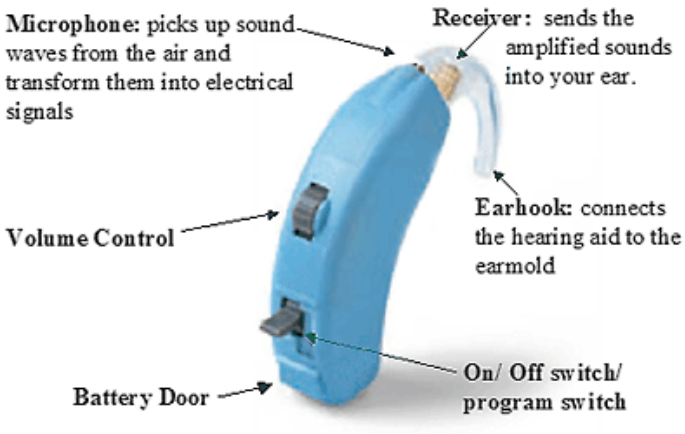
Hearing aid technology remained unchanged until the advent of electricity and Alexander Graham Bells invention of the telephone in the early 1900's. These hearing aids amplified sound by a microphone and a large battery. These hearing aids were worn around the neck as cumbersome boxes that contained visible wires and a heavy battery that only lasted a few hours. This allowed for the first truly portable hearing aid that amplified sound electronically.



Eastman's Online Geneology

Beltone

Over the next few decades, with the development of vacuum tubes, transistors and the miniturization of the battery soon hearing aids decreased in size beginning in the 1950's. In the following decades hearing aids evolved to the point where they could be worn behind the ear and then in the ear. These hearing aids used an analogue hearing system which simply increased the sound a person hear's usually over a very broad range of frequencies. This ususally lead to other sound pitches that a person could hear well to become amplified as well and some sounds became uncomfortable. Imagine turning up the volume on a T.V. All noise was amplified.



Equal Voice for Deaf Children

In the mid 1990's the advent of digital technology once again radically changed the development

of the hearing aid. "Digital circuitry allowed sound to be amplified, flitered and directed, as needed. Hearing aid programs could be customized to a user's lifestyle." (Belltone 2017). For the first time hearing aids could be customized to amplify the specific frequencies where the hear loss occurred. This eliminated the drawback of analogue hearing aids amplifying everything and allowed the users a more comfortable and natural hearing experience.

The following illustration from Starkey gives a summary of the development of hearing aids throughout history to the current technology available.

Starkey

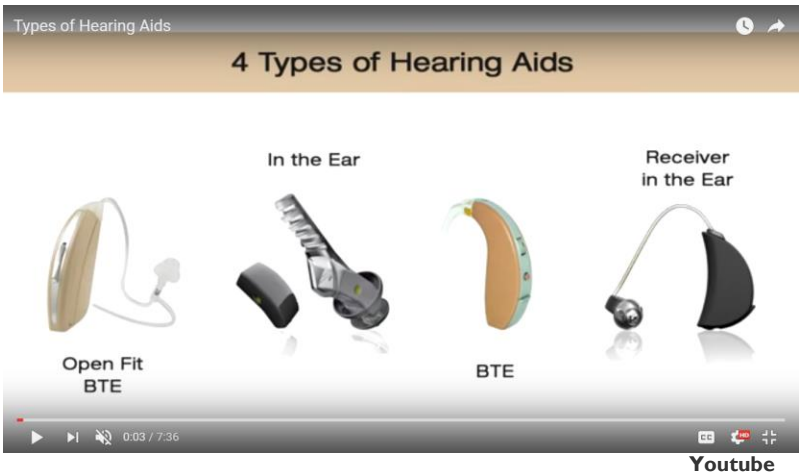
Current Technologies to Assist Hard of Hearing Individuals

These days hearing aid technology is quite sophisticated and there are a variety of options that can assist hard-of hearing individuals. They are broken into three general areas: hearing aids, cochlear implants and FM systems.

