Exploring the Impact of Wireless Group Aid (WGAS) Technology on learners in the classroom

A study submitted in partial fulfilment of the requirements for the degree of Master of Science of the University of Hertfordshire

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Contents

List of tables

List of figures

Abbreviations

Table 1 Abbreviations

Abbreviation	Term
ALD	Assistive Listening Devices/ Technology which for the purpose of this research includes Radio aids and Personal Wireless Systems
Amplifier	multiple mixer unit
BAEA	British Association of Educational Audiologists
BAHA	Bone Anchored Hearing aid
BATOD	British Association of Teachers of Deaf Children and Young People
CI	Cochlear Implants
CRIDE	Consortium for Research into Deaf Education
CYP	Children and young people
DM	Digital Modulation (2.4GHz)
Ed Aud	Educational Audiologist
EM	Electromagnetic Induction
FM	Frequency Modulation (216-217MHz)
GA	Group Aid
GA	Group aid
HA	Hearing aids
HAT	remote microphone hearing assistance technology
HL	Hearing loss/ level of deafness
IR	Infrared
Mini-mic	Cochlear Wireless Mini-microphone 2/2+
NDCS	National Deaf Children's Society
NDCS	National Deaf Children's Society
RAS	'Radio aid' or 'FM radio aid systems or ALD
SEN	Special Educational Needs
SFS	Soundfield Systems
SiN	Signal in noise
SNR	Signal-to-Noise Ratio
Streamers	proprietary wireless devices
TA/ TAs	Teaching Assistant/ Teaching Assistants
TCA	Thematic Content Analysis
Testbox	Fonix FP35 hearing aid analyser (FP35)
ToD	Teacher of the Deaf
UHL	Unilateral hearing loss
USP	Unique selling point
WGA	Wired Group Aid
WGAS	Wireless Group Aid System
WDRC	Wide Dynamic Range Compression

Terminology

Table 2 Glossary

Term	Definition
2.4GHz	License free frequency band used for wireless transmission including proprietary streaming, Bluetooth and microwaves.
Amplifier	Compact audio mixer which enables the gain to be adjusted.
Bluetooth	Bluetooth is a wireless technology that uses a radio frequency to share data over a short distance' There a number protocols for data and audio. The higher up the number, the more modern. SIG overseas standards for Bluetooth (Harris, 2023).
Cochlear Implant	'An electronic device that stimulates the auditory nerve through electrodes placed in the cochlea' (Oxford, 2023).
Compression	Reducing the wide dynamic range To preserve the natural speech through the wireless audio system.
Deafness or hearing loss	'When one or more parts of the ear aren't working effectively' (NDCS, "What is deafness?", 2023).
DM protocols	Wireless connectivity with hearing assistive devices operating on 2.4GHz frequency band which is designed for public.
Flight mode	All hearing aids and processors with the streaming technology have the function to switch off (legal requirement). This is sometimes referred to as flight mode. It can be activated by pressing a button on the hearing instruments. For Phonak hearing aids, 'press the lower part of the button for 7 seconds while closing the battery drawer.' This will turn the streaming facility off. To switch back on the battery drawer simply needs opening (Harris, 2023).
Frequency Response Curve	A graphical representation of the hearing aid output (Starkey, 2017).
Gain	The amount of amplification applied to the input signal (dB) (Starkey, 2017).
Group aid (GA)	A Group aid works on the same principle as an Assistive listening device but also enables the pupil to hear themselves and their peers as well as the teacher
Hearing aids (HAs)	Sound amplifying devices designed to help people who have a hearing loss with microphone to pick up sound and amplifier circuitry that makes the sound louder. (FDA, 2023).

Inclusion	Making the school a strong part of the local area's provision for CYP who have SEN and/or disabilities (Gov.UK, 2023).
Infrared	Infrared assistive listening systems, send signals via invisible light beams (Ward, 2023). Thus need a direct line of sight.
Inverse square law	Doubling of the distance from a noise source reduces the sound pressure level with 6 decibels.
Juno	FrontRow Juno SFS
Level of deafness/ level of hearing loss	A level of deafness is identified as hearing thresholds of less than 20dB in one or both ears' (CRIDE, 2021).
M mode	Microphone setting on hearing aid.
Monitor Speaker	A speaker for hearing staff to access WGAS which is the Juno SFS speaker in this research
Pairing	The connection between the student's personal amplification and the proprietary streamer.
Personal amplification	Term used to describe personal hearing instruments (Cochlear Implant processors, Hearing aids and BAHAs).
Processor	Cochlear Implant Speech processor.
Proprietary definition	Relating to ownership in the case of a product it is marketed and protected by a registered trade name (Oxford, 2023).
Proprietary protocols	Practices designed and created by one manufacturer.
Proprietary wireless protocol	All use 2.4GHz wireless but how they communicate is specific to the brand (Phonak, Cocheal and Oticon in this research).
Propriety Streamers included in the study	Oticon, Phonak and Cochlear streamers lock into one channel and stream on that channel.
Rebroadcasting	Rebroadcasting is when the RAS and SFS are connected together via an audio output lead. The signal from the SFS transmitter is sent directly to the student's personal amplification via the RAS (Atkin, 2017).
Roger frequency modulation	Roger 'hops randomly around in the 2.4-GHz band'. This is the method Phonak Roger uses as it is crucial when multiple Roger products are used in a setting to ensure channels do not interfere. However, it can cause interference if it 'hops' onto or near a fixed channel frequency.
Signal-to-noise ratio	The ratio between signal and background noise.
Soundfield system (SFS)	SFS can help improve classroom listening conditions by 'increasing the level of the teacher's speech compared to the background noise throughout the classroom' (Mealings, 2022).

Streaming	For the purpose of this dissertation the word streaming is describing the connectivity between the personal amplification and the proprietary wireless TV streamers (Cochlear TV Streamer, Phonak TV Connector and Oticon TV Adaptor).
T mode	Telecoil setting on hearing aid.
Total Auditory Integration (or “Patching)	Enables multiple audio sources to be connected at one time, so the student with hearing loss can hear the teacher’s voice, other students’ voices, and audio from multimedia sources.
Wide dynamic range	The ability to hear quiet sounds audibility and loud sounds more comfortably
Wired Group aid	Group Hearing aid which is hard wired and connects the students to the system with wired connections.
Wireless	No wires.
Wireless Group aid system	Group Hearing Aid connecting students wirelessly.
Wireless protocols	Within the wireless technology there are protocol that the manufacture has to abide by (Harris, 2023).

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Abstract

Aims: The intention of this study is to explore the wireless technology adaptations to Mary Hare's Group aid (WGAS), a previously hard-wired system in a school for the deaf[1]. It focuses on how infrared (IR) microphones and proprietary streaming technology can enhance the learning environment for both students and teachers within the classroom.

Background: For over 30 years, Mary Hare School has had a wired Group aid system (WGA). Adaptations have been made during this time (Appendix I). Following recent developments in personal amplification, hardware issues and the Coronavirus pandemic, a need to update the system was identified (Appendix II). Phonak (2015) highlighted that, 'despite significant advances in hearing instrument technology over the last 15 years, patients continue to struggle when listening over distance and in background noise' and while there have been many further updates in technology since then, hearing aids (HA) and cochlear implants (CI) still cannot restore normal hearing.

Research: There has been a lack of research specifically into Group aid systems and the benefits of students being able to hear their peers as well as themselves and the teacher. However, there has been a significant amount of research and marketing on remote microphone technology: Phonak FM and Roger networks. This study will, therefore, focus on the needs of students in the classroom and how the wireless adaptations benefit the users.

Methods: A mixed methods approach, using quantitative and qualitative data, was chosen. 27 staff and 56 students' viewpoints were included in the study. A combination of questionnaires, semi structured interviews and observational data was collected to form a case study.

Results: Both quantitative and qualitative results identified positive responses to the WGAS wireless adaptations (streamers and microphones) as well as concerns

[1] Mary Hare caters for students aged 5 to 19 years

and solutions. Including staff in addition to students in this study enabled greater depth of understanding of the impact of the adaptations. Simplicity, ease of use, clarity of sound, hearing everyone and being cued into listening were highlighted.

Consequently, WGAS needs to be compatible with student personal amplification. For this study, Cochlear, Phonak, Advanced Bionics and Oticon products have been used. Findings have been largely positive and while the system needs time to embed, evidence would suggest that both streaming technology and wireless microphones have improved the Group aid.

1 Introduction

The Mary Hare Wireless Group aid (WGAS) enables all students to hear their peers and themselves as well as their teachers. To explore the impact of wireless Group aid (WGAS) technology on learners in the classroom, students and staff were surveyed through questionnaires and interviews. The wireless adaptations enable students to have wireless access at ear level to WGAS as well as contributing to lessons through their own personal wireless microphone.

1.1 Background

Mary Hare is the largest school for the deaf in the UK (BATOD, 2018). The school prides itself in enabling all students to connect to WGAS regardless of the type of personal amplification they wear (Clements, 2023). An auditory/oral approach is used at Mary Hare to maximise pupils' use of residual hearing and listening skills (School, 2020) through students using their personal amplification Within the school, there are students with HA, CI and BAHAs as well as a combination. The students come from all over the country and are seen by multiple Audiology departments and Implant centres. CRIDE (2022) identifies, '3% [of deaf children] attend special schools for deaf children[2]. While Najeeb (2022) identifies that there have been numerous updates in Hearing aid (HA) technology, including: speech enhancements, noise reduction, microphone focus,' Thibodeau (2020) highlights how HAs are often insufficient for optimal communication between a listener and a talker'. Thus, students having access to WGAS enables streaming to optimise the signal-to-noise ratio (SNR).

1.2 Group aid (GA) Definition

The first GA was designed over 30 years ago. It was based on Ross (1973)'s ten 'general principles underlying the utilisation of amplification systems in any

[2] A level of deafness is identified as hearing thresholds of less than 20dB in one or both ears' (CRIDE, 2021)

educational environment' for deaf children. These included the importance of 'the child's own utterances must be clearly available' Ross (1973) to enable them to develop optimal speech and the need to always optimise SNR. To enable WGAS to remain a GA, it needed to also comply with these original rules.

1.3 WGAS adaptations

Students attend Mary Hare from all over the UK, with differing levels of deafness and personal amplification, thus WGAS needs to ensure: access for all, flexibility to adapt to future models of personal amplification, ease of use for staff and students, robust and affordable.

Different types of technology were investigated with the intention of providing a system which meets student needs considering the technological advances without losing the core ethos of the school. The propriety wireless devices, using the license-free 2.4GHz[3] to stream, working directly with the user's personal amplification and wireless Juno student microphones were chosen and will be addressed in this study.

1.4 Summary

In order to explore the impact of wireless technology in the classroom, volunteers completed questionnaires and talked about their experiences of WGAS. The aim of the research is to provide a detailed assessment of the impact of the wireless adjustments on the Group aid. Thus, the Literature review will reflect the factors impacting learners in the classroom environment and educational amplification which can support them.

[3] See definition in Table 2: Terminology

2 Literature review

2.1 Searches

Limited research has been published on GA systems. Hardwired GAs have been used in schools for the deaf previously, however, Mary Hare's GA was the only one still in operation in the UK[4] (Byrne-Bellinger, 2022).

Scopus and Google Scholar, as well as the Hertfordshire electronic library, were used as research tools. Initially, '*group+hearing+aid*' was searched with no success. The search terms were then increased to include radio+aids, deaf+education, Soundfields and room+acoustics+in+classrooms and auditory+trainers. Links between articles were a particularly useful feature in finding other relevant articles. The research was also evaluated to find the most relevant to this research. The criteria for this judgement was based on the relevance to classroom listening environment and the technologies available to enhance it.

Table 3 Examples of Literature Review Scopus Searches

Search terms in Scopus	**Number of articles**	**Number of articles with relevance to this study**	**How the search was modified**
Group + hearing + aid	3436	0	Changing the wording produced more choices. Links were then found from these documents.
Schools for the deaf+microphones	14	8	Adding deaf into the search. Changing Group hearing aid to radio aid and children to education.
Schools+hearing impaired+radio	3	1	Search focusing on use of radio aids in schools for deaf students.

[4] St John's Boston Spa Group aid was decommissioned prior to 2012 when the wired group aid was updated.

			Schools+deaf+radio produced no responses.
Auditory training unit deaf	7	3	Search focusing on research on Auditory training units for deaf students.
Multiple+microphones+system	1994	0	Search to find multiple microphone systems in general. Large number found but none had relevance to the study.
Group+ microphones +deaf	16	3	Search focusing on microphones for deaf students.
Induction+loop system+deaf	5	2	Search focusing on induction loops in relation to deaf students and adults
Induction+loops+hearing +technology	11	8	Search widened through changing deaf to hearing and adding the word technology.
Soundfield+education	5	3	Soundfield and education while only identifying 5 journal articles, 3 of the articles were relevant.

While these searches have shown that there is much literature on SNR and the benefits of FM/ALDs in mainstream classrooms, research specifically on the impact of GA technologies and their provision within schools for the deaf or large resource bases was limited to Mary Hare documentation.

2.2 Environmental

2.2.1 Classroom environment and acoustics

While Mary Hare makes optimal use of horseshoe shaped seating and all classrooms meet the BB93 standards[5], this may not be the case for all schools. Schafer (2020) identifies school classrooms as noisy and reverberant

[5] BB93 sets out minimum performance standards for acoustics of school buildings (Gov.UK, 2015).

environments with poor acoustics being a potential ‘barrier to successful learning in children, particularly those with multiple disabilities, auditory processing issues, and hearing loss’. Shannon (2010) highlights how ‘deaf children are affected more by noise and reverberation than children with normal hearing’. Erdeich (1999) summed up the importance of good classroom acoustics by comparing poor acoustics, ‘to turning out the light’ in a classroom and expecting the children to read in the dark. It becomes even more important when taking on board that children are more susceptible to environmental acoustic challenges as they have a systematic progression in language acquisition, (Mulla, 2013). Thus, by using correctly set up remote microphone technology it means that ‘high reverberation time (RT) has a minimal effect’ (BATOD, 2001).

2.2.2 Impact of Signal-to-noise ratio (SNR)

Shannon (2010) explains that for adults to make sense of a speaker’s voice in noise, the signal needs to be 6dB louder than the noise. The justification for this is that ‘Adults can fill in the blanks of missed information only if they have that information already stored in their brain’s ‘databank’ (Flexer, 2002). However, children need a greater SNR[6] of +16dB SNR and +20dB for prelingually deaf children (Keen, 2013). As they are still acquiring language and consequently do not have the ‘databank’ to retrieve information from. Ross (2003) concludes for this reason, ‘young children with normal levels of hearing experience greater difficulty discriminating speech in noise than adults**.**

Furthermore, Shields (2013) highlights how deaf children, ‘are more susceptible to the effects of noise and poor acoustics than other children' and thus need greater SNR. Similarly, ‘children with additional needs, learning difficulties and pupils who are not taught in their first language’ Shield (2013) also need preferential SNR.

[6] The difference between the signal (speaker/teacher’s voice) and the noise (classroom/background noise).

This is likely to be because, ‘the more favourable the SNR, the more intelligible the spoken message’ (Flexer, 2002).

While CRIDE (2019) identified 14% of deaf children use an additional spoken language other than English in the home’, Alqattan (2021) illustrated the great importance of SNR for deaf bilingual listeners in the classroom when studying bilingual Arabic listeners. Similarly, Ruscetta (2005) highlights that children with Unilateral Hearing loss ‘require more advantageous listening conditions to perform’ as well as their hearing peers.

High levels of noise and reverberation which are often present in classrooms are known to result in greater speech recognition deficits in children relative to adults, despite the presence of normal pure-tone hearing sensitivity (Schafer, 2020). Thus, a child might perform well in the Audiology suite but struggle to access within the classroom. Consequently, the recommended SNR for a deaf child is +20dB for frequency range 125Hz to 750Hz and +15dB for frequency range 750Hz to 4000Hz (BATOD, 2001). As the low frequency sounds are mainly vowels and these are the most powerful phonemes, it is, therefore, ‘important to reduce low frequency reverberation as much as possible for good speech intelligibility’ (Vaughan, 2010).

While HA and CI technology has made significant advances, current devices still do not restore normal perception of speech in the presence of background noise or multiple speakers. do Nascimento (2005) found that ‘all the implanted adults presented a significant reduction in the scores for sentence recognition as the S/N decreased’ at +10dB SNR this dropped to 50% accuracy.

