
Classroom adaptations for effective learning of deaf students

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Abstract

During the last two decades the population of deaf children has changed tremendously due to the combination of universal newborn hearing screening, early intervention, and cochlear implants. This changing population has led to changing communication approaches, changing educational settings and changing educational demands by these deaf learners.

Deaf children have always been a heterogeneous group, difficult to study, but cochlear implantation has added even more variables, making the group even more diverse. For this heterogeneous population, there is not a one-size-fits-all approach which meets the needs of all deaf children and their families. An increasing number of deaf students are educated through spoken language in a regular school, where classroom acoustics are often very poor. The needs of deaf learners today are more varied than ever before, with expectations that many achieve at levels equal to their hearing peers, and their educational environment may not be staffed or equipped appropriately to ensure deaf students meet their full potential in today’s world. Adapting the classroom for effective learning of deaf students is a big challenge for professionals supporting deaf students today. We must ensure that teachers have the skills to meet these challenges.

Keywords

Deaf students, deaf education, classroom adaptations, effective learning, changing educational setting
<1> Recent changes in deaf education

<2> Changing population

With the introduction of universal neonatal hearing screening (UNHS) in many countries, hearing loss in children is being identified earlier in life than ever before (Van Kerschaver, Boudewyns, Stappaerts, Wuyts, & Van de Heyning, 2007). Many studies to date provide strong evidence of the benefits of early identification and intervention for the development of expressive and receptive language, listening and reading skills and for social and emotional development (Moeller, 2000; Yoshinaga-Itano & Sedey, 2000; Yoshinaga-Itano, 2006; Kennedy et al., 2006; Vermeulen, van Bon, Schreuder, Knoors, & Snik, 2007; Watkin et al., 2007; Verhaert, Willems, Van Kerschaver, & Desloovere, 2008; Philips et al., 2009; Niparko et al., 2010; Boons et al., 2012; Dettman, Wall, Constantinescu, & Dowel, 2013).

Greater numbers of deaf children are receiving cochlear implants (CI) to improve their hearing skills substantially: in Flanders, the Dutch speaking part of Belgium, 93% of all newborn deaf children receive cochlear implants (De Raeye & Lichtert, 2012). Not only has the rate of cochlear implantation been increasing, the age of implantation has also been falling steadily, and the use of bilateral implants or binaural hearing (CI + conventional hearing aid) is becoming common (De Raeye, Vermeulen, & Snik, 2014). Studies on the effects of cochlear implantation in children show a positive influence on their auditory perception (Kirk, Miyamoto, Ying, Perdew, & Zuganelis, 2000; De Raeye, 2010), speech recognition, speech intelligibility and other aspects of spoken language development (Svirsy, Su-Wooi, & Neuburger, 2004; Schauwers, Gillis, Daemers, De Beukelaer, & Govaerts, 2004; De Raeye, 2010; Boons et al., 2013). Evidence shows that children who receive a CI at a younger age do better
on a range of auditory, speech, and language measures than children who are implanted at an older age (Kirk et al., 2000; Svirsky et al., 2004). Yoshinago-Itano (2006) concluded that early-identified profound hearing loss combined with early cochlear implantation and a high-quality auditory stimulation program results in outcomes that are similar to those of early-identified children with a mild-to-severe hearing loss, using conventional hearing aids.

Separate to the importance of early screening and early implantation, the heterogeneity of the population of deaf children is another major factor emphasized in the research literature. In addition to factors associated with the cause of the hearing loss (maternal illness, child infections, toxins, syndromes, …) itself influencing the outcomes, there is also huge variability in early auditory, linguistic, family and educational environment.

In recent literature, 30 to 40% of deaf children are reported to have additional disabilities (Fortnum, Marshall, & Summerfield, 2002; Nikolopoulos, Archbold, & Gregory, 2005; Verhaert et al., 2008). The main reason for the increase of this group is the fact that more extremely preterm babies survive. In the USA, 80% of babies born at 26 weeks (extremely preterm) and 96% of those born between 28 and 31 weeks (very preterm) survive. The risk of hearing loss or other additional disabilities is three to four times higher in this group in comparison to the general newborn population (National Center for Health Statistics, 2008). The EPICure study, which has followed all children born prematurely in England in 1995, found that, at age 6 years, over 50% of children born very or extremely premature survive with disabilities (Johnson et al., 2009). Even premature children who do not show apparent difficulties early in life have persistent and mildly poorer grammatical skills and verbal working memory (Lee et al., 2011).

In the early years of cochlear implantation, children with additional disabilities were not candidates for CI. The number of children with additional disabilities receiving CIs has now increased substantially (Meinzen-Derr, Wiley, Grether, & Choo, 2011), although outcomes
are often poorer than for children with no additional disability (Geers, Nicholas, & Sedey, 2003; Duchesne, Bergeron, & Sutton, 2008; Boons et al., 2012).

Many deaf children are raised by parents whose first language is not that of the country in which they are living in, or who may speak multiple languages proficiently. Some of these children are born in the country where they are educated, others (parents changing work conditions, refugees) enter the local educational system during their school years. In these situations, hearing children will learn their parents’ first language, as well as the national language. Studies of young implanted deaf children (Robbins, Green, & Waltzman, 2004; Boons et al., 2012; De Raeve, Vermeulen, & Snik, 2014) showed that multilingualism in the family, often in combination with low social economical status (SES) of the parents, was related to lower language and verbal cognition scores even when taking into account their knowledge in both languages.