Hearing aids

In the 21st century hearing aids have become even smaller, faster, lighter and more powerful than ever before. Hearing aids can now fit right into a persons ear canal and be virtually invisible when worn. They can be programed with a variety of hearing level programs and can inteligently adjust the hearing level throughout the day as the user moves between different hearing environments (think going from a quiet library to a noisy street and the hearing aid autimatically decreses the amount of noise heard). These days it is possible to pair hearing aids with a variety of accessories wirelessly. Some have bluetooth capibilities that allow them to communicate with telephones, stereos, televisions and computers. "Recently, Apple developed a "Made for iPhone hearing aids" (MFi) program which enables users of MFi digital hearing aids to stream phone calls, music, and podcasts directly from iOS devices." (Apple, 2017).

There are 4 general types of hearing aids that are explained in this video.

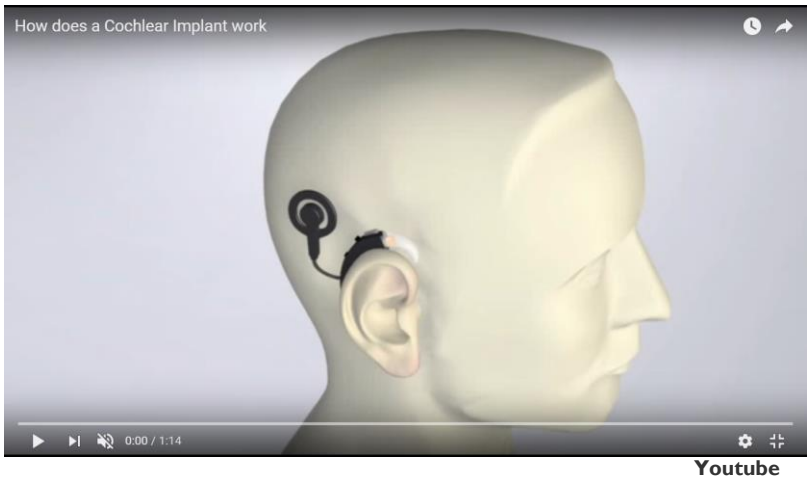


Youtube

An important factor to remember is that all hearing aids run on batteries. Battery life will vary from one hearing aid to the next depending on the size of the battery and the power requirements of the hearing aid. Typically the more powerful the hearing aid the shorter battery life they have. A typical battery can last from as little as 3 day to 10 days, with the average being around a week. It is also important to realize that the effectiveness of a hearing aid diminishes as the battery gets near the end of its life. If you notice a hard-of-hearing student is having difficulties hearing in class, have them check their batteries and perhaps replace them with new ones. It is also a good idea to keep extra batteries on hand in the classroom in case the student's batteries die and he/she forgets to bring his/her own from home.

Cochlear Implants

Cochlear Implants are a fairly recent development in the way of assistive hearing technology. For those individuals who have a severe or profound hearing loss or have suffered damage to their cochlea, a cochlear implant can provide the ability to detect and interpret sound. "A cochlear implant is an electronic medical device that replaces the function of the damaged inner ear. Unlike hearing aids, which make sounds louder, cochlear implants do the work of damaged parts of the inner ear (cochlea) to provide sound signals to the brain." (Cochlear, 2017).



Youtube

By inserting electrodes directly into the damaged cochlea the cochlear implant is able to innervate the nerve cells in the cochlear region and provide a sense of sound. The benefits are that it allows individuals to hear sounds they could not perceive before. With training and rehabilitation, individuals can begin to interpret and understand the sounds they are hearing, leading to speech development. Cochlear implants do require surgery that usually can be done in a day, but requires a recovery period of a few days. A cochlear implant can be fitted on a child as young as one year of age. This benefits the child by allowing them to perceive sounds they could not hear and assist with auditory language acquisition.

Youtube

Some of the drawbacks of cochlear implants are that they require invasive surgery, are very costly at $24,000 which does not include the cost of surgery. (CBC News, 2011) Batteries can also be quite costly and can last on average two and a half days (CHHA Calgary, 2017). In addition "many parents and advocates believe the potential benefits of cochlear implants have been overstated by healthcare providers. Some (critics) indicated that there is a lengthy wait for cochlear implants and the lack of follow-up care, is a barrier for deaf children." (Saskatchewan Human Rights Commission, 2016).

It has been reported that "there is still ongoing debate, especially active among children of deaf

parents, as to whether children with profound hearing loss should embrace their Deaf culture and grow up using sign language (i.e. ASL) for communication. They feel that deafness is not a handicap that needs to be treated or corrected but a shared experience and cochlear implants are disrespectful." (CBC News, 2011).