2.2.3 Adults within the classroom

Although the focus of this study is on the learners in the classroom, adults should also be recognised. While many deaf students have the provision of Teachers of the Deaf (TOD), TAs and/or Communication Support Workers (CSW), these extra adults will add to the number speaking in a classroom.

Also Teaching unions for many years have documented concerns related to teacher voice. Teachers are ‘eight times more likely to suffer from voice-related health conditions than other professionals’ (NEU, 2019). Shield (2013) highlighted that this is likely to be due to frequent use of raised voices to overcome noise. Consequently, teachers make up a disproportionate part of the case list of voice clinics (NEU, 2019).

2.3 Educational Amplification

2.3.1 Soundfield systems (SFS)

Mealings (2022) highlights how SFS can help improve classroom listening conditions by increasing ‘the level of the teacher’s speech compared to the background noise throughout the classroom’, which can benefit children’s speech perception, listening comprehension, auditory analysis, language outcomes, academic outcomes, and behaviour. As ‘the better a child can hear, the more able they are to learn.’ Similarly, da Cruz (2016) found ‘an improvement in listening and attending when using dynamic SFS’ in their study.

Consequently, with SFS ‘teachers are able to communicate in normal, effective voices without straining themselves to be heard’ (Dickinson, 2011) which benefits both students and staff. SFS are particularly beneficial in good acoustic environments. However, poor acoustics can reduce the effect. Thus, Trinite (2021) highlighted the importance of acoustics being ‘fixed to recommended condition or at least excess reverberation should be attenuated when amplification systems are used.’

2.3.2 Assistive Listening Devices (ALD)

For the purpose of this research the term ALD will include radio aids and personal wireless systems. With the majority (77%) of deaf students attending mainstream schools and 6% in mainstream schools with resource provision (CRIDE, 2022), Athalye (2015) identifies that ALDs are widely used to overcome SNR issues. The

SNR is improved by ‘placing the microphone closer to the target of interest and sending that audio input directly to the user’s hearing devices’ (Quilter, 2017). Thus, by bringing the speaker’s voice within the critical distance of 15cm from their mouth, the optimum quality sound is transmitted directly to the student’s personal amplification rather than losing quality over distance. Lin (2018) identified the FM system can effectively improve speech intelligibility for children with a wide spectrum of HL conditions. Similarly, Jacob (2014) identified that, “there is an increase in accessibility and improvement in lessons by students with radio aids”.

While, Wesarg (2020) found ‘Speech recognition for distant speakers in multisource noise improved significantly[7], Schafer (2020) identified a limiting factor to ALDs being cost. Furthermore, Gregory (1998) highlighted issues relating to teachers forgetting to turn ALDs off, meaning the student hears the teacher when they don’t need to, leading to distraction from their work. Similarly, Johnson (2015) observed that ‘nearly half of the reasons why teens reject FM/DM are issues that audiologists can manage’.

2.3.3 Wireless microphone and streaming technology

Thibodeau (2020) highlights that there is a wealth of options of wireless transmission ‘that can result in significant improvements in communication in challenging environments.’ Of these, the majority use 2.4GHz technology, including the Cochlear Mini-mic and the streamers[8] used within this study. By connecting with compatible personal amplification equipment, they can stream sound directly to the users’ personal amplification.

However, a common misconception when referring to proprietary streaming is to use the term ‘Bluetooth’. Thibodeau (2020) identifies the rapid growth in the development of wireless connectivity options, as the reason the terminology has often been simplified to just ‘Bluetooth’’. While Bluetooth low energy data is being

[7] with the application of Roger’ for adults with unilateral MED-EL processors
[8] Cochlear TV Streamer, Phonak TV Connector and Oticon TV Adaptor.

used to enable HAs to be programmed and connected to phones, no brands are currently using it to stream (Harris, 2023).

Wireless microphones can accompany processor upgrades[9]. Quilter (2017) identified that 'while social stigma is often cited as a deterrent of FM, students are not opposed to streaming technology'. Chen's (2021) research also found wireless remote microphones significantly improve speech recognition performance in challenging conditions in China. Razza (2017) similarly found that while there was improvement in both systems (Roger Inspiro and Cochlear Wireless Mini-microphone 2 (Mini-mic)), for CI users, when increasing noise levels were assessed, the gain was higher with the Mini-mic[10].

2.3.4 Rebroadcasting

SFS can also be used for rebroadcasting[11] to enable the deaf child to access the benefits of both the ALD and SFS combined. 'However, such systems must be regularly and sensitively evaluated to ensure optimum use and benefit' (NDCS, 2017). Eberts (2019) also highlights the importance of people holding the microphone 'towards their mouth while talking and speak at a normal volume' to ensure the listener accesses.

2.3.5 Auditory training units

Auditory training units, the precursor for a hardwired GAs, have been in use since the 1950s with the aim of giving deaf students the best possible chance to access in the classroom. Bangs (1953) supported the theory that 'children who have some residual hearing may profit to a degree from amplification while undergoing a language development program'. He identified that there was a general trend in schools for the deaf to use portable or semi-portable commercial units. However,

[9] Cochlear and Advanced Bionics offer accessories with their upgrades.
[10] (SRT =-4.76 compared with -3.01 with the Roger system)
[11] When the signal from the SFS transmitter is sent directly to the student's personal amplification via the RAS (Atkin, 2017)

some institutions, like Mary Hare, designed and constructed their own; their aim being to give deaf students the best possible chance to access in the classroom.

2.3.6 Induction loops

Induction loop systems work through an induced electromagnetic field proportional to a sound source receivable by HA' (Economidou, 2021). When a listener with a HA containing a telecoil moves within that electromagnetic field, the signal from the speaker is received at 'a greater intensity relative to its arrival at the HA microphone' (Thibodeau, 2020). This supports speech perception in challenging listening environments[12]. This technology was first included in HAs[13], in 1938 (Thibodeau, 2020). While Odelius (2010) observed 'better hearing with telecoil (t-mode), especially in more difficult listening situations' for students with severe deafness. They also highlighted that the HA microphones (m-mode) gave participants better awareness of the sounds around them.

While loop systems are simple and cost effective, there is the disadvantage of the electromagnetic field spilling over from adjacent rooms, dropping signal and the interference from lights, computers and other electronic/ electrical devices in the classroom. Furthermore, the inability of children to explain their experiences mean that loop systems have not been recommended in educational settings. Hansson (2017) also raised concern about the safety of induction loop pads to children, with values up to 70% of the recommended standard for magnetic fields recorded. Currently, there is limited research on the impact of magnetic fields in education.

2.4 Amplification in settings

2.4.1 GAs for hearing audiences

Group aids are not specific just to deaf education. Courts, parliament, and the United Nations conferences are examples of systems which enable all participants

[12] Background noise, over distance and poor reverberation
[13] The Multitone VPM

to hear each other as well as themselves and the key speaker. The UK parliament has had microphones since 1950 which has enabled broadcasting since 1978 (Parliament, 2023). The UN in Kenya operates an integrated conference system configured in dual delegate mode in which each participant has a microphone with loudspeaker and channel selector with headphone that they can use to talk with and listen to the other attendees or via interpreters (Cunha, 2023). These systems use microphones to ensure all utterances are captured as sound decreases over distance. Keen (2013) summarises the inverse square law as 'how energy is lost as sound travels away from the sound source in all directions.'

2.4.2 Resource bases and provision abroad

While there are no other known group aids in the UK, digital wireless technologies in the form of Phonak Roger and DigiMaster Classroom reinforcement systems and SFS are used. Sheldon School[14] has SFS in every classroom which 'transmits the frequencies of speech with clarity at equal volume around the room' (Freeman, 2023). Frank Barnes School has Digimasters in every classroom however 'they have not been fully integrated into the classroom[15]' (Harris, 2023). In Scandinavia traditionally high priority has been given to GAs. Rekkedal (2014) highlights how 'ALDs, such as teacher-microphones and pupil-microphones, can ensure an enhanced listening environment for such pupils and thus induce a higher level of participation in the teaching'. Comfort Audio[16] was a Scandinavian company. It's RAS had digital and inductive loop receivers (Harris, 2023).

2.4.2 Mary Hare Group aid (WGA)

The last major update to the Mary Hare WGA was in 2012 (Appendix I). This, enabled students to benefit from the latest HA technology at the time: compression

[14] Sheldon School has a hearing resource unit with over 30 students
[15] Whiteboard audio has not been connected.
[16] Comfort DigiSystem is a digital wireless communication system consisting of a series of microphones and receivers that can be combined flexibly according to individual needs and requirements (GordonMorris, n.d.)

and frequency shifting algorithms on HAs which ‘improved the SNR of WGA, ear infections were reduced due to less handling of the HAs and CI users were able to connect both their processors. (Ogg, 2019)

WGA enabled teachers to see who was connected on the teacher control panel. As well as to mute and unmute the student microphones (Bellinger, 2004). However, due to the wires, all the students needed to be in their seats. This limited movement within the lesson and time was needed to connect every student each lesson and wiring needed regular maintenance.

2.5 Justification for a Wireless Group Aid (WGAS)

WGAS enables everyone to connect in all classrooms, movement in lessons and quick connections. Ogg (2019) highlights the importance of all pupils needing to have the technology not only to hear the teacher but also to be able to hear themselves and their peers. Thus, an inclusive classroom is created by the school providing a strong provision for CYP (Gov.UK, 2023) where all students can access both the teacher and their peers. ‘Short-distance pupil microphones provide each child with the clearest possible audition of their own speech’ (Bellinger, 2004).

While Wolfe (2015) found that the digital adaptive system shared a greater improvement in moderate to high level noise, both the streaming accessory and digital adaptive system showed improvement in sentence recognition in quiet and low competing noise levels, which would be typical for classroom teacher input. Thibodeau (2014) found[17] that digital technology was significantly better, and that most listeners also preferred listening with the digital technology in real-world noisy situations. Similarly, Mehrkian (2019) found[18] significant improvements in ‘speech discrimination in noise (SiN) in all CI children when wireless remote microphones

[17] Comparison study included: 3 types of remote microphone hearing assistance technology (HAT), adaptive digital broadband, adaptive frequency modulation (FM) and fixed FM.
[18] Study of unilateral CI users.

(RM) were used', compared to without which highlighted the usefulness of this accessory.

Furthermore, Ross (2003) highlighted that even with advancements in radio aid (ALD) technology, some students will not use RAS for a number of reasons. While ALDs have become smaller, ear level and more modern in appearance, Morris (2017) highlighted, 'the limitation of only hearing the teacher and not their peers while using the device'. Similarly, Athalye (2015) found teachers not using the equipment correctly as causes of ALD rejection.

Consequently, Warner-Czyz (2015) highlighted how hearing-impaired teenagers are perceived to have a lower self-image due to differences from their peers in mainstream in relation to communication skills, physical appearance, and social maturity. Therefore, WGAS enables everyone to use the same system to access in class. Marschark (2002) summarises how enabling students to hear in their lessons is essential as 'we cannot expect students to achieve high levels of performance without effective educational practices'.

2.6 Limitations in the Literature and Conclusion

In conclusion, greater research is needed specifically on the impact of WGAS technology. This study has emerged to meet the need of deaf students at Mary Hare and ever evolving technology. Therefore, this Literature review has focused on aspects of audition which impact deaf students in education. Further research into provision for multiple deaf students and wireless streaming technologies used in the classroom is needed.

3. Methodology

3.1 Introduction

A mixed methods approach, using quantitative and qualitative data, was chosen to research the impact of Wireless Group Aid technology (WGAS) on learners in the classroom. The aim was to generate a full picture of the impact, using a range of sources. Goertz (2012) highlights that although the differences between quantitative and qualitative research methods are significant, 'the paradigms can nicely complement one another within an overall project.' Both staff and students' viewpoints were included in the study. Hoppe-Graff (2006) described a mixed methods approach as drawing 'upon the strengths and minimize the weaknesses of both' quantitative and qualitative approaches. A combination of questionnaires, semi structured interviews and observational data was collected to form a case study. Within case studies, the qualitative approaches of ethnographic, phenomenology, action research and thematic content analysis as well as triangulation and quantitative can be included.

3.2 Research methods

Research method	Definition	Relation to research
Triangulation	The combination of different methodologies is known as "triangulation" (Hameed, 2020). Furthermore, triangulation may uncover hidden phenomena. When different techniques yield divergent findings, the need for the researcher to reconcile the data forces him to refine his approach which may lead to the discovery of hidden phenomena' (Hameed, 2020).	While this study is primarily made up of qualitative research, quantitative is also used to give percentages. Jick (1979) argues that triangulation allows the researcher to be more confident of the data, particularly if the data collected by different methods converge.
Quantitative	Quantitative research is, 'the process of collecting and analysing numerical data' (Bhandari, 2022). The quantitative data	Giving statistical data which gives patterns within the research to

	is recognised as ‘a precise sample number that can be calculated according to the level of accuracy and the level of probability that researchers require in their work’ (Cohen, Manion, & and Morrison, 2007).Thus giving statistical data which gives patterns to confidence and difficulty or ease of use within the research. Goertz (2012) summarises quantitative research as ‘typically, seeks to identify causes that affect the value on an outcome’ of the population.	identify confidence levels, ease and difficulty of use as well as percentages of participants.
Qualitative	Qualitative research involves collecting non-numerical data. It ‘covers a range of methods including ethnographic, naturalistic, anthropological, phenomenological, and case study approaches’ (Hameed, 2020). Qualitative studies are generally found ‘to be accompanied by quotations from interviews or similar data sources’ (Eldh, 2020) as well as including transcriptions of interviews or questionnaires which relate to experiences, attitudes, beliefs and opinions.	The WGAS research aim is to gather an in-depth understanding of human behaviour and the reasons that govern such behaviour (Dickens & Watkins, 1999) through transcriptions of interviews or questionnaires which give opinions of WGAS.
Case studies	Case studies are an in-depth analysis of a single or small number of people and allow for an in-depth study within a limited time scale (Bell, 2014). They are a unique example of real people in real situations which give readers a clearer understanding of ideas rather than simply presenting abstract theories (Cohen, 2007). They can also establish cause and effect and identify significance rather than frequency. A case study begins with ‘the researcher’s interest in a particular set of phenomena whereas action research project begins mostly with the issues and concerns of	A case study begins with ‘the researcher’s interest [WGAS] in a particular set of phenomena whereas action research project begins mostly with the issues and concerns of some practical situation’ (Blichfeldt, 2006).

	some practical situation' (Blichfeldt, 2006).	
Ethnography	Ethnography "involves observing people in their own environment to understand their experiences, perspectives and everyday practices" (Gov.uk, 2020) to give in-depth insight into a particular context, such as the GA changes and thus can involve long-term fieldwork which can be time consuming.	Gives an in-depth insight into a particular context, such as WGAS.
Phenomenology	seeks to describe experiences as they are lived or in the case of the GA, experienced. Rodriguez (2018) summarised, 'themes are derived but are also understood as the structures of experience that contribute to the whole experience'	As the research involved an integral part of school life, participants were describing their experiences. This research was collected through the filmed interviews where experiences were described.
Action Research	While action research approaches may vary depending on the research. As one or several methodologies may be used to inform their research, it may be difficult to identify just one particular methodology. "Action researchers typically assume that knowledge and truth are forged in a combination of theories and practices which feed off one another, both being changed in the process" (Griffiths 1990).	The research enables action to be taken and findings written up which would then be accessible to wider audience. Usually, this research is qualitative as it involves interviews and observations. This research is qualitative as it involves interviews and observations.
Thematic Content Analysis (TCA)	TCA is a common form of qualitative analysis which identifies the findings in themes. This qualitative data may take the form of interview transcripts collected from research participant'. TCA assumes that the recorded messages themselves are the data, and codes are developed by the investigator 'during close examination of the texts as salient themes emerge inductively from the	This qualitative data may take the form of interview transcripts collected from research participant.'

	texts' (Neuendorf, 2019). Reasonable attempts are made to generate names for themes from the words of participants and to group themes in manner that directly reflects the texts as a whole (Anderson, 2007).	