This all implies that the range of educationally relevant individual differences is large, much larger than it would be in a population of hearing children (Swanwick & Marschark, 2010).

<2> Adapting our communication approaches to the changing population

For this heterogeneous population, there is not a one-size-fits-all approach which meets the needs of all deaf children and their families. A combination of communication approaches may be used and modified over time depending on the needs of the child and his or her family. The language and communication approaches and strategies for a young implanted deaf child may be different from those for a child obtaining an implant when he or she is older and at a later stage of language development (Archbold, 2010). The challenge is to develop effective strategies for identifying which option is best at a specific moment for a specific child (Leigh, 2008).
We have to recognize that the improved auditory experiences provided by cochlear implants over hearing aids has facilitated the acquisition of spoken language in children with profound deafness, not only for those in oral educational settings, but also for those in total communication (TC), and sign bilingual approaches, although also these results are very heterogeneous (Geers, 2006).

With regard to these different communication approaches, there are many reports of children attending oral communication programs achieving higher speech perception and language scores than children in total communication settings (El-Hakim et al., 2001; Geers, Nicholas, & Sedey, 2003; Moog & Geers, 2003). Chin and Kaiser (2002) found that children educated through oral communication had better articulation than did those educated through TC. This is confirmed by Tobey and co-authors (2003) who found teaching methods that emphasized speaking and listening to be the most influential factors in determining speech production development in implanted deaf children. Percy-Smith and colleagues (2012) found significant regional differences in speech and language outcomes after CI in Denmark, based on their rehabilitation approach. Although the age of implantation and the level of audition were comparable between the group from West and from East Denmark, there were significant differences on all speech and language tests in favor of children with implants from East Denmark. Further analysis of the data showed that these differences in speech and language outcomes could be explained by the fact that the parents from West Denmark were less involved in the auditory rehabilitation of their children and they were using more signs and less spoken language. It is also remarkable that in the West, the children had even more individual speech therapy and more learning support assistance yet the children from East Denmark scored more highly on speech and language measures.

Comparable results were found in a study by Wiefferink and colleagues (2008) in which they compared children using cochlear implants in a spoken monolingual environment in Bel-
gium with a group of children from the Netherlands in a signed bilingual environment. In this study the auditory perception, speech intelligibility and spoken language development were also better in the monolingual spoken language environment. These authors also concluded that despite possible alternative explanations, such as better residual aided hearing before implantation or more professional support, it is plausible that the differences are partly caused by the linguistic environment.

In contrast with the above studies, other but fewer research findings indicate that children with CIs educated with some form of sign language have significantly higher vocabulary levels than those educated orally (Robbins, Bollard, & Green, 1999; Connor, Hieber, Arts, & Zwolan, 2000). Some studies suggest that when signs support spoken words, they do not hinder the auditory speech perception in children with cochlear implants. On the contrary, in both the perception of perceptually confusable words (Giezen, 2011; Giezen, Baker, & Escudero, 2014) and in reading comprehension (Spencer, Gantz, & Knutson, 2004) children using cochlear implants appear to benefit from the availability of bimodal input. This is confirmed by Davidson, Lillo-Martin and Pichler (2014), who investigated the spoken English language skills of 5 deaf children with CIs having deaf signing parents. These children receives exposure to a full natural sign language (American Sign Language, ASL) from birth, in addition to spoken English after implantation. The researchers compared their spoken language skills with those of hearing ASL/English bilingual children of deaf parents and concluded that natural sign language input does no harm and may even mitigate negative effects of early auditory deprivation for spoken language development. Tait (2003) found that children who are good communicators before implantation, whether gestural or vocally, are likely to have good speech perception abilities in later years after implantation.

Mayer and Leigh (2010, p.177) in discussing sign bilingual programs, state that “the key point is that there is no data to suggest that, as a group, students in bilingual programs are
achieving at the age-appropriate language and literacy levels that were predicted when biling-
gual models were first implemented and that for the first time in history, spoken language has
become accessible as the first language for many, arguably the vast majority of profoundly
deaf children.”

Wheeler and Archbold (2009) described the communication journey of parents, based
on parent interviews. Prior to implantation parents wanted the most effective form of commu-
nication, which (for 95% of the hearing parents) was spoken language with or without some
signed support. Following implantation parents reported a reduction of signed support as spo-
ken language developed through increased access to speech through audition. Later parents
and young deaf people themselves showed interest in the use of some sign support or sign
language itself, once spoken language had been established. So parents recognize that differ-
ent approaches may be appropriate at different times or in different settings. These young
people using the latest technology report being both ‘deaf’ and ‘hearing’ (Wheeler & Arch-
bold, 2009). These deaf children and young people are functioning neither as those with a
significant hearing loss did in the past, but nor quite as hearing children.