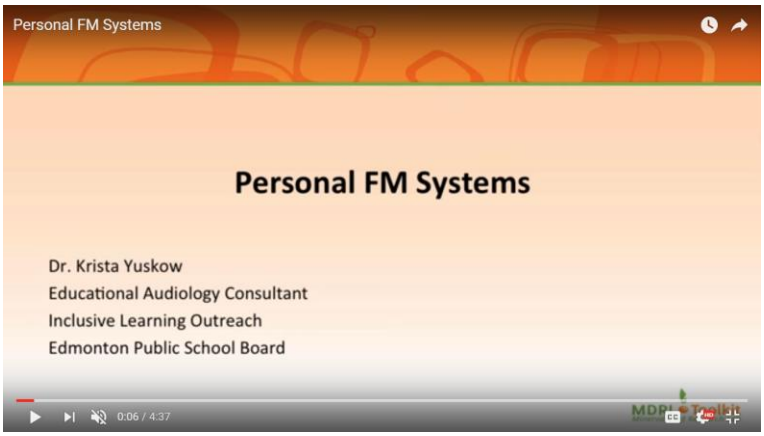
In spite of this criticism there have been many success stories with the use of cochlear implants and individuals who receive them have noticed a profound difference in their ability to hear and communicate effectively.

FM systems

Personal FM systems are wireless assistive hearing devices that enhance the use of students wearing hearing aids and cochlear devices allowing them to directly hear the teacher. Personal FM systems consist of a microphone and a receiver. The teacher or speaker wears the microphone clipped to his/her shirt. The microphone is then connected to a transmitter that is either worn around the neck or clips on to a belt. The microphone picks up the teachers voice and converts the sound into a FM signal that is transmitted to the student. The student wears a receiver that sends the signal to the hearing aids via a magnetic field. The most common way this works is that the student wears a neck loop underneath his/her clothes that connects to the receiver he wears on his belt. Other options include body worn receivers and even receivers that connect directly to behind-the-ear hearing aids. This field is picked up by the telecoil in the hearing aid or implant processor and converted into sound. The system works much the same way as listening to the radio in the car. The sound of the person's voice is transmitted directly to the hard of hearing students ears. The range of the FM transmitter can be as large as 50 feet and the signals can transmit through walls. This is of great benefit to the hard of hearing student as the teacher can move around the classroom and it will always sound as if the teacher is right beside them. Caution should be observed when the teacher wishes to speak to someone but not want their conversation broadcast to the hard-of-hearing student.

Drawbacks of this technology are that they only amplify the voice of the person wearing the microphone, so in group conversations the microphone needs to be passed around when different people speak or the teacher needs to repeat or paraphrase what the students say in order for the hard-of-hearing student to follow the conversation.

The following two videos provide further detail as to the how FM systems work and their benefits.



Youtube

Youtube

Current Best Practices to Assist Hard of Hearing Individuals in the Classroom

So what are the best practices to use within the classroom to help hard-of –hearing and Deaf students? Before we look at the strategies the following video on the next page provides an important starting point.

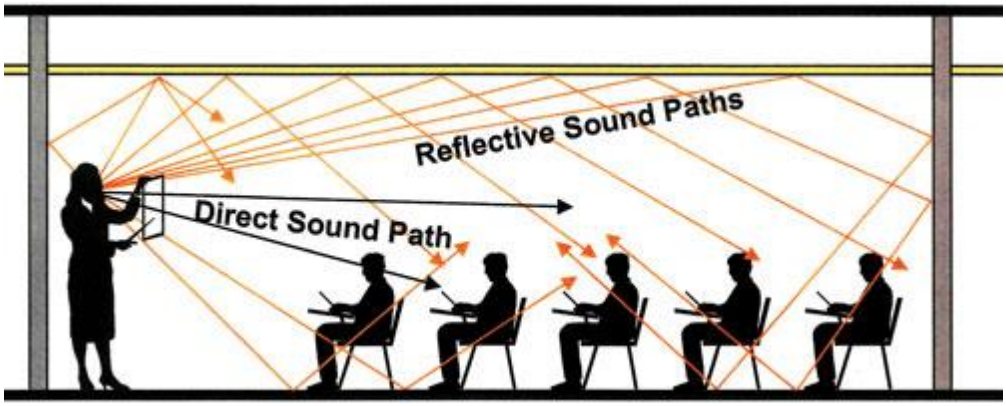
Minerva Deaf Research Lab

As you can see from this video the ability to hear sound and to understand sounds are two very different abilities. When we use our teacher voice we tend to punch the vowel sounds, which get louder. Unfortunately when we make the vowel sounds in a word louder we tend to mask the consonants sounds, especially soft ones like "s" "th" "w". It is important when we use our teacher voice that we focus on speaking clearly, not simply loudly.