3.2.1 Research methods justification

A case study was chosen, as the aim of a case study is to 'analyse a subject of particular interest to the researcher,' (Blichfeldt, 2006). In this case the research centres around the impact of WGAS adaptations. However, case study pitfalls can include selective reporting, 'only choosing evidence that supports a particular agenda or just the striking features rather than looking at all the evidence' and generalisations which are not supported by evidence and use of an anecdotal style (Cohen, 2007). Thus, using a range of research methods should aim to limit this.

Furthermore, Ethnographic research was included to focus on observations of classroom practice. With the aim of arriving at 'a better understanding of [WGAS] and to challenge one's own knowledge systems and practices' (Seligmann, 2020). This has been essential in enabling the research to identify positives through observation as well as issues and give time for issues to be solved. In addition, phenomenology research describes experiences as they are lived (Rodriguez, 2018) or in the case of WGAS, experienced, for example, the observation of the first time a student accesses their teacher's voice through WGAS.

Similarly, WGAS fits into action research as the questionnaires and interviews give insights into how WGAS runs and highlights next steps. Dickens (1999) described action research as 'an umbrella term for a shower of activities intended to foster change on the group, organizational, and even societal levels' which 'can be summed up as of cycles of planning, acting, reflecting or evaluating, and then taking further action'. It is often used when research is part of researcher's normal

job role as the researcher is continually assessing and revisiting the issues which occur as the project is implemented. Both case-study and action research are concerned with the researcher's gaining an in depth understanding of particular phenomena in real world settings' (Blichfeldt, 2006).

TCA then identifies the findings in themes. It fits well with this research as it 'is a descriptive presentation of qualitative data' (Anderson, 2007). While Content analysis (CA) assumes the data is the recorded occurrences of specified codes as applied to these units (Neuendorf, 2019). When comparing CA and TCA (Vaismoradi, 2013) 'concluded that despite many similarities between the approaches, their main difference lies in the opportunity for quantification of data. It means that measuring the frequency of different categories and themes is possible in content analysis with caution as a proxy for significance'.

3.2.2 Comparing qualitative and quantitative research

While qualitative research involves collecting and analysing non numerical data, quantitative analysis involves the use of numerical data. Flick (2002) summarised that the 'limitations of quantitative approaches have always been taken as a starting point for developing more general reasons why qualitative research should be used'.

As qualitative research becomes increasingly recognised and valued, Nowell (2017) highlights how 'it is imperative that it is conducted in a rigorous and methodical manner to yield meaningful and useful results' and emphasises that for it to be accepted as trustworthy researchers need to ensure data analysis has been conducted in 'a precise, consistent, and exhaustive manner through recording, systematizing, and disclosing the methods of analysis with enough detail' (Nowell, 2017). Thus, enabling the reader to recognise the credibility of the process as trustworthy. Eldh (2020) summarises how 'presenting authentic citations of what informants have uttered has become the "gold standard"' (Eldh, 2020).

3.3 Recruitment and participants

The criteria for student participating in this research was:

- A level of deafness.
- Attend Mary Hare School.
- Use WGAS in lessons.
- Auditory/oral communication method in lessons.
- Use personal amplification (HA, CI, BAHAs or a combination) with wireless connectivity.

The criteria for staff participation in this research was:

- Use WGAS in lessons either as a teacher or TA working with students in the classroom.
- Deaf[19] or hearing.

3.3.1 Student participation

Fifty-six students participated in the research. Student data is highlighted in blue.

Table 4 Student Participants

Student	Year Group	Bilateral/ unilateral hearing loss	Average level of deafness left	Average level of deafness right	Type of hearing loss	Personal amplification	Manufacturer	Streamer
S1	7	Bilateral	Severe	Moderate	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S2	7	Bilateral	Moderate	Moderate	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector

[19] Criteria based on BATOD Audiometric descriptor dBHL (Underwood, 2009)

S3	7	Bilateral	Profound	Profound	Sensorineural	Bilateral Hearing aids	Oticon	Oticon TV Adaptor
S4	8	Bilateral	Mild	Normal	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP and P	Phonak TV Connector
S5	8	Bilateral	Severe	Profound	Sensorineural	Bilateral hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S6	8	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Advanced Bionics Sky CI Marvel processors	Phonak TV Connector
S7	8	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Advanced Bionics Sky CI Marvel processors	Phonak TV Connector
S8	8	Bilateral	Moderate	Moderate	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S9	8	Bilateral	Moderate	Moderate	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S10	8	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S11	8	Bilateral	Moderate	Moderate	Sensorineural	Bilateral Hearing aids	Oticon	Oticon TV Adaptor
S12	8	Bilateral	Severe	Severe	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S13	9	Bilateral	Severe	Severe	Sensorineural	Bilateral Hearing aids	Oticon	Oticon TV Adaptor
S14	9	Bilateral	Severe	Severe	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S15	9	Bilateral	Moderate	Moderate	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S16	9	Bilateral	Profound	Profound	Sensorineural	Bilateral hearing aids	Phonak Sky Marvel SP	Phonak TV Connector

S17	9	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear implants	Cochlear Nucleus 7	Cochlear TV Streamer
S18	9	Bilateral	Severe	Moderate	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Streamer
S19	9	Bilateral	Profound	Profound	Sensorineural	One Cochlear Implant	Cochlear Nucleus 6	Cochlear TV Streamer
S20	9	Bilateral	Profound	Profound	Sensorineural	Bilateral Hearing aids	Phonak Naida Paradise P70-UP	Phonak TV Connector
S21	10	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S22	10	Bilateral	Profound	Severe	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S23	10	Bilateral	Moderate	Moderate	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel P	Phonak TV Connector
S24	10	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S25	10	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S26	10	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 6 and 7	Cochlear TV Streamer
S27	10	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 6	Cochlear TV Streamer
S28	10	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S29	10	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S30	11	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S31	11	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S32	11	Bilateral	Profound	Severe	Sensorineural	One Hearing aid (right)	Phonak Sky Marvel SP	Phonak TV Connector

S33	11	Bilateral	Profound	Profound	Sensorineural	Cochlear Implant	Cochlear Nucleus 7	Cochlear TV Streamer
S34	11	Bilateral	Profound	Profound	Sensorineural	One Cochlear implant on left	Cochlear Nucleus 7	Cochlear TV Streamer
S35	11	Bilateral	Moderate	Moderate	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S36	11	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S37	11	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Advanced Bionics Naida 90 with Connect	Phonak TV Connector
S38	11	Bilateral	Profound	Profound	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S39	11	Bilateral	Profound	Moderate	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S40	11	Bilateral	Severe	Severe	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S41	11	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S42	11	Bilateral	Moderate	Moderate	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S43	11	Bilateral	Moderate	Moderate	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Connector
S44	11	Bilateral	Severe	Severe	Mixed	Hearing aid and BAHA	Cochlear BAHA and Phonak Sky Marvel SP Hearing aid	Cochlear TV streamer for the BAHA and Phonak TV Connector for the hearing aid.
S45	11	Bilateral	Severe	Severe	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer

S46	11	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear implants	Cochlear Nucleus 7	Cochlear TV Streamer
S47	12	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S48	12	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S49	12	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Advanced Bionics Sky CI Marvel processor	Phonak TV Connector
S50	12	Bilateral	Severe	Severe	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S51	12	Bilateral	Profound	Profound	Sensorineural	One cochlear implant (left)	Cochlear Nucleus 7	Cochlear TV Streamer
S52	13	Bilateral	Profound	Profound	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S53	13	Bilateral	Severe	Severe	Sensorineural	Bilateral Cochlear Implants	Cochlear Nucleus 7	Cochlear TV Streamer
S54	13	Bilateral	Severe	Profound	Sensorineural	Hearing aid on left and Cochlear implant on right	Cochlear Nucleus 7 and Phonak Sky V70-SP	Cochlear TV Streamer
S55	13	Bilateral	Profound	Profound	Sensorineural	1 Cochlear Implant (right)	Cochlear Nucleus 7	Cochlear TV Streamer
S56	14	Bilateral	Severe	Severe	Sensorineural	Bilateral Hearing aids	Phonak Sky Marvel SP	Phonak TV Streamer

Student participation was greatest in years 8 to 11. This is likely to be because these year groups had the microphones first.

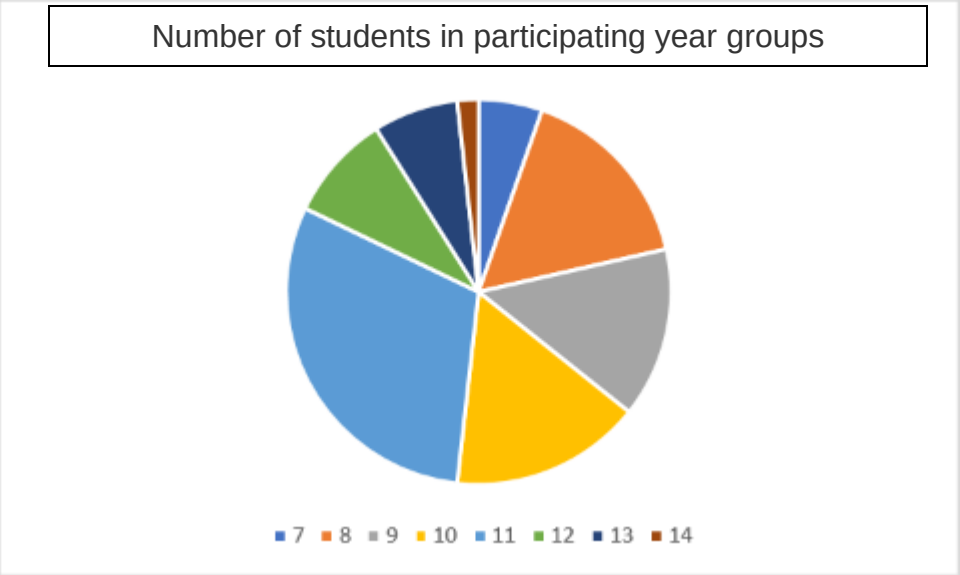


Figure 1 Pie chart of student year group

Interestingly, there were the same number of bilateral HAs and CIs (24) as well as combinations of personal amplification and unilateral aiding.

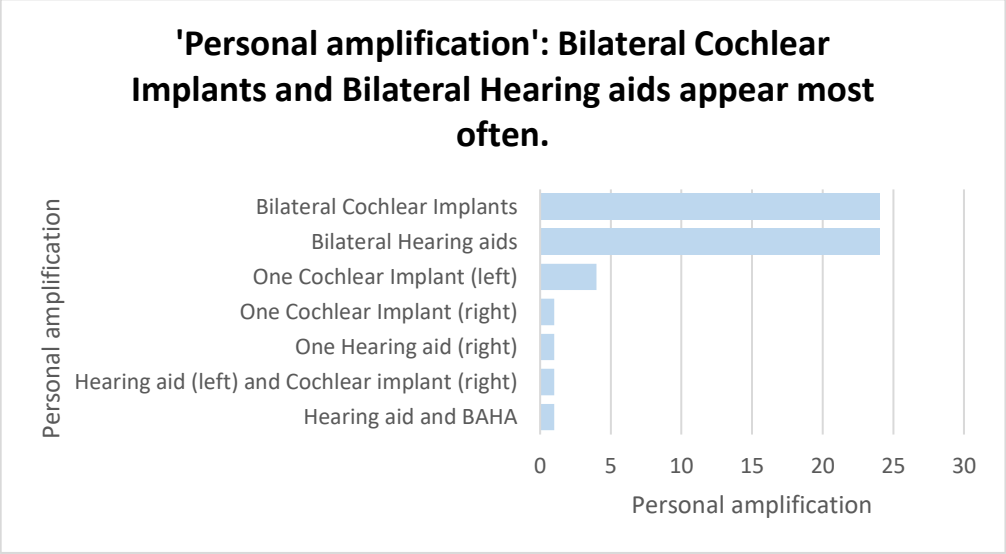


Figure 2 Types of student personal amplification

3.3.2 Staff participation

Fourteen teachers and thirteen TAs (including three deaf TAs) participated in the research. Staff were primarily based in the secondary school with one primary TA. Teacher data is highlighted in yellow and TA data in green with light green for hearing TAs, mid green for deaf TAs and dark green for all TAs.

Table 5 Hearing Staff Participants

Staff	Teacher/TA	Year Groups taught/ work with
T1	Teacher	Secondary Science
T2	Teacher	Secondary Science
T3	Teacher	Secondary Textiles
T4	Teacher	Sixth Form
T5	Teacher	Secondary Leadership
T6	Teacher	Secondary/Primary PE
T7	Teacher	Secondary Maths
T8	Teacher	Secondary Graphics
T9	Teacher	Secondary Legs[20] Plus
T10	Teacher	Secondary French
T11	Teacher	Secondary English
T12	Teacher	Secondary Leadership
T13	Teacher	Secondary Photography
T14	Teacher	Secondary Maths
TA4	TA	Secondary
TA5	TA	Secondary
TA6	TA	Secondary
TA7	TA	Secondary
TA8	TA	Secondary
TA9	TA	Secondary
TA10	TA	Secondary
TA11	TA	Secondary
TA12	TA	Secondary
TA13	TA	Secondary

[20] LEGs and LEGs plus language enrichment classes are language enrichment classes for children whose language might be delayed by four years (School, 2020)

Table 6 Staff participation deaf[21]

Staff	Teacher/TA	Year Groups taught/ work with	Level of deafness	Type of hearing loss	Hearing aid technology/ personal amplification	Manufacturer	Streamer
TA1	TA	Primary	Severe	Sensorineural	Hearing aids	GNResound	Cochlear
TA2	TA	Secondary	Profound	Sensorineural	Hearing aids	Phonak	Phonak
TA3	TA	secondary	Profound	Sensorineural	Hearing Aids	Cochlear	Cochlear

3.4 Ethics

The data was collected as part of the researcher's normal job role as Head of Audiology at Mary Hare School, a partner programme of University of Hertfordshire. The researcher is an Educational Audiologist. Consent was sought from parents of participants under the age of 18 and from participants over 18 years, through the EC3 and EC4 forms. Taking part in the research was optional. Ethics approval was sought from the Research Committee, University of Hertfordshire and Mary Hare School (Copies of Ethics documentation are included in Appendices V-IX).

3.5 GA Technology/Equipment

3.5.1 Wired Group Aid (WGA)

WGA was used between 2012 to 2022. While it enabled all students to hear their peers and themselves as well as the teacher, it involved wired connections.[22]

[21] The term 'deaf' is used to refer to persons with hearing levels from mild to profound as per UK practice (NDCS, 2023).
[22] (see table 7).

Table 7 Wired GA components

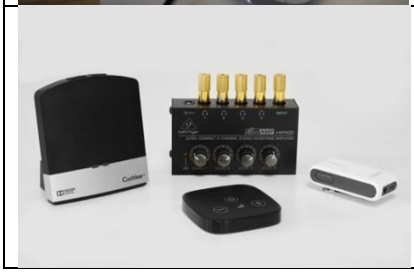
WGA Features	How WGA worked
	GA control panel, GA box, monitor headphones and keyboard to adjust gain for students. Teacher wore a microphone which was connected to the Teacher control unit.
	Students wore a GA box on a lanyard round their neck which was connected by wires to their personal amplification. Those that could not connect used headphones attached to their GA box. Students plugged their GA box into the control box at the start of each lesson.
	GA headphones with microphones originally used prior to 2012 (School, "New Technology Moving with the times", 2022)
	GA wires/ leads from GA box connect into personal amplification.

3.5.2 Wireless Group Aid (WGAS)

WGAS need to keep the core ethos of the school while enabling all students to connect. Different types of technology were considered carefully by the school, before agreeing upon WGAS. Key features of WGAS are the ability for all students to hear their peers and themselves as well as the teacher, connect wirelessly and be able to move between classrooms.

Table 8 WGAS Features

WGAS Feature	Justification for inclusion in WGAS
	The Frontrow Juno SFS. Chosen to minimise any potential interference and any delay in signal transmission as IR cannot go through any material except glass (Harris, 2023). ‘Line arrays (FrontRow ToGo, Juno, and Phonak DigiMaster) give a good balance of sound coverage and portability, having measurable dispersion patterns that minimize signal drop’ (FrontRow, 2013).