<2> Changing educational placement

The current heterogeneous population of deaf children is educated in a variety of settings us-
ing a variety of communication approaches. Although there is variation in outcomes, more
children with implants are going to mainstream schools and use spoken language as their pri-
mary means of communication (Archbold & Mayer, 2012). Regular education is now consid-
ered to be a realistic option for the majority of children using cochlear implants with normal
learning potential, by both parents and professionals. Many parents hope their child will be
able to attend a regular school in their home environment to be part of their community, with
siblings, neighbors and classmates. However, we do not know whether the expectations of the
parents and professionals are always realistic, knowing the amount of deaf children (and families) with special needs (Nikolopoulos, Archbold, & Gregory, 2005).

For many of these children their speech perception in quiet is often excellent (Kirk et al, 2000), but speech perception in noise is known to remain difficult for children with (unilateral) cochlear implants (Dunn, Tyler, Oakley, Gantz, & Noble, 2008). The excellent levels of speech intelligibility typically achieved by those implanted early in life may mask their language delay or difficulties in the more complex grammatical and pragmatic communication skills required in the classroom (Archbold & Mayer, 2012). Although they may have access to greater levels of spoken language through hearing than ever before, they continue to require support as learners in the classroom.

<1> Natural learning

There are two crucial milestones in language and development of verbal cognition in both hearing and deaf children.

First of all there is the development of joint attention around the age 8-12 months, in which children start to look actively at another person’s intention. Caregivers play a crucial role in learning to interpret linguistic symbols as referring to the focus of joint attention. They talk about things the child is looking at. Hearing children are able to look at the object the adult is talking about, while listening to the adult. This combined input results in comprehension of the language of the adult. In the past, profoundly deaf children with conventional hearing aids had difficulty achieving joint attention through audition, because they had no or unclear auditory input. If one wanted to accomplish joint attention in these situations, it was important to bring the object one was talking about into the visual field between the adult and
the child and to support the spoken language with signs or use sign language (Loots, Devise, & Jacques, 2005).

Nowadays most children receiving cochlear implants early in life have the auditory skills to achieve joint attention as typical hearing children do. With access to audition given by the implant, the child can receive the spoken language input at the same time that he is looking at/playing with the object, rather than having to divide attention between the object and the (subsequent) communication (Tait, De Raeve, & Nikolopoulos, 2007; Tasker, Nowakowsk, & Schmidt, 2010). So now it is possible for hearing parents of deaf toddlers to do what comes most naturally to someone caring for the very young: to supply the language for whatever is occupying the child’s attention at any one time, without having to attract their visual attention all time (Tait et al., 2010). If this auditory joint attention is not possible, for one reason or the other, we still have to use additional visual communication strategies (Loots & Devisè, 2003).

Secondly, 80 to 90 % of the vocabulary of normal hearing children is learned incidentally (Gillis & Schaerlaekens, 2000). This incidental or random learning refers to unintentional learning occurring at any time and in any place, usually by overhearing conversation. Children need good auditory conditions to stimulate and develop the cognitive skills needed for incidental learning. Children using cochlear implants and who have good binaural hearing skills are often able to hear speech from distance and in challenging listening situations, which are precursors to incidental learning (De Raeve, Vermeulen, & Snik, 2014). These auditory incidental learning precursors can be assessed by Tait’s Non-Looking Vocal Turns (NLVT) (Tait, De Raeve, & Nikolopoulos, 2007). Incidental learning and better access to spoken language also stimulates the development of executive functions, theory of mind (Wiefferink, Rieffe, Ketelaar, De Raeve, & Frijns, 2013), pragmatic skills (Boons et al., 2013) and cognitive development (Pisoni & Cleary, 2003). To enable incidental learning, the ideal
acoustic environment for children with a hearing loss would have minimal background noise and low level reverberation with a signal-to-noise ratio of +15 dB, i.e. the speech is 15 dB louder than the surrounding noise level (Boothroyd, 2004). Assessing speech perception in noise and at a soft speech intensity of 45 dB HL is advised (De Raeve, 2014).

It is important that deaf children access incidental learning for language, verbal cognition and social emotional development. This can be on an auditory basis by picking up spoken language from the environment, or visually by picking up sign language from the environment. To enable this to happen, all children should have fully accessible language and communication during the sensitive period for linguistic development at home and in school (Leigh, 2008). Before the time of CI, deaf children from deaf families may have had an advantage in access to incidental learning (Brackenbury, Ryan, & Messenheimer, 2006). Now it is also possible for deaf children from hearing families (95% of the deaf population), especially for those wearing bilateral CI’s or having bimodal hearing early in life, giving them good access to auditory information. (De Raeve, Vermeulen, & Snik, 2014).

Binaural hearing

In recent years increasing numbers of deaf children are receiving bilateral CIs (Litovsky, Jones, & Agrawai, 2010; Sparreboom et al., 2010; De Raeve, 2014) with benefits shown for localization of sound (Beijen, Snik, & Mylanus, 2007; Greco-Alub, Litovsky, & Werner, 2008; Van Deun et al., 2009), the perception of soft speech (De Raeve, Vermeulen, & Snik, 2014) and speech discrimination in noise (Kuhn-Inacker, Shehata-Dieler, Muller, & Helms, 2004; Litovsky et al., 2006; Dunn et al., 2008; De Raeve, Vermeulen, & Snik, 2014).