Setting the environment

Developing an appropriate classroom environment is important for ensuring all students have the chance for success. One area that is often overlooked is the level of background noise in the classroom. Even in the most ideal circumstances classrooms have a high level of background noise. Besides the regular talking and movement that happens in the classroom another source of noise are such things as, heating systems and fans, florescence lights and hallway noises that filter into the classroom. These noises lead to the overall level of noise in the class and can make hearing difficult as it becomes a noise that students, especially hard-of-hearing students, have to filter out.

Another important aspect that is overlooked is the actual construction of the classroom. Poorly designed classrooms can lead to a lot of echoing, which is known as reverberation. Reverberation is the ability for sound to echo off of structures in the classroom. When a person speaks their voice projects out throughout the classroom and bounces off ceilings, floors, and walls. Reverberation causes the speakers voice to loose clarity as the echo soundwaves become mixed with the speakers and makes it hard to discern what was clearly said.



Whole System Acoustical Treatments

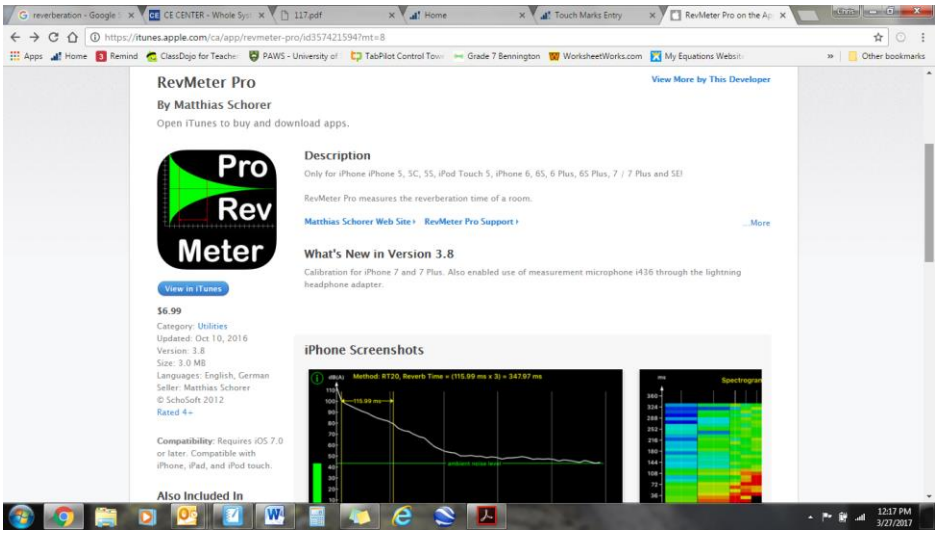
A recent study looked at classroom reverberation and how children performed and their level of comfort in a set of classrooms in Denmark. "In classrooms with different reverberation times (RT), they compared the children's short-term memory, speech perception abilities and attitudes about their classrooms and teachers. They compared classrooms with RTs from as fast as 0.49 to as long as 1.1 seconds and found a significant negative impact on short-term memory and speech perception as reverberation time increased." (Klatte et al, 2010)

A classic example of a poorly designed classroom are portables. Portables tend to have hollow floors, if the floors are not carpeted the sound reverberates through the floor every time someone moves. Portables also tend to have ceiling tiles that don't absorb sound but rather reverberate it back into the classroom. Portables also tend to not be connected to the schools central heating system and tend to have their own heating systems installed either on the roof or right outside the building. These heating and cooling systems tend to be loud and cause a high level of background noise within the classroom. This all leads to a higher level of background noise that makes it difficult to discern what is being said.