	The SFS speaker provides a monitor speaker for hearing staff to access WGAS. It also acts as the base of WGAS (a platform for the proprietary streaming devices) as the streamers are connected via an amplifier (compact audio mixer).
	The Amplifier is attached to the Juno SFS via the Audio output socket on the Juno. It enables each of the streamers to offer low noise and optimum gain and not go into compression. Enabling WGAS 'to be transparent to the listener's personal amplification'. (Harris, 2023). Thus, preserving natural speech from the teacher. These levels were set through assessment using the hearing aid analyser (Fonix FP35) – see diagrams.
	The streamers (proprietary streaming devices) are attached to an amplifier. As the amplifier has four sockets, other devices including Roger devices and Med-EL Audiolinks can be connected.

	The aim being that all students, regardless of their personal amplification, can connect to WGAS. The streamers, using the license-free 2.4GHz frequency ranges for wireless devices, work directly with the user's personal amplification. For this research three streamers have been connected: o Phonak TV Connector, o Cochlear TV Streamer, o Oticon TV Adaptor/ Edumic.
	The Frontrow Juno microphones for staff and students were chosen, as multiple microphones can be connected to WGAS. However, only one teacher and one student microphone are used at a time.
	The teacher microphone can also be given priority over the student microphones.
	The student microphones work in all classrooms and are allocated to individual students.
	The Juno also connects via Bluetooth to the class PC to enable all audio to play through WGAS.

	Juno SFS screen can be locked with voice commands to ensure settings are not changed unnecessarily.
	The SFS gives the teacher a wireless microphone that is worn around the neck at the 15cm/6 inches optimum height and has ability to have a handheld microphone for every student.
	Multi chargers are stored in student form rooms. This enables students to put their microphones on charge each evening and collect them charged at morning form time.

Consequently, multiple audio sources can be connected at one time, which enables student to hear their teachers, other students, themselves and audio from multimedia sources. ‘Since patching can be done with infrared (IR) systems, channel management is not an issue’ (FrontRow, 2013) and any ALD including radio aids and streaming technologies can be connected[23]: These adaptions replace the GA boxes, wired teacher microphone, teacher control unit and wiring connecting the boxes and participant personal amplification. There are 50 WGAS in the school. To enhance the robustness of WGAS, replacement personal amplification can be connected easily with no activation charges and technology changes can be managed by onsite Audiology.

[23] While Phonak Roger can connect to the GA it has not been included in this research due to it using frequency hopping within 2.4GHz (Thibodeau, 2020) compared with the selected streamers which lock into one channel (Harris, 2023). Thus there was a potential for interference and further research is needed.

3.5.3 WGAS Streamers

The Proprietary Wireless Communication (Streamers) used in this study operate on the same 2.4GHz frequency range. Phonak (2017) clarified that ‘the amount of radio frequency energy the body is exposed to is so little that there are no foreseen risks in the continual use of wireless Has’. Each manufacturer has their own name for the streaming technology, and it only works with their products (as shown above) hence the term ‘proprietary’.

Table 9 Proprietary wireless names and manufacturers

Manufacturer	Proprietary wireless name	Benefits identified by manufacturer
Cochlear	Truewireless	Cochlear (2023) highlight that their streamer ‘is designed to help you enjoy clear, crisp stereo sound directly from your TV, without the need for extra wires’.
Phonak	Airstream	Phonak (2022) publication states that the ‘TV connector is a helpful hearing aid streaming solution’.
Oticon	Twinlink	Oticon (2022) advocates streaming for ‘a quality TV watching experience’.

While the manufacturers link the listening experience specifically to TV, the same experience can be applied to the classroom where students need to hear high quality, clear and crisp sound (Cochlear, 2023) as well as visuals from the Smartboard.

Table 10 Streamers within the research

Streamer:	Streamer: Manufacturer	Streamer: Proprietary Wireless Streaming Device	Compatible Hearing aids	Compatible CI Processors	Compatible BAHA/BCHI
	Cochlear	Cochlear Wireless TV Streamer	GN Resound Hearing aids	Nucleus 6 and Nucleus 7	Cochlear BAHA
	Oticon	Oticon TV Adaptor 3.0	Oticon Hearing aids		Oticon Medical BCHI
	Phonak	Phonak TV Connector	Marvel and Naida Paradise P70-UP hearing aids	AB Naida Q90 with Connect, AB Marvel Naida and Sky Processors	

The first time streamers are used they must be paired[24] to the student's personal amplification. 'Pairing is done only once and will normally not have to be repeated' (Oticon, 2022). This is the same for the other manufacturers. However, Cochlear need a 2-3 second press on their personal amplification or to be reconnected via the App on a phone or iPad each time they connect.

[24] Pairing is the connection between the student's personal amplification and the proprietary streamer.

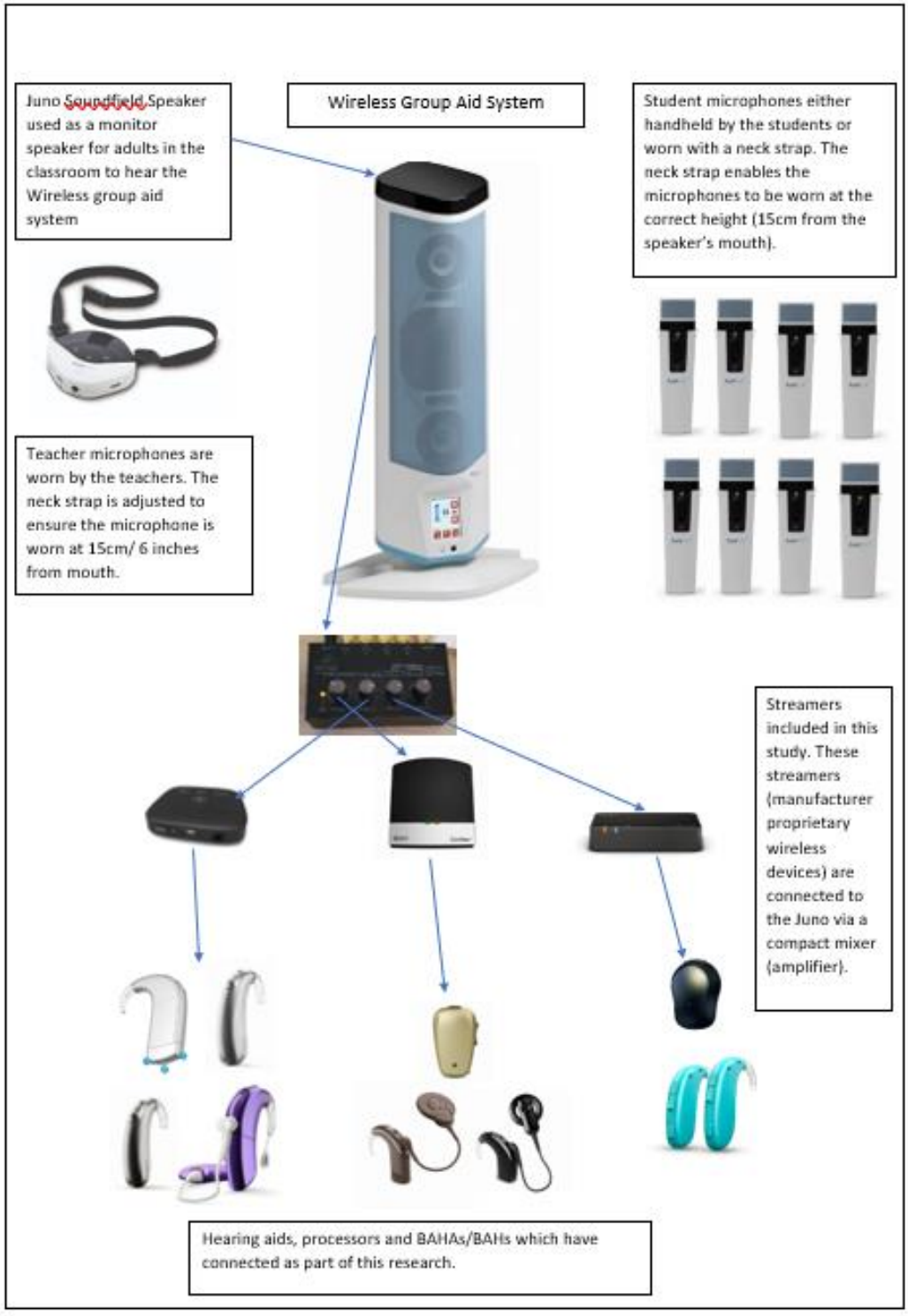


Figure 3 Wireless GA Streamer connectivity

Table 11 Streamers and how they connect

Personal amplification	How it connects to WGAS	Additional equipment needed.	How to connect
Cochlear N6	Cochlear Streamer	None	Student pairs with the Cochlear TV Streamer if they have Cochlear processors, BAHAs or GN Resound Hearing aids. • HA/CI/BAHA need to be switched off. • Button on the back pressed. • HA/CI/BAHA switched back on. • Blue light will flash. • 2/3 second press on HA/CI/BAHA to connect each time. Or click TV connector on the APP
Cochlear N7	Cochlear Streamer	None	
GN Resound Ambio Hearing aids	Cochlear Streamer	None	
Cochlear BAHA	Cochlear Streamer	None	
Phonak Marvel SP and P hearing aids	Phonak Streamer	None	Student pairs with the Phonak TV connector if they have Phonak hearing aids or Advanced Bionics Processors. • Press the infinity button to pair. • When it is connected, the hearing aids play a tune and the light comes on. • TV connector is then 'live' when the Juno mic is on. • Automatic reconnection happens when the student comes back in range of the streamer. • Streamer should be kept horizontal as it can act as an aerial.
Phonak Naida Paradise UP hearing aids	Phonak Streamer	None	
Advanced Bionics Marvel Sky and Naida Processors	Phonak Streamer	None	
Advanced Bionics Q90 Naida processors	Phonak Streamer	AB Connect attached to battery	

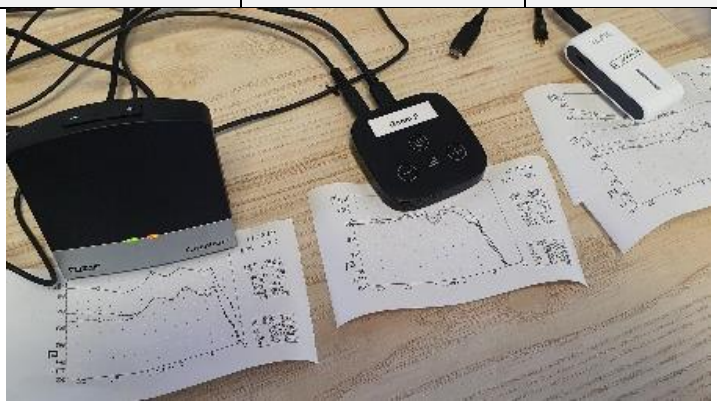
Oticon Hearing aids and Ponto 5 Bone conduction device	Oticon Edumic or Streamer	None	Student pairs to the Oticon TV Adaptor if they have Oticon Hearing aids or BAHAs. • To pair, switch the hear aids off and on. Then place them ontop of the streamer. • The lights will flash on the streamer. • The hearing aids will then be connected. • Automatic reconnection when the student returns to the classroom.

3.5.4 Electroacoustic verification

The optimum gain[25], to ensure comfort and clarity without pushing levels into compression, was set through electroacoustic verification using the Fonix FP35 Hearing aid analyser (Testbox). The gain was then verified by the student listeners who could say if the streamers were too loud or quiet. Student verification matched that achieved using the Testbox on all occasions checked. Jacob (2021) highlights the importance of this electroacoustic verification in the fitting protocol as the type of receiver, the model and brand have different levels of sensitivity and this influences the adjustment needed. Thus, it is essential to check and adjust the gain setting accordingly, including the streamers (proprietary streaming technology). Atkin (2017) also found that without effective verification of the rebroadcasting process, the signal was significantly under-amplified resulting in reduced access to the speech signal.

Table 12 Electroacoustic verification

[25] The optimum gain is the amount of benefit received from the streamer. If it is too high, the personal amplification will go into compression and the sound will become distorted. If it is too quiet, the student will be disadvantaged as they will not be receiving the signal sufficiently loud enough (Harris, 2023).

Streamers and settings	Cochlear TV Streamer	Phonak TV Connector	Oticon TV Adaptor/ Oticon Edumic
Streamers with (Testbox Fonix FP35) Printouts showing how the hearing aid and streamer curves match to ensure the optimum gain is achieved.			
Amplifier settings.			
Hearing aids used in testbox with correlating streamers.			

3.5.5 Wireless microphones

All students have their own Juno SFS student microphone, either used handheld or worn around the neck. The neck cords were set so the microphones sat at the optimum height 15cm/6 inches from the mouth. Younger students (years 7 and 8) were actively encouraged to wear their microphones. Whereas older students (Years 10 and up) were given the option of handheld or neck worn to promote independence.

3.6. Procedure

Students moved over to streaming at different times due to several reasons, including their personal amplification and where they were seen for Audiology. All staff and students in the school were given a questionnaire (Appendix IV) to complete as part of the researcher's job role. Questionnaires for students who had switched over to WGAS and had their own microphone were included in the study. The questionnaires were completed in July and December 2022. In July 2022, all students in years 7-11 (year 8 -12 December 2022) were issued with handheld microphones. The new year 7, year 13, primary and the TAs received their microphones in November 2022 and were included in the December questionnaires. Interviews and observations followed the questionnaire rollout in July and December 2022 with staff and students volunteering to participate.

Edumics were used in place of Oticon TV Adaptor initially due to supply chain issues. This was made possible due to the small numbers of Oticon students within the school. All classrooms were fitted with Oticon TV Adaptors in Autumn 2022. Results of the questionnaires have been used to guide training for teachers and pupils on WGAS, inform upgrades of personal amplification and troubleshoot issues as well as provide evidence for this research. For example, a business case was made to an Audiology department to enable students with over 100dB level of deafness to upgrade to Phonak Naida Paradise P70-UP HAs. The success of the

business case enabled all students at Mary Hare on Sky V70-UP or older HA to be upgraded to HA that streamed.

3.6.1. Students

Questionnaires were structured to include students with different personal amplification that could connect to WGAS. As WGAS needs to be accessible to all to inform the research and meet needs of the school. Fifty-six students took part in the study from years 7-14 (see year group breakdown below) which is over a quarter of students in the school. There was a higher uptake of questionnaires in years 10-11. Less in sixth form and year 7 as they had had their microphones for less time due to supply chain delays. Years 8-11 received theirs in July and years 7, 13 and 14 in November 2022 and primary in January 2023.

Table 13 Numbers and percentages of student questionnaire returned in each year group.

Year group.	Total number of students in each year group included in the study.	Number and percentage of questionnaires completed July 2002 students in each year group.		Number and percentage of questionnaires completed December 2022 by students in each year		Total number of questionnaires completed in either July or December 2022 by students in each year group.	Percentage of participation in each year group.
Year 7	25	0	0%	3	12%	3	12%
Year 8	24	2	8.33%	7	29.17%	9	37.5%
Year 9	21	2	9.52%	6	28.57%	8	38.1%
Year 10	25	5	20%	4	16%	9	36%
Year 11	22	2	9.09%	15	68.18%	17	77.27%
Year 12	43	0	0%	5	11.63%	5	11.63%

Year 13/14	37+11=48	1	2.08%	4	8.33%	5	10.41%
Total students	208	12 (21.43%)		44 (78.57%)		56 (100%)	27%

3.6.2. Staff

Staff completed the questionnaires in December 2022 after using WGAS. This varied from a few weeks to a few months. Staff answered the questions related to using the microphones and pupils' access. TAs were also able to reflect on their observations in the classroom and how WGAS benefited students as well as identifying solutions to concerns they had observed.

Then staff interviews were used to discuss responses to the questionnaires and gain further information. Four teachers, three hearing TAs and three deaf TAs were interviewed.

Table 14 Numbers and Percentages of staff participation in relation to the school as a whole

	Total number of Teachers/ TAs in school	**Total number of participants who took part in the research**	**Percentage of participation in the research**
Total hearing teachers	59	14	23.72%
Total hearing TAs	22	9	40.91%
Total number of deaf staff	6	3	50%

3.7. Data Collection methods

3.7.1. Questionnaire

The questionnaire method was chosen to give participants the opportunity to share their views and enabled the researcher to survey as many staff and students as possible in a short time. They also enabled quantitative and qualitative data to be collected. However, varying literacy levels, ability to understand the questionnaire, time to complete the forms, student mood and support available affected how the forms were completed. Questionnaires completed with a reader or staff support were more detailed. Marschark (2002), highlighted that, being aware of student attitudes can be a helpful in evaluating skills and knowledge. Thus, by being aware of students' views, adjustments can be made to meet their needs.