When interviewed, young deaf learners using mostly unilateral CI’s reported that listening in groups and listening in noise in school can be extremely challenging, and resulted in missing important parts of lessons or instructions (Wheeler & Archbold, 2009). As CI-users wearing
bilateral devices achieve better speech perception in noise, one might expect that these students may have a little less difficulty than previously in an educational setting. Being able to use both ears enables easier location of the speaker and hence greater likelihood that they will understand speech in a mainstream educational setting.

Historically, the consequences of hearing with one ear only, called unilateral hearing loss (UHL), have been underestimated. Children with UHL, show language delays in preschool (Borg, Edquist, Reinholdson, Risberg, & McAllister, 2007), more academic failure (22-35% rate of repeating at least one grade) and have additional need for educational assistance (12-41%) (Lieu, 2004). Parents and teachers reported persistent behavioral problems and academic weaknesses or areas of concern in about 25% of children with UHL (Lieu, Tye-Murray, & Qiang Fu, 2012). The same challenges may occur in children unilateral hearing through a cochlear implant (Spencer, Gantz, & Knutson, 2004; Boons et al., 2012).

The positive effect of binaural hearing is demonstrated by Tait and co-authors (2010) who showed significantly more use of vocalization to communicate, and more use of audition when interacting vocally with an adult in bilaterally implanted infants compared to the unilateral ones, and by a recent study of De Raeve, Vermeulen and Snik (2014) which shows that these binaural ‘hearing’ deaf children can acquire complex spoken language and verbal cognition skills age equivalent to their hearing peers at 5 years post CI.

Suggestions regarding checking the hearing devices

The most important issue for these children using digital hearing aids or cochlear implants is the correct functioning of these devices. Devices have to function all the time and should be repaired as soon as possible in case of a problem. Deaf learners should be empowered to take care of the devices themselves. For younger deaf children, parents and educators need knowledge regarding trouble shooting in case these devices break down. The following sug-
gestions for parents and teachers are meant to optimize the functional use of amplification devices:

- Check amplification daily to ensure that it is working properly;
- One frequently used procedure to check the child is able to hear all the sounds of speech, is by completing the Ling 6 Sound Test: the teacher says each of the six sounds (oooh, aaah, m, sh, ee, s) at 4 feet (1.2 m) distance in random order, varying intervals, and presenting the sound as it would appear in speech, at normal speaking volume (60 dB SPL) and length of sound. The sound is presented through audition alone, without speech reading cues. The child imitates the sound that is heard or points to a picture which represents the sound.
- Consult resource personnel (hearing aid manufacturers, CI-companies, CI-teams,…) to determine proper procedures for daily device checks;
- Be alert for the flashing (alarm) lights of the hearing device, which give feedback on the functioning of the hearing device;
- Contact your audiologist or CI fitting team to learn about troubleshooting and care of the hearing device, which can be different from device to device;
- Consult the manufacturers websites for maintenance and troubleshooting guides;
- It is beneficial to have some spare materials (e.g. cables, batteries) on hand at home and school and have the clinic phone number/email address available;
- Avoid exposure to moisture or dust and ensure any long cables are worn beneath clothing;
- Try to repair device problems as soon as possible so the child does not miss important language and learning opportunities.
<1> Classroom learning

<2> Changes in classroom learning

This new population of deaf children (early screened and early fitted (binaurally) with hearing aids and/or cochlear implants) are not functioning as deaf children in the past, but neither do they function as hearing children.

Success at capturing information in the classroom and assimilating it into learning relies on an intertwined set of language, cognitive and social skills. These include joint attention, working memory, executive function, theory of mind and pragmatics. These skills are typically present to a high level in hearing children’s psychology when they arrive for the first time in the classroom, but were often absent or delayed in children with a hearing loss. Recent research shows that some early screened and young bilaterally implanted children are able to acquire these skills age equivalent to their hearing peers, but there is still a huge variability in outcomes, which confirms again the heterogeneity of the population (Leigh, 2008; Beer, Kronenberger, & Pisoni, 2011; Boons et al., 2012; Ketelaar, Rieffe, Wiefferink, & Frijns, 2012).

Learning also varies from grade to grade (Bednar, 2005). Preschool and kindergarten classrooms are busy and noisy places. Children learn to share toys and materials, work in small groups, and often relate to more than one adult. There is a lot of language input from the environment which means that a lot of incidental learning can take place. In the lower elementary grades, making friends, planning games and solving conflicts through negotiation requires sophisticated social language skills. Children learn to listen to the teacher for a longer period of time (training their attention span), learn to work in a small group, where discovery takes place in joint discussions. They are expected to master reading and writing skills. In the elementary upper grades, children sometimes change classes and teachers and they are ex-
pected to read the information and to write for self-expression. A foreign language may be introduced and current events are discussed. At secondary level, children change classes and teachers nearly every hour and some of these class groups can be very noisy. Depending on their curriculum more foreign languages or vocational training may be introduced and a lot of discussion groups and group work take place. Teachers talk a lot and write less on the board. All this is very hard for most deaf learners, even for those wearing cochlear implants (Archbold, 2010; De Raeve, 2014).