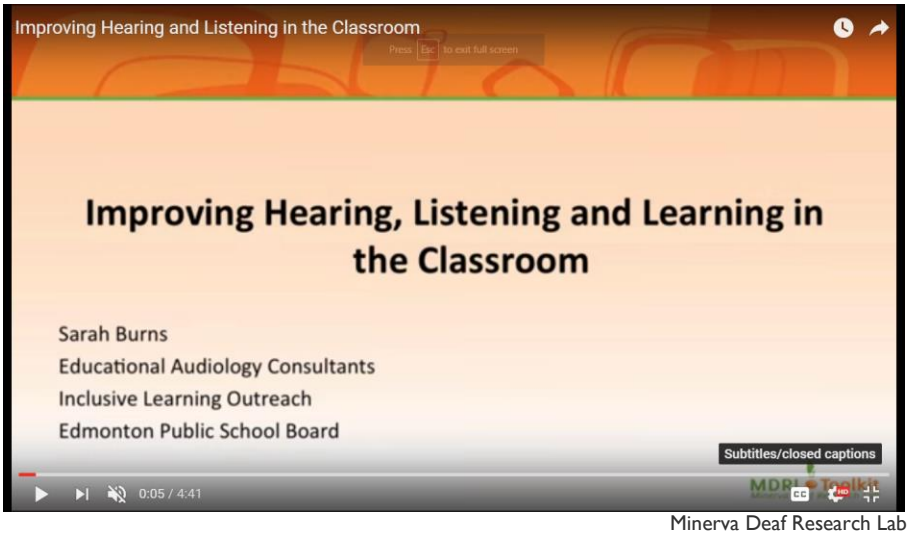
A study of reverberation was undertaken in Essex, United Kingdom which looked at improving the classroom environment in order to make it easier to hear clearly. The following video summarizes the findings of their study.

Youtube

As you can see a number of small improvements to the classroom caused a significant change to how clearly people could hear. While these improvements are designed to help hard-of-hearing students they can help all students in the classroom. Reverberation can be measured using certain apps. The following app, RevMeter Pro, which is available in the iTunes App Store, allows you to measure the reverberation within a room.



The following video from the Edmonton Public School board provides even further strategies on how to improve the Hearing, Listening and Learning environment within the classroom.



Minerva Deaf Research Lab

There are a number of strategies that can improve the listening environment within the classroom. To summarize here are a couple a teacher can easily implement:

- **Control reverberation** – look into purchasing high noise reduction ceiling tiles to limit reverberation.
- **Control the Noise** – ask for control of the heating vent system or work to minimize the noise coming from these within the classroom. Ensure all fans, aquariums or other noisy appliances in the classroom are situated as far away from the main instruction area as possible. Invest in chair and desk leg covers to reduce the amount of noise produced by them when desks and chairs are moved around.
- **Teach acceptable noise levels in the classroom**. A quiet and independent noise level, a soft talk with partner noise level and a group activity noise level. There are a number of innovative ways to do this. One is using the Starkey Sound App's noise feature, which will be described in the app section of this chapter. The second is to use the Yacker Tracker system in the classroom that monitors the noise level in the class using an innovative and familiar visual.
- It is important to stress that in order to help hard-of-hearing people hear you the speakers should speak one at a time and their face should be visible so that a hard-of-hearing student can lip read and get visual cues.
- **The teacher's voice should be above** the ambient noise of the classroom. Teacher should have good classroom management strategies to reduce noise and get students attention quickly.

Factors to consider with hard-of-hearing and Deaf students in the inclusive setting

It's important not to forget the social aspects of being hard of hearing. Hard of hearing individuals will tend to shy away from large social situations or noisy environments since these put too much strain on their limited ability to hear and can exhaust them just trying to follow along.

Also issues of acceptance may bother hard of hearing students, especially as they move into their teenage years and begin to identify who they are. Being a teenager is tough, but it is even more pronounced for a hard-of-hearing person. The potential to misinterpret individuals or miss out on subtle verbal cues can make this a very difficult time for them. It's also important to understand that hard-of-hearing individuals have a much harder time associating with a given group than other physical disabilities. Even in the case of the Deaf community there is a strong sense of identity, culture and support mechanisms that are not present for hard-of hearing people. They feel somewhere in between hearing and deaf society and this ambiguity will make them question who they are and can lead to them feeling lost, causing low self-esteem and depression. It's important to note that some students may be very comfortable with identifying themselves as hard of hearing while others will not admit they are hard-of-hearing and go to great lengths to hide it and not stand out among their peers. This can be seen through having hair cover their hearing aids to even not wearing them. Another tactic they use is to simply smile and nod when in conversations with peers even though they did not hear what was said,

but don't want to be seen as different.