Only questionnaires for staff and students using WGAS were included. This study comprised of 27% of students, 23.72% of teachers and 40.91% of TAs. Uptake of questionnaires was higher in the main school and lower in the sixth form.

3.7.2. Interviews

To gain further information from participants, semi-structured interviews were conducted with students, teachers and TAs, including deaf TAs. Individual interviews gave participants an opportunity to elaborate on the information within the questionnaires. Group interviews promoted conversation between participants and led to greater detail being shared. Lewis (1992) identified how, 'group interviews help to reveal consensus views' and 'may generate richer responses by allowing participants to challenge one another's views', Consequently, enhancing the reliability of student responses. Semi-structured interviews a given agenda and open-ended questions' (Cohen, 2007). As individual interviews might be intimidating for certain individuals, group interviews were used where appropriate. The focus of the interviews was to gain greater information and to find out why.

Student interviews were collected in July 2022. The students were in years 7,9 and 11 (current 8,10 and 12). Staff interviews were completed in January 2023.

3.7.3. Observations of WGAS

Observational footage was also included through observing WGAS. This enabled, issues to be identified and dealt with as well as good practice observed. Cohen (2007) identifies how observational data comments on the physical environment and the importance of following it up in the interviews to discover participants' responses. Observational data was filmed of year 7,9 and 11 in July 2022 (current years 8,10 and 12). Questionnaires and interviews were also completed by participants.

3.8. Data Analysis

Questionnaires were collated in Excel and checked for accuracy and the transcripts of the interviews were checked for accuracy and corrected as necessary. All data was anonymised. Interview data was transcribed and analysed using NVivo software and the questionnaires were analysed using an Excel spreadsheet to organise. Both methods were used to give a greater understanding and depth to the data. Auld (2007) summarised how Nvivo improved 'the efficiency of the analysis [by] providing greater capability to do more sophisticated comparisons'. However, he also highlighted that analysing by hand 'may allow for a better contextual understanding of the concepts or patterns that emerge from the data analysis'

3.8.1. Quantitative Data Analysis

Questionnaires were transferred to an Excel data sheet to enable quantitative data to be extracted, rather than use an advanced statistical package. Surrusco (2021) highlighted how 'spreadsheets may be more user-friendly' as the skills are more transferrable. Warner (2001) also highlights how using Excel if it is familiar to the

researcher would enable more focus ‘on the statistics and less on the mechanics of the software’. Questions were grouped together to show:

- Ways of connecting
- Ease and difficulties of connectivity
- Confidence in using WGAS.

56 students and 27 staff were included in the study. Cohen (2007) identifies a sample size should be above thirty, ‘if researchers plan to use some form of statistical analysis on their data’. Data was recorded in figures and tables. Percentages of each were then found and used to produce figures. Data analysis was then accomplished using Excel.

3.8.2. Qualitative Data Analysis

The questionnaires, interviews and observational data were analysed by identifying codes and themes in Nvivo and Excel. Nvivo was helpful to identify codes and themes in the larger data. Quotes on the themes were then produced using both Excel and Nvivo. The balance of manual collection and computer software helped the research have a deeper understanding of the data. These provided a narrative for the research and included themes:

- WGA/WGAS
- Sound quality of streaming
- Benefits, issues and solutions with both the streamers and wireless microphones
- Staff connectivity hearing and deaf.

As well as participant opinions and viewpoints, additional themes of the research including how staff benefitted from WGAS were included. Responses were added where it was relevant in tables to provide insights into responses.

3.9. Reflexivity/ Validity of Data

While this study is primarily made up of qualitative research, quantitative was also included. Jick (1979) argues that triangulation allows the researcher to be more confident of the data. The data in this research includes the views of students and staff. Confidence, understanding of the questions and mood can influence how they complete their questionnaires. Interviews gave participants the opportunity to share their thoughts. However, by the nature of semi-structured interviews, each one was different. They also relied on participants to volunteer and as such might draw more confident participants or those who have a particular view (Cohen, 2007).

There may also be unintentional bias due to the research being part of the researcher's job role, as an Educational Audiologist, in an auditory/oral school for the deaf who wants to make changes which are beneficial to the students and enable them to get the most access to sound. To help ameliorate that bias as much as possible students from all year groups in the secondary school and staff from different departments were included in the research.

The data was collected over 6 months therefore some of the issues raised will have been solved before the project is complete. Therefore, the later participants had less experience with WGAS, but initial issues were eradicated.

4. Results

Both quantitative and qualitative data were collected and analysed to gain an understanding of the impact of the wireless adaptations (streaming and microphone technology) on the wireless group aid (WGAS).

4.1. Quantitative results

Quantitative data from the questionnaires has been used to identify:

- comparisons between WGA and WGAS,
- ease and difficulty of wireless connectivity,
- the confidence levels of the users.

4.1.1 Student connectivity

Both connectivity to WGA and WGAS connectivity are illustrated to aid comparisons of clarity, ease of connection and ability to move about in class.

4.1.1.1 Connectivity to the Wired Group Aid (WGA)

Table 15 Methods students connected to WGA

Ways students previously connected to their GA boxes (all boxes were connected to the teacher control unit via a wired connection)	**Number of students**	**Percentage of students**
Direct input leads connected to hearing aids with direct input shoes to GA box.	22	39.29%
Mini-mic connected to GA box through lead connection. Student streaming from the Mini-mic.	16	28.57%
Headphones attached to the GA box via a wire.	6	10.71%
Leads from N6 processor connected to the GA box.	4	7.14%
Didn't connect as new to the school.	4	7.14%
Edumic connected to GA box via a wire. Student streaming from the Edumic.	3	5.36%
Wires connecting both the HA and CI.	1	1.79%
Total	**56**	**100%**

Since the 2012 adaptations to the Group aid (WGA), all students had connected via their WGA box. For most students this was a wired connection, exceptions were the use of headphones. Edumics and Cochlear Mini-mics were then introduced with Oticon[26] and Cochlear upgrades[27] which started off the move to wireless connectivity.

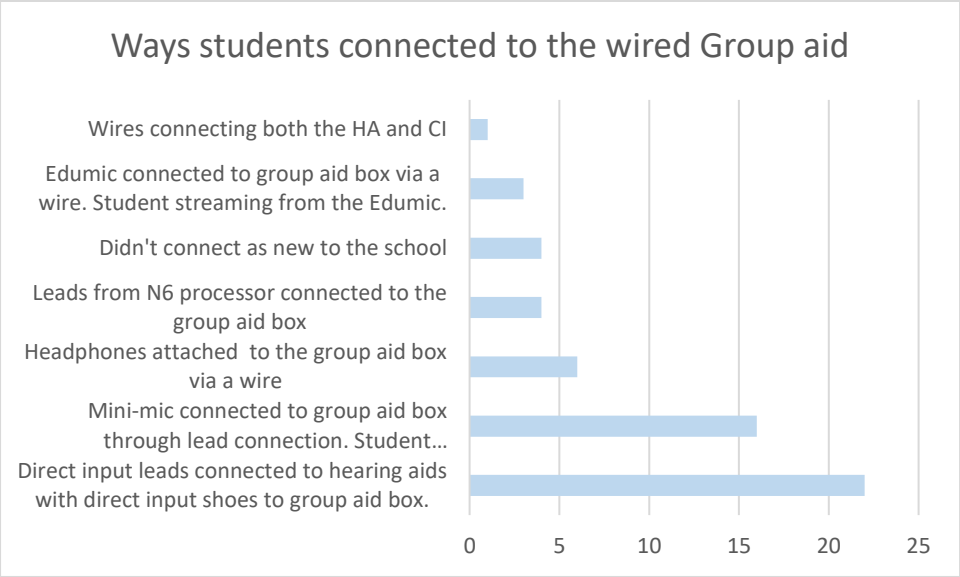


Figure 4 Ways students connected to the wired GA

4.1.1.2 Student connectivity to Wireless Group Aid (WGAS)

Table 16 Ways students connect wirelessly to WGAS

How do students connect to WGAS?	Number of students	Percentage
Connecting to the Phonak TV Connector and having a student Juno microphone.	26	46.43%
Connecting to the Cochlear TV Streamer and having a student Juno microphone.	26	46.43%
Connecting to the Oticon TV Adaptor and having a student Juno microphone.	3	5.36%

[26] Opn Play hearing aids
[27] Nucleus 7 and 8 processors

Connecting to both the Phonak TV Connector and the Cochlear TV Streamer, and having a student Juno microphone.	1	1.78%
Total	56	100%

Connections changed from wired connections to wireless connectivity with the implementation of proprietary streamers. All students within the study data range use streaming technology to connect to WGAS. The difference is the streamer they connect with. Within this research, there was an equal split of students using Phonak and Cochlear streamers (26 of each) and three students using the Oticon streamer, plus, one student connecting to two streamers. The limited number of Oticon HA in this research could be partly due to the Oticon streamers coming into the project later or there being a greater proportion of Phonak HA across the school.

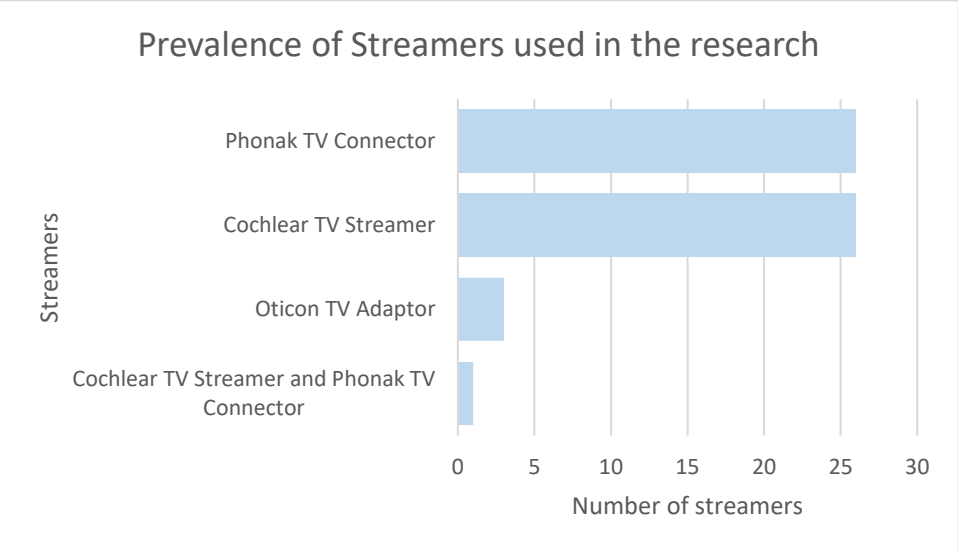


Figure 5 Prevalence of streamers used in the research

4.1.2 Staff connectivity

4.1.2.1 Staff connectivity to WGA

Table 17 Method Staff connected to WGA

How did staff connect to WGA?		Number of staff in survey	Percentage
Teachers	Used Redcat InfraRed microphone connected to the wired GA.	2	14.29%
Teachers	Used Eclarity transmitter microphone.	1	7.14%
Teachers	Used the wired microphone connected to the wired GA.	5	35.71%
Teachers	Used a Juno microphone connected to the wired GA.	1	7.14%
Teachers	without a wired GA system in their classroom.	3	21.43%
Teachers	Returning to the school.	2	14.29%
Teachers	**Total number**	**14**	**100%**
Teaching Assistants	Did not connect.	10	100%
Deaf Teaching assistants	Did not connect.	3	100%

Staff were previously unable to hear WGA despite inputting into it via the teacher microphone as there was not a monitor speaker. Different ways to connect in each department made room changes[28] challenging for teachers. The aim of using the

[28] This was highlighted during the Coronavirus period when teachers changed rooms to minimize student movement.

Juno microphones is consistency. All teachers and TAs now have their own microphones.

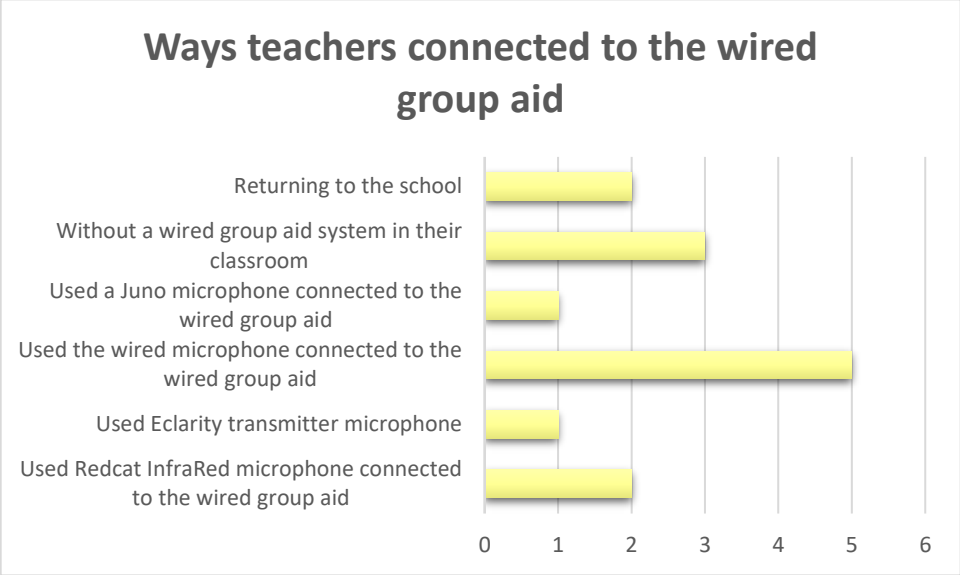


Figure 6 Ways teachers connected to WGA

4.1.2.2 Teacher connectivity to WGAS

WGA teacher connectivity was through a range of teacher microphones. However, with WGAS all teachers use a Juno microphone wherever they teach.

Table 18 Methods Teachers connect to WGAS

How do teachers connect to WGA?	Number of teachers	Percentage
Using the Juno teacher microphone and hearing through the Juno SFS	14	100%
No microphone.	0	0%

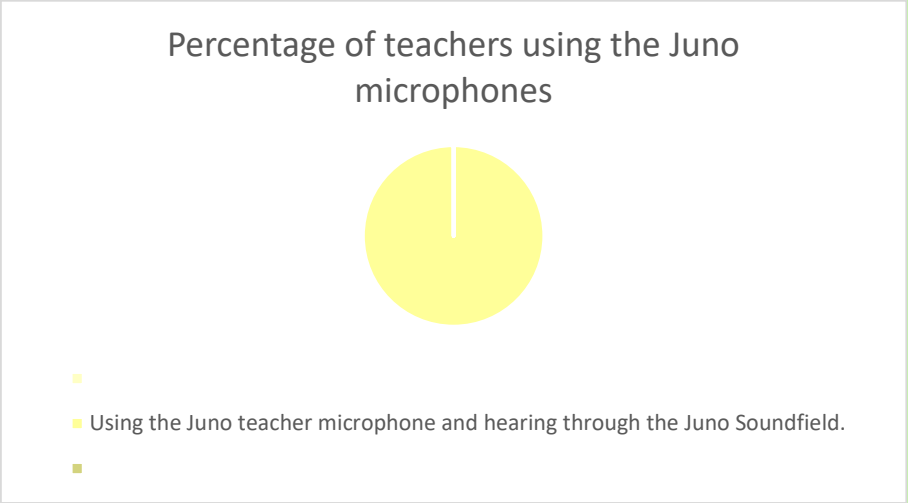


Figure 7 Percentage of Teachers using Juno microphones

4.1.2.3 TA connectivity to WGAS

Table 19 Methods TAs connect to WGAS.

How do TAs connect to the wireless GA?	Number of TAs	Percentage
Using a Juno microphone either handheld or worn on a lanyard.	10	76.92%
Using a Juno microphone either handheld or worn on a lanyard and connecting to the classroom streamers.	3	23.08%

All TAs have microphones to enable them to contribute on WGAS which not only values their contributions but enables them to act as role models to the students (TA13). While all hearing TAs access both teacher and student voices through SFS, all deaf TAs connect directly into WGAS through the streamers. Thus, everyone in the room can hear and contribute which is empowering and embraces inclusivity.