In addition to the differences in learning from grade to grade, there are also differences between special schools and regular schools. Special schools should be more adapted to the needs of deaf children: have fewer children in one class, more individual teacher support, better classroom acoustics, use of assistive listening devices, more visual support, individual therapy, and better communication and interaction with the students. Although in reality it seems this is not always the case. On the other hand, more and more deaf children are now educated in mainstream settings than in special schools or special classes for deaf children.

Suggestions regarding good communication techniques

- Face the student and be in close proximity (3-5 feet/1-1.5 m);
- Encourage students with a hearing loss to seat themselves toward the front of the room and slightly to the side where they will have an unobstructed line of vision of the teacher, but can also see some of the students. This is particularly important if the student is using an interpreter, lip-reading, relying on visual clues or using a hearing aid which has a limited range;
- Speak clearly and at a slow/moderate level and pause after asking a question to allow the student processing time;
• Give clear indications of the topic of conversation and alert the student to a change in topic;
• Gain the student’s attention prior to giving directions before speaking;
• Stand in one place if possible and don’t walk around all the time;
• Avoid speaking while writing on the board;
• Beards and moustaches can make speech reading more difficult, keep beards and moustaches trimmed and keep hair, pencils and hands away from the mouth when speaking;
• Use facial expressions, body language, gestures, etc. when appropriate;
• Rephrase (rather than repeat) message if the student has difficulty understanding;
• In tutorials, assist students who lip-read by having the student sit directly opposite you and ensure, if possible, that they can see all other participants. Control the discussion so that only one person is speaking at a time and echo back comments from students;
• If the student is just wearing one hearing device, sit on the same side as the child’s hearing device;
• Use a FM (frequency modulation) or induction loop hearing system if available in the classroom (see 3.3. Classroom Audio distribution Systems);
• Use a sign language interpreter or notetaker (see 3.4. visual support).

<2> Speech perception in a classroom

Classrooms are intended for learning and most of that learning is mediated by speech, especially in regular schools, the place most of our current population of deaf children are educated. Boothroyd (2012) states that if these assumptions are correct, students in a classroom need to hear speech clearly, both the speech of the teacher and the speech of the other students. The
amount of information in a talker’s speech that actually reaches the ear of the listener depends on the intensity and the intelligibility of the talker’s speech but also on the acoustic properties of the room. Poor acoustics can undermine the very purpose for which the classroom was intended. The effect of poor acoustical environments is seen in decreased speech perception in typical hearing children with auditory processing disorders, hyperactive behavior, auditory neuropathy, second language learners and in children with a hearing loss (Whitelaw, 2004).

Perfectly clear hearing is difficult to achieve. Fortunately, there is a high level of redundancy in spoken language. It is generally assumed, for example that hearing adults can function adequately when only around 60 percent of the useful information in speech is available (Smaldino & Flexer, 2012). However, this requires that the listener takes full advantage of mature language knowledge and processing skills. Performance will break down if the language becomes more complex and unfamiliar.

This is not the case for children, who are acquiring language and who do not have mature language proficiency. They are not able to take full advantage of context and they do not have the mature speech processing skills that might enable them to keep pace with the talker while absorbing the meaning of what is being said. Also much of the language used in a classroom is unfamiliar. For that reason, Boothroyd (2012) concluded that children in a learning environment have to receive 90 to 100 percent of the useful information carried by the sounds of speech. He also describes three main enemies of good speech perception – distance, noise and reverberation.

The first of these is distance from the talker. As speech sounds travel away from the talker, 6 decibels (dB) of amplitude is lost for every doubling of distance. A listener who is standing at a distance of 3 meters (10 feet) might perceive speech at an average level of 56 dB sound pressure level (SPL), but a listener at a distance of 6 meters (20 feet) would hear the same speech at a level of only 50 dB SPL. In open air at 40 feet (12 meters) it is perceived as
only 44 dB SPL. Inside a classroom this 6 dB rule applies up to a certain critical distance and then the level of sound is determined by reflected sound and remains fairly constant in spite of increasing distance. So the same speech can still be perceived at 50 dB SPL at 40 feet (12 meters) inside a classroom. Although the intensity of the speech can be the same, the quality of the speech signal is poorer because the sound is being reflected via wall and ceiling (Smaldino, 2011).

Secondly, classes tend to be very noisy places. To avoid speech being obscured by noise, the average level of speech needs to be at least 15 dB above that of the noise (Boothroyd, 2012). Consider a classroom with background noise of 55 dB SPL (which is not unusual) and the teacher’s speech of 60 dB SPL (+ 5 dB SPL above the background noise) it is likely that only 50% of the speech will be perceived, which is far below the criterion of 90 to 100 percent audibility, required by children for understanding speech in a learning environment. In addition to preventing audibility of information in the speech signal, noise can be distracting. This is especially the case if the noise carries interesting (speech) information. Individuals differ in terms of their ability to ignore distractions and focus attention on a specific talker. Distractible students with a hearing loss, and students with an attention deficit hyperactivity disorder (ADHD) may require a speech to noise ratio that is higher than 15 dB (Taub, Kanis, & Kramer, 2003).