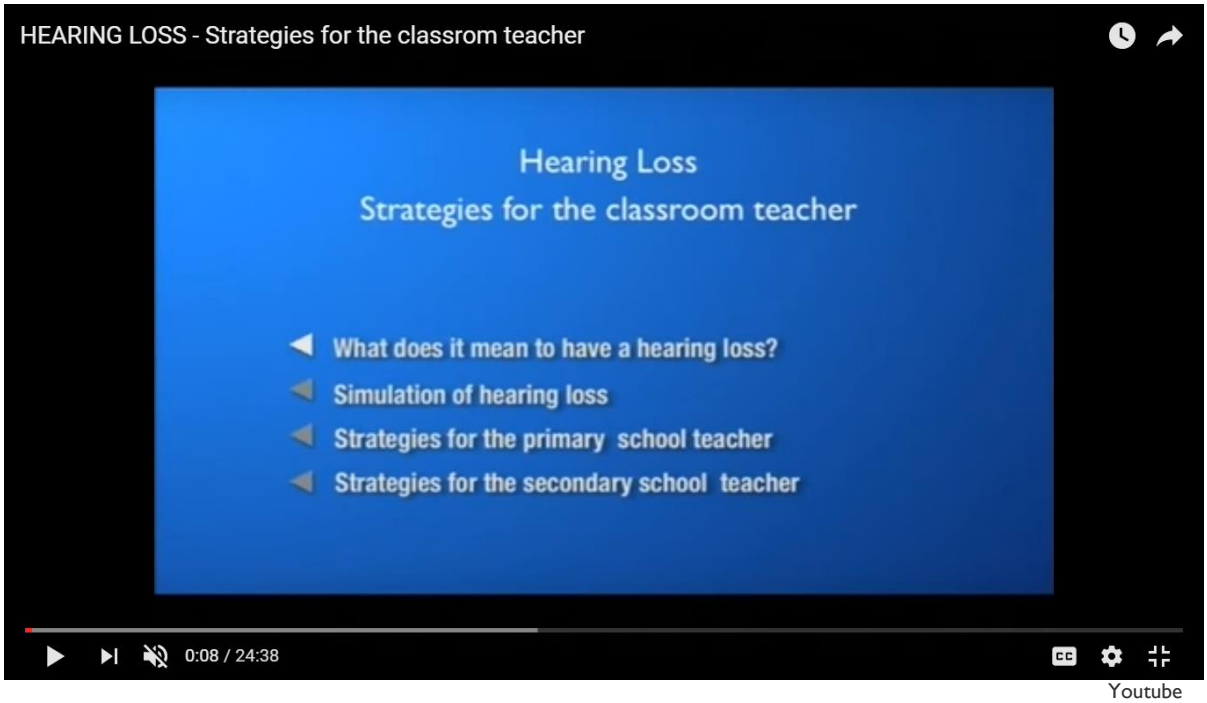
The best way to assist hard-of-hearing students. Be open and willing to listen to them. Encourage them to speak up. Assist them with helping them hear what is said in class. Be helpful and considerate and treat them with respect. A great read on the topic of Personal and Social Identity of hard of Hearing People can be found in an article by Dr. Mark Ross who captured the this issue well.

Strategies for teaching a student with hearing loss in the classroom.

There are a number of simple strategies teachers can utilize in order to help hard-of-hearing students to learn within the classroom.

- Have the hard-of-hearing student sit at the front, or near the front of the class, where he will be able to hear you speak easier.
- Make sure you face the student when giving the instructions so that they may read your lips and be able to see your facial expressions. Many hard-of-hearing students will learn how to lip-read in order to help them accommodate for loss of hearing, sometimes this is taught to them or they naturally pick it up.
- Avoid talking with you back turned to a hard-of-hearing person, especially when writing on the board.
- Avoid low light situations that make it hard for the hard-of-hearing student to see your face.
- Actively be aware of background noises that are in the classroom and work to remove them or minimize them as much as possible.
- Be ready and willing to repeat yourself throughout the day.
- Use a clear voice, not a loud voice.
- Use closed captioning when watching videos for those that are hard-of-hearing.
- Providing notes for following along with the days lesson will help older students stay on top of what is being taught.
- Have a note taker assist the hard-of hearing student with taking notes in class.
- Record your class lessons using recording programs like Audacity and send them to the student later on.
- Have lots of visuals. Some hard-of hearing students will respond well to visuals that compliment auditory instruction.