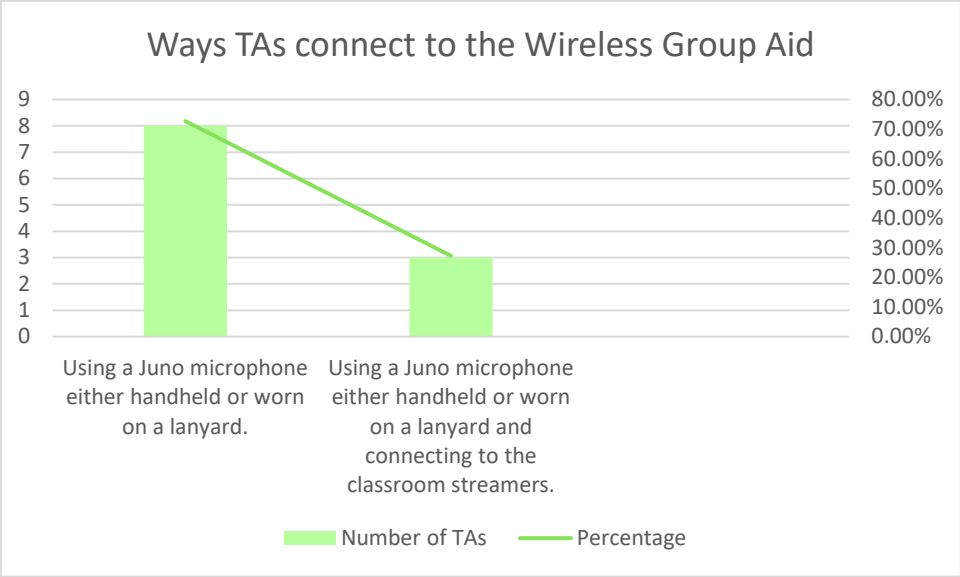


Figure 8 Ways TAs connect to the WGAS

4.1.3 Staff and student ease of connectivity and access WGAS

Table 20 Ease of connecting to WGAS for participants.

How easy do staff and students find connecting to WGAS?					
	Very Easy/ Easy/works well	Better/ much easier/simple/ relatively easy/ quite easy	Generally ok/ medium	Quite difficult/ hard/issues	No answers/ irrelevant answers
Teachers	5 (35.71%)	2 (14.3%)	1 (7.14%)	1 (7.14%)	5 (35.71%)
TAs (hearing)	4 (40%)	1 (10%)	1(10%)	0 (0%)	4 (40%)
TAs (deaf)	3 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
TAs (deaf and hearing)	7 (53.85%)	1 (7.69%)	1 (7.69%)	0 (0%)	4 (30.77%)
Students	37 (66.07%)	5 (8.93%)	5 (8.93%)	2 (3.57%)	7 (12.5%)

The majority of students (66.1%), teachers (35.71%) and TAs (53.85%) found connecting to WGAS, whether through streaming or accessing through the Juno,

easy or very easy. Terminology generated by participants was grouped together to make a scale of ease of use[29].

4.1.4 Staff and student difficulties connecting and accessing WGAS

Table 21 Participants feelings about connectivity to WGAS

Do staff and students have any difficulty connecting to WGAS?					
	No/ None/Nope/very rare	Not really	sometimes	yes	Other answer/N/A I don't know
Teachers	4 (28.57%)	3 (21.43%)	0 (0%)	1 (7.14%)	6 (42.86%)
TAs (hearing)	4 (40%)	1 (10%)	2 (20%)	0	3 (30%)
TAs (deaf)	3 (100%)	0	0	0	0
TAs (hearing and deaf)	7 (53.85%)	1 (7.69%)	2 (15.39%)	0	3 (23.07%)
Students	43 (76.79%)	2 (3.57%)	4 (7.14%)	2 (3.57%)	5 (8.93%)

The majority of students (76.79%), teachers (28.57%) and TAs (53.85%) shared that they had no difficulty connecting to WGAS. Some responses were discounted as they were examples or statements rather than measures of difficulty. Teachers' results were lower than both students and TAs. However, Teachers had a much higher response to 'not really' (21.43%) compared with TAs (7.69%) and students (3.57%). This data reflects the previous chart which identified that most staff and students found it easy to connect.

4.1.5. Staff and student confidence in WGAS

Table 22 Participant confidence levels in using WGAS

Confidence levels of staff and students using WGAS						
	Not confident	A little/ not overly confident	So so/ same as before.	Quite confident/ medium	Confident /very/ pretty/	No answer/ comment

[29] Scale of very easy/easy to quite difficult/hard was created from participants responses. Researcher organised based on grouping synonyms.

					extremely / good confident.	not relevant
Teachers	1 (7.14%)	1 (7.14%)	1 (7.14%)	3 (21.44%)	4 (28.57%)	4 (28.57%)
TAs(hearing)	0	1 (10%)	2 (20%)	3 (30%)	3 (30%)	1 (10%)
TAs (deaf)	0	0	0	1 (33.33%)	2 (66.67%)	0
Teaching Assistants (hearing and deaf)	0	1 (7.69%)	2 (15.39%)	4 (30.77%)	5 (38.46%)	1(7.69%)
Students	2 (3.57%)	2 (3.57%)	6 (10.72%)	11 (19.64%)	23 (41.07%)	12 (21.43%)

Confidence levels in using WGAS was highest for students (41.07%) and 60.71% when including quite/medium confidence. Then deaf TAs with 66.67% for confident and 100% when including quite/medium confidence. Least confident were teachers (28.57%) and 50.1% when including quite confident. However, teachers had the highest level of non-participation for this question. Followed by students with 21.43% no comment. These high levels of no comment for students are reflective of the confidence question being added to the December 2022 questionnaires[30].

In summary, confidence levels of users correlated to how easy/difficult they found using WGAS. For example, student confidence was 41.07%, ease of use 66.7% and having no difficulties 76.79%. While TAs were 38.46% confident and ease of use and no difficulties were both 53.85%. The TA who responded as not overly confident explained that she hadn't 'encountered any trouble within the classroom. Therefore, [she] was not overly confident at dealing with potential issues as she hadn't needed to deal with any'. It would therefore suggest that confidence would increase as participants had more time using WGAS.

[30] 21.43% of student questionnaires were completed in July 2023.

Table 23 Participant opinions on WGAS

Participants	Positive feedback Number and percentage.		Negative feedback Number and percentage.		No response Number and percentage.	
Students	54	96.42%	1	1.79%	1	1.79%
Teachers	10	71.43%	1	7.14%	3	21.43%
TAs	13	100%	0	0%	0	0%

Similarly positive feedback about WGAS was received from most participants (96.42% of students, 71.43% of teachers and 100% of TAs).

4.2. Qualitative analysis

Qualitative results were extracted from the questionnaires, interviews, and observations. Questionnaire data was collated in an Excel spreadsheet. Quotes were taken from data to reflect patterns observed. Additional information from interviews and observations, analysed using Nvivo, was then used to give greater depth to the patterns found in Excel. Patterns were examined to organise questionnaire answers. The research aimed to evidence the impact of wireless adaptations on students, by gathering experiences and perspectives from WGAS users in the classroom.

4.2.1 Wireless Group aid (WGAS) connectivity

Participants described WGAS streaming connectivity. Responses were then categorised into positive responses, concerns and solutions.

4.2.1.1 Positive aspects of WGAS streaming

Table 24 Student quotes highlighting the positives of WGAS streaming.

Positive aspects of WGAS streaming highlighted by students	
S44	Fairly easy because once you’re connected you’re connect once you are in the room [sic].
S5	Easy. Set up once then never again.
S24	relatively easy due to wireless.

S29	It is a lot easier than before because I only have to do one thing.
S42	My hearing aids connect instantly and have a good range.
S50	It's really easy because there is nothing I have to wear and with a single tap on my phone I connect and disconnect instantly.

Students appreciating streaming was reported by all students in the interviews and favourable responses in the questionnaires. A contributing factor was simplicity and the streamers connecting automatically. Mostly students referred to the connectivity as easy (66.1%).

Table 25 Teacher quotes highlighting the positives of WGAS streaming

Positives aspects of streaming highlighted by teachers	
T9	They [students] can hear quiet speakers more clearly and hear the teachers better as long as their own amplification is working properly.
T2	Very straight forward.
T1	It makes a massive difference because they're getting that really good quality input which they previously wouldn't have done.

Similarly, Teachers identified ease of WGAS streaming plus improved access for students. Further benefits included: students hearing quieter students speak, the simplicity of WGAS and good sound quality. However, T9 caveated that this is dependent on personal amplification working.

Table 26 TA quotes highlighting the positives of WGAS streaming.

Positive aspects of streaming highlighted by TAs	
TA6	The pupils seem to be ok now that they regularly go into a classroom, as it connects automatically.
TA7	Very easy to connect to.
TA13	It's fantastic. It's amazing watching when they've connected and the realisation. It's quite empowering for them that it's going directly to them and they can hear the sound.

Likewise, TAs highlighted ease of connectivity. In addition, they shared their observations of students being empowered.

Table 27 Deaf quotes highlighting the benefits of WGAS streaming.

Positive aspects of streaming highlighted by deaf TAs	
TA1	Perfect, very clear. Goes into ear, very close connection.
TA3	It's much clearer.
TA2	It's um louder. A little bit clearer. So I'm more aware of what is going on in the classroom.
TA3	It's been great I think because it blocks out the background noise as well so if like maintenance or anyone's outside working we won't be able to hear that. It's not a distraction once you're connected because it only focus on the teaching of students in the classroom.

Furthermore, deaf TAs[31] appreciated streaming themselves and shared their personal experience of using WGAS. Clarity and loudness related to the student response. TA3 also observed that unwanted background noise was also reduced making it was easier to hear the speaker using the microphone.

Multiple benefits focused on sound quality and greater access to sound. Although TA2 carefully pointed out that while WGAS made the sound louder it didn't make it suddenly intelligible. They still needed to be able to lipread. However, it did cue them in to listening. TA3 clarified how 'there are still some sounds that I might miss out but it's definitely better.'

4.2.1.2 WGAS Streaming Concerns

While strengths were identified, some concerns were observed regarding streaming. Many concerns were solved during the research and have guided training and support of both staff and students.

Table 28 Student quotes highlighting concerns related to WGAS streaming

Concerns with WGAS streaming highlighted by students	
S40	Disconnects, hard to connect, connects to other classrooms.
S14	I find it difficult because sometimes it turn off/on automatically.

[31] One had a processor and two had hearing aids.

S19	I prefer to hear through my preference.
S48	It's too loud in the implants.
S37	Obviously, I'm so deaf I can barely hear.

.

Firstly, students identified personal amplification connecting to streamers in other classrooms or disconnecting from the streamer within the classroom. Communication with students has helped identify the concern and enable instances to be solved more easily, for example securing the position of streamers on shelves in the classrooms. S40 shared that they liked to know solution in case they happened again.

Secondly, a preference not to stream was highlighted with three students who found it too loud or distant, preferred their personal amplification. Another shared they were so deaf they could barely hear.

Table 29 Teacher quotes highlighting concerns related to WGAS streaming

Concerns with WGAS streaming highlighted by teachers	
T8	Trust that all pupils are definitely connected – as there are so many different pieces of equipment.
T13	Cable management with lots of streamers etc.
T10	I have no idea who is connected or what to do when pupils say their peers are too loud.
T2	Reliance on students to give honest responses when asked about their auditory experiences.

While Teachers raised concerns related to knowing if students were connected, managing streamers and what to do if something goes wrong. Training opportunities, classroom visits and posters about the streamers (Figure 1) have been used to support these concerns.

Table 30 TA quotes highlighting concerns related to WGAS streaming.

Concerns with WGAS streaming highlighted by TAs	
TA6	I can find different models i.e. cochlears difficult to remember how each one connects.
TA13	Sometimes it picks up the next the classroom next door that's the only thing I think we've had a few teething problems.
TA7	Some students are reluctant to use it. They're not going to tell you if they're not connected because they don't want to connect.

Similarly, to students, TAs highlighted WGAS connectivity concerns but linked them with teething trouble. Like teachers, management of the streamers was raised. However, they also highlighted how reluctant users may not share connection issues. This observational feedback connects student and teacher concerns.

Table 31 Deaf TAs quotes highlighting concerns related to WGAS streaming.

Concerns with WGAS streaming highlighted by deaf TAs	
TA 1	[They] don't turn off automatically.
TA 3	Annoying having to connect in every room at the start.

Minimal WGAS connectivity concerns were recorded by deaf TAs. These related to connecting for the first time classroom and sometimes the connection remaining despite changing room. This feedback helped remind staff that if students have new personal amplification, they will need to reconnect. Likewise, the need for students to disconnect and reconnect manually if this hasn’t happened automatically.

4.2.1.3 Solutions to WGAS streaming

Table 32 Student quotes highlighting solutions to WGAS streaming concerns

Solutions to WGAS streaming concerns highlighted by students

S7	I don’t know, maybe speaking to Audiology.
S10	Audiology would come.
S38	You can't to be honest. Obviously, I'm so deaf I can barely hear.
S39	Just more simple connectors.
S48	Have different ways of connectivity.
S56	Someone reminds me.

The majority (89.29%) felt there were no need for solutions. Students who gave suggestions for solutions identified connectivity being simplified, reminders and help from Audiology. A profoundly deaf student shared that being deaf meant there was no solution. When followed up they explained that even with WGAS equipment, they needed to lipread to understand.

Table 33 Teacher quotes highlighting solutions to WGAS streaming concerns

Solutions to WGAS streaming concerns highlighted by teachers	
T2	Benefitted from individual chat through set up and what I can expect e.g. when a class walks in.
T14	List next to names on SIMs of pupils' audiological equipment.
T1	Read up again on the sort of connections, because we did it all at the beginning of the year and I was lucky that with a lot of my classes, so I'm I think if there was an issue about connecting, I'd probably have to double check what they needed to do for their particular equipment to make sure that they were reconnecting,
T1	I've got TAs who are very switched on for switching on the students. They know how to connect, so I haven't had to do an awful lot of that myself.
T9	I think I could do with 1:1 instruction and a help sheet for all the different models that connect to the Juno.

Interviews highlighted that teachers wanted the reassurance of knowing who connects to each streamer and seeing that students were connected. With WGAS

streaming, cues are more subtle[32]. In addition to support and working with the TAs in their classrooms.

Table 34 TA quotes highlighting solutions to WGAS streaming concerns

Solutions to WGAS streaming concerns highlighted by TAs	
TA9	An UpToDate register of which pupils use what connector.
TA10	It's made it easier with the instructions.
TA6	Training and a reminder sheet.

TAs focussed on practical solutions including training, instructions and reminders.

Table 35 Deaf TA quotes highlighting solutions to WGAS streaming concerns.

Solutions to WGAS streaming concerns highlighted by deaf TAs	
TA 1	Turn off manually.
TA 3	Once you connect in one room you don't need to connect again.

As deaf TAs had very few concerns, minimal solutions were identified. The solution to switch off streaming manually[33] was identified if a streamer would not disconnect. This can occur if students are connected to adjacent streamers, but one teacher isn't using WGAS or they are in an intervention room without WGAS.

4.2.1.4 Ways all TAs know students are connected

Table 36 TA quotes highlighting how they know students are connected

Ways TAs know the students are connected highlighted by TAs	
TA13	You know if they've gone into a new room because they're still quite fidgety. They're looking around but once they're connected they seem more engaged.
TA1	Their eyes light up and they're like oh oh this is good and they're more awake and they're feeling yeah at least more confident I think and they're willing to learn and actually listening a lot longer they seem to listen a lot longer than before they don't get as tired.
TA12	Observing how the students connect – Some connect easily and it is obvious that they have connected.

[32] See table 68 in Discussion
[33] See Flight mode in Terminology Table 2

TA3	I see some changes in students as well. They're able to understand the teacher clearly and able to engage with their group as well and it's nicer because it's not connected to the table like the old original ones.

TAs shared how they knew students were connected. Having not previously had a screen to check connectivity, they were more reliant on observations. Body language and lesson engagement were highlighted. TAs also can observe students in lessons.

Table 37 TA quotes highlighting the impact of first connection to WGAS streaming

TA observations of students when first connected	
TA13	It was just amazing. It was one of those little bits of a lightbulb moment and it's just quite a breakthrough really nice’

Similarly, TA13 shared an observation of a student when first connected and the positive impact it had one both themself and the student.

4.2.2 Student microphones

Participants were asked for their views on the wireless microphones. Responses were then categorised into positive responses, concerns and solutions.