A third enemy of good speech perception is reverberation in the classroom, that is the persistence of sound in a room because of multiple, repeated reflections from the room’s surfaces. At each reflection some of the sound energy is absorbed, and the strength of the reflected sound is reduced. As a result, by the time it reaches the listener, the reflected sound is weaker than that traveling directly from the talker. We measure the persistence of sound in a room in terms of reverberation time - the time it takes for the sound level to decrease by 60 dB after the sound stops. A reverberation time (RT) of 0.25 seconds means that it takes the
speech sound 0.25 seconds to fall by 60 dB. A reverberation time up to 0.5 second is still reasonable, but when it comes closer to one second the sound quality may be poorer due to the late reflection of sound (Boothroyd, 2012).

Hard surfaces such as ceramic tile, plasterboard, glass and varnished wood are efficient sound reflectors. Other surfaces such as carpeting, acoustic tiles, curtains, and clothing absorb most of the sound hitting them. Room size also affects reverberation time. In a large room the sound has to travel farther between reflections. As a result, it takes longer for sound to be absorbed at the reflecting surfaces. In a small to medium-size classroom, these guidelines call for a maximum noise level of 35 dB SPL and a maximum reverberation time of 0.6 second. These specifications are for an unoccupied room. Ones the room is occupied, the RT will be somewhat lower because of sound absorption by the children and their clothing. So the goal of standard norms for deaf learners is to attain at least a 15 dB speech-to-noise ratio and a reverberation time of less than 0.6 seconds (ANSI, 2002).

Despite these standard regulations for noise and reverberation levels for educational settings, the reality is that mainstream kindergarten or educational settings are often very noisy and the reverberation is high. An example reported by Buch and Fielding in 2001, showed that noise in a kindergarten at 11 of 14 daily educational situations that were measured, reached peak levels intensities over 80 dB SPL. This occurred not only in the situations expected to be noisy: collecting children, free play time and eating, but also during painting-drawing, in circle time sessions when children were having a conversation together on a certain topic, noise levels were high.

Many children achieve excellent speech perception in quiet and teachers may underestimate the difficulties they have listening in noise. Children do not have the sophisticated auditory or language skills to ‘fill in the blanks’ where auditory information is missed.
In a study conducted by Taub and colleagues (2003), the influence of classroom acoustics for language learning was studied using the Screening Instrument for Targeting Educational Risk (SIFTER), developed by Anderson (1989). The SIFTER was used to study the effect on children of improvement in the acoustic environment in a kindergarten located in a low socio-economic area. The conclusion of this study was that the risk for language/learning problems decreased significantly when sound field systems, in which a teacher speaks in a microphone and the speech is amplified and distributed through several loudspeakers, are used to improve classroom acoustics.

The effect of poor acoustical educational environments on learning capacity, concentration, listening skills, is known to be detrimental for typical hearing children, and even more so for children with a hearing loss whose speech perception decreases more in poorer acoustic situations than typical hearing children. Numerous researchers have thoroughly documented the negative effects of excessive classroom noise and reverberation levels on speech-recognition ability and educational/social development (e.g. Davis, Elfenbein, Schum, & Bentler, 1986; Finitzo-Hieber, 1988; Crandell & Smaldino, 2000; Johnson, 2000).

<3> Suggestions regarding classroom acoustics

There are lots of things that can be done to improve listening conditions in a classroom (NDCS, 2001):

- Encourage children to maintain a quiet working atmosphere and try to make hearing children aware of various noises that a hearing aid can amplify, such as chairs scraping, doors banging, general chatter, shouting, and dropping objects;
- Avoid placing a deaf child in a noisy part of the classroom. For example make sure they are away from radiators, noisy equipment or windows which overlook busy areas;
- Reduce background noise: close doors and windows to reduce noise from outside;
• Use wall displays to cover and soften large flat surfaces and carpet floors where possible, as this will help to reduce reverberation;

• Where possibly have a ‘quiet’ area within the mainstream classroom that can be used for individual, paired or small group work;

• Have acoustic tiles on the ceiling;

• Modify chairs (i.e. attach soft materials to chair legs) or desk (i.e., felt cloth/rubber cushions) to reduce noise level;

• Remember ANSI-guidelines: signal-noise ratio of +15 dB SPL and reverberation time < 0.6 sec.

• Use Classroom Audio Distribution Systems (CADS).

<3> Classroom Audio Distribution Systems

It is known that all children require a louder signal and a quieter environment than adults in order to distinguish words. Flexer (2004) recommends using of sound distribution systems in every classroom. There is a lot of evidence that the poor acoustics of many classrooms can be ameliorated using classroom amplification systems. Children who are deaf or hard of hearing (D/HH) can be fitted with a personal system. Both sound distribution and personal systems can be used in a complementary way.

Most personal amplification systems used by D/HH students are FM (Frequency Modulation) –systems using a wireless FM transmission, Infrared systems using infrared light for wireless transmission of the acoustic signal or electromagnetic induction loops, by which an amplifier transmits the electrical signal from a microphone to a wire encircling the room. The electrical current flowing through the wire creates an electromagnetic field that can be picked up by a telecoil, which is included in most hearing aids or cochlear implants.
The technology used in CADS is evolving and promises to further improve in the near future. Very recently, as described by Smaldino and Flexer (2012), several manufacturers have started using new ways to transmit sound: digital transmission technology using the 2.4 GHz frequency band, bluetooth technology, automatic noise compensation technology which could automatically adapt the intensity of the speech to the level of the background noise.