For further information about strategies for the classroom teacher, the following video by the Victorian Deaf Education Institute provides a detailed overview of hearing loss and offers strategies for both the elementary and secondary teachers directly from hard-of-hearing students.



Youtube

This video really highlights the struggles and issues that students who are hard of hearing have within the classroom. It is important to remember that each situation is unique and that teachers should ensure that they discuss with the student what are the best strategies to help them hear better within the classroom.

Apps to Support Hard-of-Hearing and Deaf students

There are a number of apps that can assist teachers, regular students and hard of hearing individuals with better understanding hearing loss, noise levels and American Sign Language.

Jacoti ListenApp

This app allows the user to turn their phones into hearing devices and allows them to utilize the processing power or the phone to discern hearing.

Ava – 24/7 Accessible Life

This app turns real-time speech into text and allows a hard of hearing person to read what was said. The apps works fairly well and is believed to get better with practice as it begins to understand a person's voice.

Mimix Sign Language Translator

This app will sign anything you speak or type into it. It has a virtual person who will sign what is said. Can be helpful for communicating with someone using American Sign Language.

Too Noisy Pro.

This app measures the sound level within the classroom and provides a colourful representation on an iPad or iPhone screen. It is a great tool for keeping track of noise level in the class.

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SoundCheck Hearing Test.

This is a mobile app that can test a person's hearing. It also has a feature that allows it to determine the level of noise in a room and displays it as sound waves and gives the decibel rating. It is also able to track the loudest level achieved in a room.

TruLink

This app works with "Made for iPhone" Hearing Aids that allows users to control their hearing aids through iPhones, iPads, iPod Touch and Apple Watch. It allows you to stream music, phone calls directly to your hearing aids.

Additional Resources for Teachers of Deaf and Hard-of-Hearing students

The following websites are great resources to further help teachers of Deaf and Hard-of-Hearing students.

- Canadian Hard of Hearing Association – The National organization for Hard of Hearing individuals. This website has a wealth of information and resources for Hard of hearing individuals and the people who work with them. http://www.chha.ca/chha/

- Saskatchewan Deaf and Hard of Hearing Services – This provincial organization works on behalf of Deaf and Hard-of-Hearing individuals in the province to advocate for better assistance and provide resources and services to both groups. http://sdhhs.com/#

- Starkey Canada – This website provides information on hearing aids and other assistive listening devices. There are also hearing tests that you can take on the website to determine if someone has a hearing loss. http://www.starkeycanada.ca

- Edmonton Public Schools – Deaf and Hard of Hearing Program – This website provides information on Edmonton Publics Schools program to assist students who are Deaf and Hard-of-Hearing. https://www.epsb.ca/programs/deafandhardofhearing/

- Alberta School for the Deaf – This website provides an overview of the Alberta School for the Deaf and the services provided. http://asd.epsb.ca/

- Minerva Deaf Research Lab – This website has a wealth of resources and tutorials to assist teachers, parents and the general public with understanding what Deaf and Hard-of-Hearing is and how to best assist these individuals. http://mdrltoolkit.ualberta.ca/

- Hand Speak – This website is a sign language resource online. It provides an American Sign Language (ASL) dictionary, tutorials to learn ASL, finger spelling tutorials and tests, and even translation services. This site had great videos of people signing that were easy to follow. https://www.handspeak.com/

What does the future hold for Deaf and hard-of-hearing students in the classroom?

There is great potential in the near future for hard of hearing students. In the way of hearing aids advances in the next few years it's likely that hearing aids will come with more fine-tuning power given to the user. I believe many programs will be moved over to smart phones and you will be able to harness the power of these devices to adjust your hearing aids, connect to other media and run diagnostics on your hearing aids. I also believe that rechargeable hearing aids will come into play, eliminating the excessive waste of one use batteries.

In terms of the classroom it is possible that wearable technology may further assist students like speech to text glasses to capture what is said in class. There will be more hearing assistance apps that can allow people to hear, at a low cost. Audio visual instruction within the classroom will continue to improve allowing for a more immersive experience utilizing all the senses.