4.2.2.1 Positive aspects of microphone use

Table 38 Student quotes highlighting the positives of microphone use

Positive aspects of microphones highlighted by students	
S1	Louder, clearer.
S2	I can hear my voice better.
S5	Everybody can hear when you talk.
S44	They are easier to carry around. Hear better when they hold it properly.
S42	The microphones are much better as you don't have consistently wear it. Microphones are smaller and easier to use.
S34	Can take [sic] any rooms. Carry the microphones.
S7	Every student has a microphone.

Positive student responses included the microphones being louder, clearer and easier to carry around. Students found being heard by everyone when they spoke important and hearing their own voice as well as the benefit of being able to hold the microphone rather than wearing it if they wanted[34].

Table 39 Teacher quotes highlighting the positives of microphone use

Positive aspects of microphones highlighted by teachers	
T13	I can hear if it is working or not and I can adjust volume easily.
T14	fantastic amplification around the room.
T10	I like the Soundfield of the Juno.

While some teachers (21.43%) had used wireless microphones[35], most teachers (35.71%) had wired microphones which limited movement. Therefore, the ability to move around the room has been a benefit in addition to the amplification from the Juno enabling teachers to hear WGAS.

Table 40 TA quotes highlighting the positives of microphones for all

Positive aspects of microphone use for staff and students highlighted by TAs	
TA10	Everyone can hear clearly.
TA4	When reading aloud or having discussions, everyone can hear clearly what is said.
TA9	Easier for me with microphone.
TA7	Simple, just turn on the microphone in any room and it will connect.
TA8	It helps pupils and adults to see who is talking. Much clearer.
TA7	It's obviously helpful for the pupils because they can hear their peers better but also it's helpful for staff because some of our pupils are quite shy and very quiet. So it means we can hear them better as well.
TA5	If you're just hearing the teacher all the time you don't know what other children say. if you want to have a conversation within the classroom you can have a conversation because you can hear what that person says then you can answer them. As opposed to waiting for the teacher to say what that student is said and it just flows more naturally as a conversation in the classroom.

[34] The WGA microphone was attached to the GA box which needed to be worn around the neck.
[35] Juno or Redcat microphone

TAs highlighted the ease of having their own microphone and the simplicity of it working in any room. Plus, the benefits of knowing who is speaking and being able to hear everyone clearly. Rather than the teacher needing to repeat back student comments, they had been accessed first hand.

Table 41 Deaf TAs highlighting the benefits of microphones for all

Benefits of microphone use for staff and students highlighted by deaf TAs	
TA 1	I can hear who is talking. The students enjoy using the microphone because they can hear their own voices and they are quite aware that it sounds different. If what they're saying is not the right thing, they kind of self-correct themselves. Also beneficial for them to hear the other children talking to each other because some children's voices are much softer than the others. For example one child in our class has a particularly soft voice. Quite a few of the other children can't always hear him but when he has the microphone, they were like, 'Oh yes he can talk, yes I can hear what he is saying'. It's definitely a bonus.
TA 2	It makes me aware of that someone is speaking. I can see who is talking as they pick their microphones up.
TA 3	Perfect, very clear. Goes into ear, very close connection.

Similarly, deaf staff highlighted the benefits of the microphones included being able to hear what was said and knowing who is speaking.

4.2.3.2 Concerns regarding the student microphones

Table 42 Student quotes highlighting concerns regarding student microphones

Concerns about the microphones highlighted by students	
S43	They are not being used efficiently.
S44	I prefer the microphones. It's clearer but it can get too loud sometimes and there is some feedback sometimes.
S35	You didn't have to charge the box GA but microphones you do.
S9	I am quite confident but I struggle to remember to turn my mic on.
S4	Two people can't talk at once. Sometimes there are buzzing sounds.
S27	Must remember to switch off when other person is talking, too close and not hear the speech [sic].

A range of microphone concerns were raised including, lack of efficiency, needing charging, and being forgotten. In addition, how they are used, for example, students needing to remember to switch them on.

Table 43Teacher quotes highlighting concerns regarding student microphones

Concerns about the use of student microphones highlighted by teachers	
T12	There are some challenges when the students use their microphones incorrectly (e.g., blowing on them, or holding them to close). This tend to rectify fairly quickly as their peers don't like it.
T12	It can be incredibly painful getting them to actually use them in the first place.
T2	My main concern is that in the limited time that I have been back at MH, very few of the students are using the microphones.
T7	It is difficult to have the students to use them as it breaks the discussion.
T8	There is a delay with them not wearing them so we have to wait for them to pick them up and then switch on.

Similarly, teachers highlighted concerns regarding microphone use include correct use, under use and a delay in conversation.

Table 44 TA quotes highlighting concerns regarding student microphones

Concerns about the use of student microphones highlighted by TAs	
TA 10	Getting the pupils to use the mics.
TA 5	Pupils losing them! Reminding pupils to put them down and switch off when not in use.
TA5	A lot of them like to use it like handheld as opposed to using the neck strap but then the problem with that is when they do either too close to the mouth or they do it too far away so you're trying to get them to get the right distance from the mouth.
TA7	They've got out of the habit of using the GA system.

Furthermore, TAs highlighted management and use of microphones as concerns. TA7 summed it up as everyone being out of the habit of using WGA.

Table 45 Deaf TA quotes highlighting concerns regarding student microphones

Concerns about the use of student microphones highlighted by deaf TAs	
TA2	Consistency of microphones being used in classrooms.
TA1	They hadn't charged.
TA3	Issues with students losing them or misplacing them and it's quite time consuming going around trying to find their microphone.
TA2	So yes it has made me a little bit more aware of what is being said.

Deaf TAs also highlight concerns around consistency of use, students having the microphones in every lesson and not losing them. This may be as the microphones are so different to WGA. However, to make WGAS work efficiently they need to be addressed.

4.2.2.3 Solutions to microphone concerns

Table 46 Student quotes highlighting solutions to microphone concerns

Solutions to microphone concerns highlighted by students	
S42	Remembering to pick it up when talking but it is not that big [sic] of a challenge. Also not losing microphone and remembering to charge it.
S40	Teachers actually telling us to use them.
S35	Nothing. one person turns it on and takes turn to turn it on.
S12	By contacting Audiology.
S27	Not sure hold away distance [sic].

Some students (67.86%) gave no solutions for microphone concerns, S35 summed it up as, 'one person turns it on and talks.' Others felt Audiology would solve problems (1.79%). However, practical advice, on how to hold the microphones (1.79%) and support as well as reminders (7.14%) and charge the microphones (1.79%) were also raised. These focused on classroom routines and expectations; making the use of the microphones part of the normal way of working.

Table 47 Teacher quotes highlighting solutions to microphone concerns for themselves

Solutions to support teachers with microphones highlighted by teachers	
T12	Remember to charge my microphone! Longer form time in the morning to make sure pupils are leaving with all the right audiological equipment.
T2	Benefitted from individual chat through set up and what I can expect e.g. when a class walks in..
T9	I think I could do with 1:1 instruction and a help sheet

Teachers identified solutions for both staff and students. Some of these were personal and others focused on logistics or training. For example, remembering to charge the microphone and extending form time to enable tutors to check personal amplification as well as ensuring the GA equipment is managed well.

Table 48 Teacher quotes highlighting solutions to microphone concerns for students

Solutions to support students with microphones highlighted by teachers	
T12	Staff expectations that students must come prepared to lessons Some spare microphones (perhaps marked in some way) for students to borrow so that at uncharged microphone is not seen as an excuse to not use it all day.
T2	Making everyone i.e. students buy into the system i.e. trying to dissuade them that it is enough to just rely on their aids/CI and lip-reading (or friends) and instead appreciate the benefits of optimal amplification.
T8	I feel all students should be wearing them in lessons at all times then we would reduce the time delay and the conversation would be more natural in terms of spontaneity and with no delay in waiting.
T5	Groups will become more proficient at switching this on and off - dependent on all teachers using them effectively in ALL lessons.

To support students, teachers identified solutions centred around students having a greater understanding of how WGAS helps them. With staff expectations being clear to enable students to know what is expected of them. Students also being encouraged to use the microphones to enable them to use them more proficiently, particularly switching the microphones on and off.

Table 49 TA quotes highlighting solutions to microphone concerns for students

Solutions to microphone concerns for students highlighted by TAs	
TA7	Teachers getting pupils to use the microphone.
TA13	We encourage the students to use them.
TA5	You have to just do that little nudge, 'remember your microphones' so they'll do it and then we'll speak. Sometimes they'll naturally pick them up and other times you sort of have to give them a nudge. Don't forget your microphones' she sums up, 'again that's just gonna come with like practice' - a matter of time and consistent use within all lessons.

Likewise, TA solutions focused on staff supporting students, consistency and time. There was a consensus on the impact of the microphones. However, getting the microphones used consistently was also raised. TA7 summarised, 'I think the teacher mic and the SFS itself has been a huge benefit but the pupils themselves are reluctant to use the microphones.' However, TA5 highlighted how TAs can actively encourage students to support their use.

Table 50 Deaf TA quotes highlighting solutions to microphone concerns

Solutions to microphone concerns for students highlighted by deaf TAs	
TA3	Perhaps leaving mics in classrooms and any student can use it when they are in that lesson.
TA3	Time to get used to it. It is much easier for them to have it in their school bags or in their blazers.

Deaf TA solution suggested were based on microphone management and organisation. Microphones kept in classrooms or a set off microphones for each classroom were suggested.

4.2.3 Teacher connectivity

Teachers changed from using a range of microphones (see table 17) to all using Juno microphone regardless of where they taught.

4.2.3.1 Ease of connectivity for teachers to WGAS

Table 51 Teacher quotes highlighting the ease of connecting/ accessing to WGAS

Teacher ease of connectivity to WGAS highlighted by teachers	
T2	Use of teacher mic better as it is wireless. Teacher mic is excellent.
T13	It is much easier to connect via the Juno mic, only one button press needed, and I am free to move around as I am not tethered by a wire.
T12	Personally, it helps my voice and I feel more confident that what I am saying is going directly to the students.

All teachers (100%) found wireless microphones made connectivity to WGAS much easier, particularly as they were no longer connected by a wire. Thus enabling them to move around the classroom. Supporting their voices was also highlighted.

4.2.3.2 Difficulties for teachers connecting to WGAS

Table 52 Teacher quotes highlighting connectivity/ access concerns to WGAS

Any difficulties connecting/ accessing WGAS highlighted by teachers	
T12	Only when my microphone wasn't properly charged.
T10	Not personally, though sometimes my mic can be heard next door even though I have checked streamer pointing in the right direction.

The issues with teacher connectivity related to teachers charging their microphones and streamers connecting in another classroom. As part of action research, additional charging cables with plugs were issued to support charging issues. Positioning of the streamers was followed up to ensure students were connecting to the correct streamer.

4.2.4 Confidence levels of WGAS users

Table 53 Student quotes highlighting their confidence levels in using WGAS

Confidence levels of students using WGAS	
S10	Very confident because it's very easy.
S37	it is good, it is easy.
S50	Fairly confident but there's still more to learn.

Student confidence (60.71%) in using WGAS was related to ease of use and the ability to learn.

Table 54 Teacher quotes highlighting their confidence levels in using WGAS

Confidence levels of teachers using WGAS	
T1	Training sessions have been useful.
T2	I feel more confident about knowing what to check should there be any problems.

Similarly, teachers related their confidence levels to training and understanding the equipment.

Table 55 TAs quotes highlighting their confidence levels in using WGAS

Confidence levels of TAs using WGAS	
TA9	Reasonably confident but I have been unable to solve some problems. Great support from Audiology!
TA6	More confident that the old system. I need to learn more about each model and how it connects and streams.
TA5	I haven't encountered any trouble within the classroom. Therefore, not overly confident.
TA12	The more I troubleshoot in classrooms, the more confident I am getting with the new system. Learning about the various issues that are arising and the different solutions to try is helping to improve my knowledge.

Likewise, TA confidence was linked to wanting to learn more and solving concerns. TA12 related increased confidence to experience of WGAS.

Table 56 TA quotes highlighting their confidence levels in using WGAS

Confidence levels of deaf TA participants	
TA1	Very.
TA2	Medium.
TA3	Pretty confident.

While deaf TA confidence wasn't discussed explicitly, all three participants discussed their experiences and positive confidence levels were recorded in the interviews.

4.2.5 Comparing WGAS with WGA

Participants compared the wireless adaptions of WGAS to the previous WGA.

Table 57 Student quotes comparing WGAS with WGA

Comparing WGAS with the previous WGA highlighted by students	
S3	The microphone is a little louder than the GA box.
S4	It is a clearer sound. Quick talking with no effort to connect. More mobile.
S20	'I don't want to wear old GA again but I don't mind to wear the new one because it are much better than old one.
S9	They are less fiddly than a GA. They allow me to connect and I can hear a difference.
S41	You just pick it up and switch it on. You don't have to carry the bag anymore and not annoying around neck.

Student responses were positive (96.42%) towards WGAS. Students identified clearer sound which was a little louder as important in addition to ease of use and connectivity. Plus, not having to wear the WGA box was highlighted. S20 concluded that they didn't want to wear WGA but didn't mind WGAS.

Table 58 Teacher quotes comparing WGAS with WGA

Comparing WGAS to the previous WGA (For staff and pupils) highlighted by teachers	
T9	The students seem ok with using the new microphone. They found the GA system a little bulky. They didn't like carrying it around and plugging it in. The wires were also an issue and some of them needed constant changing as they wouldn't work during lessons.
T13	Not sure only because only now can I actually hear the output via the Juno.
T1	It [WGA] still involved quite a lot of faf in terms of getting them to plug in, and of course, once they were plugged in, they were tied to the front desk.
T5	Clear sound -easy to know that they are working [wireless]. Microphones on GAs could all be on at the same time and the teacher had overall control of which mics were on or off [wired].

Similarly, teachers shared negatives about bulky WGA equipment and the time it took to connect WGA in lessons. Plus positives about being able to hear WGAS and the speed of connectivity. However, T5 highlighted how they missed having control over pupil microphones which they did with WGA.

Table 59 TA quotes comparing WGAS with WGA

Comparing WGAS to the previous WGA highlighted by TAs	
TA10	Much better but not always used.
TA13	It's fantastic. Let's have it everywhere.
TA7	Much better, much better than the other one. Is not having to plug everybody in every time in different rooms. They don't have to have the box around their necks which they hated you know if they choose to wear the microphone around their necks it's you forget it's there it's so light and you don't have to be attached to a wire which is brilliant.

Furthermore, TAs shared that WGAS was 'much better' due to not having to plug all students in every lesson and students not needing to wear their microphones. Although one highlighted WGAS microphones were not always used. TA13 concluded WGAS by saying, 'it's fantastic. Let's have it everywhere.'

Table 60 Deaf TAs quotes comparing WGAS with WGA

Comparing WGAS to the previous WGA highlighted by deaf TAs	
TA3	Much lighter and modern looking.
TA2	Less time setting up.
TA3	Good amplification and less things to carry.
TA3	They're able to understand teacher clearly and able to engage with their group as well and it's nicer because it's not connected to the table like the old original ones.

Similarly, deaf TA comparisons reiterated those of other participants plus stating the good amplification of WGAS.

4.2.6 Benefits of WGAS for students and staff

The students were able to identify benefits for staff as well as themselves.

Table 61 Student quotes regarding the benefits of WGAS for staff

Benefits of the WGAS for staff	
S3	It is good for adults more understand what pupils say [sic].
S19	Microphones allow the others to hear me.

Students felt that staff and their peers being able to hear what they said through use of the microphones was a benefits.

Table 62 Student quotes regarding the benefits of WGAS for students

Benefits of WGAS for students	
S40	They’re easier to carry and don't annoy my neck/they don't hurt your neck.
S36	Easy, doesn't carry as much weight, better quality.
S29	It is a lot easier to use and is not so heavy.
S25	Not a big box on your neck.
S28	It is much easier to carry round/ microphones are much easier to hold, whereas, the GA box you have to have a separate bag with the equipment.
S20	Lighter and more louder [sic].
S39	Blocks background noise.

For themselves, the students included benefits as: ease of use, lightweight and background noise blocked out. For example, S50 shared how the teacher with their microphone was always clear but if the student microphones were not used, they could not hear himself or his peers clearly.