The choice of the most appropriate CADS for D/HH students is rather complex and is influenced by many variables: number of students per classroom, acoustic characteristics of the classroom, number and position of loudspeakers in case of a sound-field system, numbers of microphones needed, teaching style, availability of different CADS (FM-systems, Infra-Red system, Electromagnetic Induction Loop system), need for in-service and follow-up maintenance, and possible connections to other amplification devices (such as hearing aids, cochlear implants) by D/HH students. By giving adequate information on all these variables to your audiologist it should be possible for him to guide you in choosing the best CADS. Always try the system for several weeks, used by different teachers in different lessons before buying it. More detailed information on the advantages and disadvantages of various CADS can be found in the ‘Handbook of Acoustic Accessibility’ (Smaldino & Flexer, 2012, p. 72-88).

In addition to speech perception improvement, CADS have been shown to improve literacy skills (Darai, 2000; Flexer, Biley, Hinkley, Harkema, & Holcomb, 2002), social behaviors (Massie, Theodoros, McPherson, & Smaldino, 2004) and improve educational outcomes (Massie & Dillon, 2006; Langlan, Socalingam, Caissie, & Kreisman, 2009). Teachers have reported several benefits of CADS use as well, including reduction in vocal strain, less need for sick leave, and better attentiveness and behavior among students (Sapienza, Crandell, & Curtis, 1999; Edwards & Fuen, 2005).
Other, but fewer studies have noted a lack of benefit from using CADS. Schafer and Kleinek (2009) found that sound-field amplification systems provided no significant speech recognition benefit over cochlear implant use alone, but benefit was seen for direct-audio-input FM systems coupled with CI. Wilson, Marinae, Pitty, and Burrows (2011) reported that sound-field amplification may not be beneficial in acoustically unsuitable rooms such as an open classroom. Finally, Smaldino and Flexer (2008) argue that the provision of classroom amplification should never be regarded as a substitute for appropriate noise control in the classroom.

<2> Visual support

In addition to poor classroom acoustics, there are often few visual cues in regular schools. Teachers should provide deaf children with the visual cues they need to help maintain attention and guide them towards information in order to provide them with full access to instruction. Teachers need to be aware that they should treat the needs of the D/HH students differently in ongoing classroom activities (Knoors & Marschark, 2012). Cawthon (2001) found that teachers in mainstream classrooms directed less communication to deaf children compared to hearing children and were more likely to ask deaf children yes/no questions rather than open-ended questions. Such limitations are a frequent consequence of mainstream teachers’ lack of familiarity with deaf children, sign language interpreters and assistive listening devices (Knoors & Marschark, 2012).

<3> Suggestions regarding visual support

When teaching deaf children, it is important to think visually. Using visual clues and resources will help a deaf child access a lesson and develop their understanding. Using visual materials can give context to a subject or situation.
• If practical, modify classroom seating in a circular pattern. This will allow the deaf student to observe and interact with classmates;

• Make sure that lighting in the classroom is good. If you plan to turn off the lights, for example, to show a video, then consider the best place for a deaf child to sit. Also remember to give any instructions or explanations before you turn down the lights;

• Provide a written summary for videos and films, as they provide considerable difficulties for deaf and hard of hearing students;

• Avoid sitting/standing in front of a light source as this puts your face in shadow and interferes with speech reading;

• Wherever possible, support what you are teaching by using visual clues as well as written texts. Visual clues might include demonstrating a technique, using drama such as acting out a scene from history, using pictures, diagrams, illustrations, objects and artifacts, and showing videos with subtitles;

• Write key words, topic headings or questions on the board or overhead projector. Also smart boards can be very useful;

• Point to the objects or pictures you are using;

• Identify a few key places to stand in the classroom where a deaf child will be able to see you clearly. Don’t walk around all the time;

• Make sure that when you are writing on the white board, that you face the children when you are speaking. This will help them to lip-read, and to see your facial expression;

• Allow time for a deaf child to look at the visual clue before you start talking again, to give them time to focus their attention back on you or the teaching assistant, especially when you use slide shows, data projector, computer or video;
• Provide support staff with copies of schemes of work and lesson plans, and set aside some time to discuss these with them, so that they can carry out pre and post tutoring sessions effectively;

• Have homework tasks written on a sheet which pupils can take home. This is particularly useful for deaf children as they cannot write down the homework and watch you or the support worker at the same time;

• Recognize that some students require the services of an interpreter (sign or oral) or notetaker.

The following tips will make communication easier when using an interpreter (NIH, 2013):

• Always speak directly to the student not the interpreter;

• It is normally best if the interpreter is standing next to the main speaker and opposite the deaf person;

• Provide the student and interpreter with a glossary of new terms before the class to allow them to negotiate appropriate signs;

• If written material is presented, please allow time for the deaf person to read before continuing. Deaf people are unable to watch the interpreter and read at the same time;

• The interpreter always lags a little behind the speaker. Be aware of this. You may have to pause or speak more slowly to ensure the interpreter is keeping up.