I also believe that advances in genetics will help to better identify hearing loss and deafness earlier and possibly eliminate it all together in the future. There is great potential for remarkable advances. If the advances in the last ten years are any indication, the sky is the limit in terms of where we will be in the next decade.

Recommendations to Improve Educational Success among Deaf and Hard-of-Hearing students.

Classroom Level:

- If a hearing loss is suspected in a student make contact with the parents and caregivers, express your observations and recommend that their child gets a hearing test.
- If you have a student who is hard-of-hearing in the classroom place them near the front of the class and also close to your desk so that they will be able to hear you easily.
- Be aware of the noise level within the classroom and reverberation. Make efforts to reduce unnecessary noise by carpeting the floors, putting covers on chairs and desks. Moving noisy appliances (fish pumps, electric pencil sharpeners) away from the hard-of-hearing individual, install sound resistant ceiling tiles and set appropriate noise guidelines with your students and monitoring sound level with sound apps for phones and computers.
- Try to incorporate as many visuals into your lessons in order to compliment your verbal instruction. This could be diagrams, chalkboard notes, short PowerPoint notes reinforcing the important points of a lecture.

School Level:

- If you have a student who is deaf ensure that adequate supports are available to assist them in the classroom.
- If the student uses American Sign Language Take an American Sign Language Course.
- Ensure that the educational support worker tasked with the individual is certified in American Sign Language.
- Invest in classroom sound systems that amplify sound to assist all students.
- Invest in an FM systems for all cases where there is a student who is hard-of-hearing.

Division Level:

- Create a consultant position within school divisions whose role is to work to educate, support and improve the lives of students who are deaf, Deaf and Hard-of-hearing in the classroom and the teachers who will work with them (similar to the Edmonton Public School Board's Educational Audiology Consultants).
- Deliver ASL courses for teachers in order to build capacity within the school divisions.
- Develop short course video's that can quickly educate staff and public on Hard-of-Hearing and Deaf teaching strategies to utilize within the classroom.
- Conduct a sound test within classrooms under occupational health and safety for background noise levels and work to minimize reverberation and background noise propagation in all classes (especially portables).
- Recognize the social difficulties Deaf and Hard-of-Hearing students experience and set up a class or group that allows them to come together on a regular basis within the school day to meet, discuss and share experiences in order to build a sense of belonging and fellowship.

Province Wide:

- Implement a universal early screening hearing program for all newborn children in order to catch hearing loss early.
- Recognize the Deaf community and their unique cultural and language requirements.
- Recognize American Sign Language as an official language and develop workshops and courses that teach this to government employees, health and educational professionals across the province.
- Recognize the high cost of assistive listening technology and provide a funding program to support the purchase of personal assistive listening technology.
- Provide funding for assistive listening technology to all school divisions across the province so that they may purchase FM systems and improve the sound environments in classrooms.
- Create a consultant position, within the Ministry of Education, that works with school divisions, consultants and develops partnerships between the Ministry of Health, Ministry of Social Services, audiologist, the Saskatchewan Deaf and Hard of Hearing Services, National Partners (Canadian Hard of Hearing Association, Canadian Association of the Deaf) and other provincial government partners (Government of Alberta, British Columbia and Manitoba) in order to identify deaf and hard-of hearing individuals across the province, investigate best practices, implement services to assist hard-of-hearing students in the classroom and monitors the success of supports to help these individuals achieve their best possible academic potential.
- Similar to Braille for the blind, provide some form of universal assistive listening technology and ASL services in all government buildings.
- Provide public education campaigns and information packages about the duty to accommodate all hearing disabilities.

"If you talk to a man in a language he understands, that goes to his head.
If you talk to him in his own language, that goes to his heart."
–Nelson Mandela

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Chris Bennington has been a teacher with the Saskatchewan Rivers School division for the past nine years. He holds a Bachelor Degree in Kinesiology from the University of Calgary and a Bachelor Degree in Education from the University of Saskatchewan. He is currently completing a Master's Degree in Educational Technology and Design through the University of Saskatchewan. Chris is also a hard-of-hearing individual who was born with a high-frequency hearing loss. He credits his parents for inspiring him to chase his dreams and pursue education. He also credits his mother for the hard work ensuring he was given the best chance to succeed. Chris actively enjoys the great outdoors with his wife Carolyn and his three children.