<2> Teacher training

The challenge for the field is to embrace the diversity of the current population of deaf learners and to appropriately address the specific needs of each child in his/her family in a specific country. This is particularly relevant to children whose home language is not the national language or those who have additional needs. Just as the population of deaf children has changed very rapidly in locations with access to advanced technology, and as more children attend
mainstream schools, the demand for professional development opportunities and for specialized staff training increases. As Leigh (2008, p.10) suggested, “there is currently more knowledge and skill required of a teacher of the deaf than at any time in the history in the field.” Cochlear implantation has served to expand the range of this diversity within the student population, and of the competencies teachers require in meeting the learner’s needs, which has implications for the teacher and the teacher education program.

Teachers of the deaf also need to know how to manage these new high tech hearing devices and they should be able to teach others how to manage the devices. This can be very challenging given the extensive variety in hearing devices and CADS from different manufacturers, and the rapid changes in technology. Ongoing professional development to teachers of the deaf, already in the field, is also vital (Archbold & Mayer, 2012).

Many support staff start to work as itinerant or peripatetic support teachers immediately upon completing their teacher training with little or no specific experience in educating or supporting deaf children. With more students in mainstream classes, more specialist staff are needed to support them in their mainstream school, while fewer staff are required to educate the smaller population in the special schools for the deaf. The mainstream teachers of the regular schools also need some basic knowledge on children with a hearing loss.

There is also a huge variety in educational training courses to become a teacher of the deaf. Some countries have a very specialized training, but others don’t have a specific training (Lichtert & van Wieringen, 2010).

With higher levels of academic achievement and involvement in mainstream education, rather than teaching a separate curriculum or one designed for deaf learners, teachers of the deaf need to know how to appropriately differentiate the mainstream program for deaf learners.
<1> Summary and conclusion

Universal neonatal hearing screening and cochlear implantation have not only changed the choices for parents but have also changed the early intervention approach, the language and communication approach and school placement.

Deaf children are a particularly heterogeneous population and cochlear implantation has added even more to the diversity, which results in considerable variations in outcomes. All health professionals and educators of deaf children have to be aware of this current change, so that they can provide appropriate support and advice for the diverse group of children, many of whom have additional needs and whose families share complex expectations regarding the educational placement and expected outcomes for their children (Powell & Wilson, 2011).

This huge variability in outcomes necessitates regular documentation of the child's progress in order to monitor device functioning, to inform the tuning process, to monitor progress in language development and learning, to identify additional problems or areas of difficulty, as well as specific abilities and skills. It is of the utmost importance to keep monitoring the classroom performance closely because difficulties may be subtle in mainstream deaf children. The SIFTER has proven to be a useful instrument for this purpose (Vermeulen, De Raeve, Langereis, & Snik, 2012).

As a result of early identification and intervention of hearing loss, early cochlear implantation, and increased belief in inclusion of students with disabilities, there has been a notable increase in the number of deaf students in mainstream schools (De Raeve & Lichtert, 2013). The reality of attendance in mainstream education, contrary to many parents’ expectations, is that mainstream teachers have little or no specific knowledge about deaf learners; in addition speech perception in regular schools can be poor, hindered by a noisy classroom environment. It is desirable that schools follow ANSI guidelines recommending a maximum
noise level of 35 dB SPL, a maximum reverberation time of 0.6 sec and at least a 15 dB speech-to-noise ratio (ANSI, 2002).

Teachers of the deaf need to know how to manage new highly technological hearing devices (cochlear implants, FM-systems, digital electromagnetic induction loop systems, classroom audio distribution systems, Bluetooth,…), and be able to teach others (classroom teachers, educational assistants, …) to manage the technology. This can be a challenge given the range of technologies and devices they will encounter, and the rapid pace at which the technology changes. Therefore heightened emphasis on technology and on classroom acoustics in teacher training is warranted. To guarantee a high standard of education for all students with a hearing loss the outcomes of research need to feed back into the development of training courses, in order to inform good practice. Ongoing professional development to teachers of the deaf already in the field is vital.

In addition to the poor listening conditions, there are often few visual cues in regular schools. Children may have relatively good speech intelligibility and appear to have good basic conversational language skills, but lack the depth of language demanded in an academic situation. Visual cues can not only increase language comprehension, but may also create a longer attention span.

Newborn hearing screening and cochlear implantation have provided new opportunities for profoundly deaf children, have changed their educational choices and options, and as a consequence created new challenges for teachers of the deaf. Teachers need to increase their expectations regarding what deaf children can achieve. They have to adapt their way of working and ensure that they have the skills to meet the challenges. Teachers need to be flexible and continually updated with the technology and changing expectations. They need to be able to provide (auditory and visual) classroom adaptations to create a fully accessible learning
environment. They also need to meet the psycho-social needs of this group as they grow through adolescence. And finally teachers need to be able to work with other professionals.

The challenge for the field is to embrace the diversity of this population of deaf students and to appropriately address the specific needs of each child in his/her family in each specific country. As the population of deaf children has changed very rapidly in locations with access to advanced technology, and as more children attend mainstream schools, the demand for effective teaching in the classroom, for professional development opportunities, and for specialized staff training is higher than ever before.
<1> References