Table 63 Teachers quotes regarding the benefits of WGAS for staff

Benefits of WGAS for staff highlighted by teachers	
T12	I feel more confident that what I am saying is going directly to the students.
T1	Less lesson time wasted on GA issues, easier to move students in lessons.
T13	Only now can I actually hear the output via the Juno.
T6	The TA using a handheld.
T3	The staff mic is easier to use-wireless really helps in a larger, practical space.

Teachers identified hearing WGAS through the SFS and less time being spent on WGA issues.

Table 64 Teacher quotes regarding the benefits of WGAS for students

Benefits of WGAS for students highlighted by teachers	
T12	You can see them receiving clearer messages.

T2	Allows everyone in the group to benefit from enhanced sound, even in a horseshoe.
T11	Teacher mic is excellent

While some teachers expressed concern at not being able to see if students were connected, others observed students receiving a clearer message and reflected how students benefitted from hearing each other.

Table 65 TA quotes regarding the benefits of WGAS for staff

Benefits of WGAS for staff highlighted by TAs	
TA10	Everyone can hear clearly.
TA11	Hands free for teachers.
TA7	As staff, we can hear what the pupils hear.

Staff being able to hear WGAS and teachers wirelessly connecting were highlighted.

Table 66 TA quotes regarding the benefits of WGAS for students

Benefits of WGAS for students highlighted by TAs	
TA5	Pupils can hear one another better than just using their voice and staff too.
TA12	I was aware how clear everyone's voices were. Compared to students talking without the mics a lot more could be heard. It created a nice, relaxed discussion.
TA9	Less to carry and more popular with pupils.

Similarly, observations revolved around how much clearer student voices were and improved pupil opinion.

Table 67 Deaf TA quotes highlighting how WGAS has benefitted students

Benefits of WGAS for students	
TA1	I've noticed that when they are on they light up their eyes light up and they're like oh oh this is good and they're more awake.
TA3	Good amplification and less things to carry.

TA1	Teacher uses it well for getting students to listen to each other. When watching the video. They can seem to understand what they're saying. So, you don't have to stop and pause it as much.
TA1	They can hear their own voices
TA2	Less time setting up.

Likewise, deaf TAs centred student benefits around the amplification, hearing their own voices and organisation of use.

Table 68 Deaf TAs highlights the benefits of WGAS for deaf staff

Benefits of WGAS for deaf staff	
TA1	I still have to listen harder. It won't solve the problem but it really helps me just to um keep on top of things. Sometimes I miss out. With the stream on I can actually pick up what's going on because it's it goes in the ear and this goes to the brain very quickly. That there's not such a delay. It seems to be quicker message if you see what I mean. It sends a message to the brain. It's a lot quicker than before you have to process a bit longer so with the stream you don't seem to process as slowly.
TA3	Once you connect to that classroom is absolutely fine and it's good amplification as well once you in that classroom once you are connected.
TA2	'Maybe if I could understand it clearer then I'd be more interested.'

Deaf TAs reflected on their experiences to illustrate how they benefitted. Increased engagement, quicker message and greater understanding were included. TA3 concluded that it is good amplification. TA2 shared his realisation that being able to hear better directly correlated with lesson engagement, 'Maybe if I could understand it clearer then I'd be more interested.' TA3 then sums up 'I think it just takes time but once we keep encouraging them and enforcing it it'll be a great system to use'.

4.2.7 Solutions to WGAS concerns

Table 69 TA quotes on solutions to WGAS concerns

Solutions to WGAS concerns

TA12	Training for both teachers and students on the importance of using the system properly. Practical demonstrations of the improvement in access.
TA12	With Marvel hearing aids you can hear a little tune playing that indicates it is pairing. Listening with a stetaclip allows you to hear if the hearing aid has connected. Looking at the lights on the processors indicates whether they have paired or not. Also checking that they output is set high enough on the Juno to prevent disconnection.
TA6	Training and a reminder sheet.
TA5	Getting into a habit of constant use in each lesson and using every time the pupils speak.

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As TAs can observe classroom practice, they were able to identify solutions to WGAS in addition to using visual and auditory cues to check student connectivity. These included training and guides to support use in addition to forming habits.

4.3 Results conclusion

The four participant groups shared their views, each from different perspectives: students receiving their learning through WGAs, teachers using WGAS for lesson delivery, TAs being active participants within the lesson and deaf TAs also accessing through WGAS. TAs have been crucial in this project as they move from class to class with the students. Their modelling of the equipment and highlighting concerns in classrooms has helped the researcher identify concerns and solutions. Their confidence in using the equipment is also reflected in the successes in the classroom.

Similarly, feedback from deaf staff has enabled hearing users to understand the impact of WGAS. This information has been used in staff training and to support students. One deaf TA reported when she first connected, ‘Oh, wow. That is so much clearer. I can hear you speaking without looking at you. I can hear your accent. Your voice is so much clearer. I can hear sound I’ve never heard before’. Another shared how it improved the listening experience. While another shared, ‘I still can’t hear the teacher with WGAS but it is easier to lipread – clearer – easier to

understand. It helps me to know who is talking.’ A reminder that while WGAS will not restore hearing, the aim is to provide optimal access.

In summary, both quantitative and qualitative results have shown that WGAS adaptations have impacted positively on learners in the classroom. The research has identified positive responses to WGAS wireless adaptations (streamers and microphones) as well as concerns and solutions. Including staff in addition to students in this study has enabled the researcher to gain a greater depth of understanding of the impact of the adaptations.

5. Discussion

In this study exploring the impact of WGAS technology on learners in the classroom, the views of staff and pupils has been invaluable. Despite Mary Hare's WGA being over 30 years old, there has been minimal research specifically on Group aids. Over a quarter of teachers, TAs and students, participated in this study which has provided different perspectives of the impact of WGAS technology on learners and staff in the classroom. The study has captured many positives points as well as areas for development and solutions.

5.1 Impact of WGAS adaptations

WGAS aim is to give the students the best possible access to sound. S40 explains how, 'It is a lot easier to use and is not so heavy'. Dickenson (2011) highlights how 'children spend a considerable proportion of each school day in activities that involve listening.' Similarly, Mealings (2022) highlights 'the better a child can hear, the more able they are to learn.' This is particularly the case in an Auditory/oral environment. Therefore, Thibodeau (2020) identifies the ability to enhance SNR between listener and the talker as the 'greatest impact of wireless technology advances.' Flexer (2002) shared how through SFS microphone use, 'amplified voice[s] can sound soothing, as [they are] evenly distributed throughout the room to reach every child.' The Front Row Juno SFS was chosen as a neutral platform for WGAS as it works on InfraRed technology and thus reduce the chance of interference with the different wireless streamers using 2.4GHz. Ward (2023) explains how SFS, 'send signals via invisible light beams [which need a clear line of sight. Consequently] the audio cannot be picked up outside the room', ensuring signal does not leak between classrooms and meaning teachers can use their microphone in any classroom.

5.2 WGAS Streamers

5.2.1 WGAS streaming directly to personal amplification.

WGAS streaming enables students to connect in every classroom wirelessly. Students connect automatically[36] when they enter the classroom which is less time consuming and gives more time to the curriculum (T1). Stream directly to their personal amplification has been popular, 89.29% of students gave positive feedback about streaming. S42 highlighted how their HAs 'connect instantly and have a good range.' Quilter (2017) identifies how streaming technology makes for a lighter weight, discreet system'. Similarly, TAs have observed students actively using streaming in class. Najeeb (2022) identifies, how 'users are motivated to use their HAs' due to the integration of the latest technology. T9 cautioned providing that their own amplification is working properly. Through this research, streaming failing due to moisture in HAs has been identified[37] further highlighting the benefits of dry boxes[38]. More research into this correlation is needed with both HAs and CIs to identify why this occurs.

5.2.2 Increased student focus

Increased student focus in lessons through streaming was observed, TA13 explained how 'it's quite empowering for [the students] that it's going directly to them, and they can hear the sound.' Gheller (2019) highlights how 'permanent exposure to inadequate listening conditions in [schools] may compromise the learning experience'. Similarly, Ross (1973) explains that if 'students aren't accessing, their school experience will be compromised.' Thus, the importance of ensuring students can access through WGAS and it is working effectively. NDCS (2017) cautioned 'where SFS are used in conjunction with ALDs, equipment must

[36] See Methodology Section 3.5.2 WGAS Streamers
[37] Mary Hare research 2022: Students were reporting that their personal amplification had stopped streaming. Findings: use of puffers in the short term and Dryboxes every night helped alleviated this.
[38] Mary Hare drybox research Spring 2021 found that students who used a drybox each night had greater accuracy with the Ling sounds in morning hearing checks.

be selected and set up to ensure that the performance of the ALD is not compromised.'

5.2.3 Listening fatigue

The majority of students (89.29%) found streaming a positive experience. Both students and deaf staff emphasised how they were less tired when streaming. Deaf staff can now access WGAS. TA9 shared how talking to TA2 helped them understand the benefits of WGAS. TA3 highlights that while WGAS doesn't restore normal hearing, it does help them access and reduces listening fatigue. Eberts (2019) explained that 'when less brain energy is used for physically hearing the information, more of it can be committed to memory'.

5.2.4 Student voice

However, S15 explained that they don't like the sound of WGAS as it sounds distant; preferring quiet and wanting control over what they heard. Morris (2017) identified that unlike their personal amplification, users 'have to rely on others to be able to use RAS correctly'. While turning off streaming is possible[39], further discussion with the student and their teachers would be needed to ensure vital learning wasn't missed. Johnson (2015) identifies how opportunities for meaningful experiences should be provided to enable students to make informed choices regarding usage. However, NDCS (2017) reiterates how most deaf children with personal amplification continue to need the superior SNR provided by ALDs, including WGAS. Thus staff need training to enable WGAS to be used effectively and students supported effectively.

[39] (see Aeroplane mode in Definitions).

5.2.5 Cues on connectivity

Several teachers highlighted that they cannot easily see if students are connected, missing the ability to see connectivity on WGA teacher control panel[40]. T10 shared, 'I have no idea who is connected.' Similarly, T2 explained how it's hard to know whether students are connected without testing each student, which is time consuming. Thus, they were trusting that students were connected.

However, TAs were more confident that they could tell when students were connected. TAs cited, examples of body language, increased concentration, and greater access as evidence of connection. TAs hadn't used the teacher control panel on WGA. Thus, they were already skilled in discretely checking students were connected through visual checks of equipment and noticing if students were actively engaged. TAs can be attached to a class which may help them know the students better and identify cues while the teacher is delivering the lesson. T1 explained, how they hadn't needed to solve issues as the TAs 'are very switched on for switching on the students. They know how to connect.' A conclusion drawn from this might be the importance of all adults in the classroom working together to have a consistent approach in all classrooms. Giving teachers time to observe their classes, through team teaching with another teacher or the Educational Audiologist could feature in further research.

Table 70 Indications that students are connected and accessing WGAS

Indicator	**Ways to identify if a student is streaming**
Lights	If a student has the lights enabled on their personal amplification, a blue light will show when connected. For example, Cochlear has the flashing Blue indication light on their processors confirming that they are connected to WGAS. Therefore, a visual cue to connectivity is lights.

[40] Appendix I

HA tune	With HAs, a tune will play as they connect. Use of a stetoclip to listen to the HAs, will also check connectivity and trouble shoot.
Juno SFS	If the teacher does not hear their voice through the Juno, it reminds them they are muted on their microphone.
Student engagement	Observation of students and how well they are engaging, level of interest, understanding questions, following lesson.

5.3 WGAS Microphones for everyone

WGAS gives every student their own wireless microphone (S7). Microphones in every classroom were considered, however for reasons including hygiene, pupil voice and cost, individual student microphones were chosen. Student feedback also highlighted how students felt more comfortable using their own microphone rather than touching someone else's.

5.3.1 Valuing pupil voice

Questionnaires highlighted how students valued being able to hear their peers, their own voice amplified and their teachers clearly hearing them. S3 highlighted how microphone use helps adults understand what pupils say and S2 liked being able to hear their own voice. Similarly, Mulvahill (2018) explained how 'microphones can help promote language articulation, develop public speaking skills, and provide an incentive for active participation'. Atkin (2017)'s study using one student microphone demonstrated the integral value on access and learning within the classroom. However, Eberts (2019) identified how more than one microphone in class speeds up the time between speakers. T8 shared concern regarding a delay in conversation by having to wait for students to pick their microphones up and switch it on before speaking. Johnson (2015) highlights the

impact of student knowledge of their equipment on their ultimate acceptance or rejection in teenage years. Thus, students training supports microphones use.

Through individual microphones, all students and staff can hear contributions to the lesson. Thus students can hear their peers and value their contributions. Atkin (2017) found student microphone was perceived as ‘an additional benefit by participants as it enables peers’ contributions to be more easily managed.’ Similarly, MESHGuides (2023) described SFS as evenly distributing ‘the sound of the teacher’s voice, around the room, by means of a microphone and a speaker or speakers, so that all pupils can hear the teacher clearly’. WGAS not only has this benefit but also enables students and deaf staff to hear be heard at ear level.

If people cannot hear all the comments, ‘they are less likely to feel confident in contributing their thoughts for fear of repeating something that was already said’ (Eberts, 2019). Furthermore ‘A student pass-around microphone is a must to ensure students with hearing loss[41] can hear their peers and join in on the conversation’ (FrontRow, 2013).

5.3.2 Enhancing communication

T5 highlighted how WGA microphones ‘could all be on at the same time and the teacher had overall control of which microphones were on or off.’ However, Bellinger (2004) explained WGA incorporated voice-activated microphones for each pupil. This was a passive system which potentially enabled multiple students to talk at the same time unless muted by the teacher. While this enabled flow of conversation, overlapping conversation, which is not helpful to the learning, is also transmitted.

With WGAS, only one student can talk at a time, thus the need to switch the microphones on as each student speaks has needed reinforcing. This promotes turn taking and reduces multiple voices being heard at one time. Oticon (2023)

[41] Level of deafness

highlights how language development is not only dependent on a child's ability to hear but 'listening skills influence students' ability to read and write as well as improve social skills.' Thus teachers have needed to consider how conversation within their classrooms in organised (T2) as good listening involves being able to hear classroom contributions.

5.3.3 Reduced vocal strain

Every classroom has SFS as part of WGAS. Thus, the Teacher's voice is projected, heard more clearly by all and vocal strain reduced. T12 explained that 'personally, [WGAS] helps my voice and I feel more confident that what I am saying is going directly to the students'. Previously, staff couldn't hear themselves on WGA. Bellinger (2004) highlighted how 'considerations should be given to improvements which educate teachers on the effects of elevated voice levels.' Teachers being able to hear themselves through WGAS Juno has helps them regulate their voice. Thus, reducing vocal strain and stress, supporting the access of deaf staff and creating a quieter, calmer classroom for all. Wilson (2011) highlighted how 'benefits are often attributed to the SFS reducing the overall "auditory strain" in the classroom. NEU (2019) identified voice problems in 60% of schools and 50% of NQTs. In supporting teachers' voices. Whyte (2011) reiterates the importance of acoustic intervention to 'reduce the risk of hearing damage, stress and benefits communication and learning'. Thus, by using wireless microphones and SFS technology, in acoustically treated rooms, voices are heard more clearly, and vocal strain is reduced.

5.3.4 Inclusive classroom with WGAS in every classroom

Inclusive education is 'a continuous process of educational transformation' (UNESCO, 2017). A profoundly deaf student (S3) shared that although the sound was louder and easier to hear, they still needed lipreading to access. While technology can improve classroom access, HAs do not restore normal hearing. Lin

(2018) highlighted how, ‘HAs have varying performance in conditions with background noise and reverberation and when listening at a distance'.

5.4 Student perception of WGAS

All students in this study connected wirelessly to WGAS. Usage varied from days to six months. This variation is likely to impact on the results[42], particularly with confidence and consistency which often comes with time, when a system is embedded. TA12 highlighted, ‘The more I troubleshoot in classrooms, the more confident I am getting’. While one collection of data would have been optimal, the second gave insight into how WGAS was progressing plus increasing participation[43]. Ofsted (2021) highlighted the importance of ‘professionals listening, understanding and learning from student views in the fullest possible way. The aim of this research is to involve participants in WGAS to ensure it works optimally for them. Similarly, Atkin (2017) observed how ‘ongoing dialogue with users is essential to ensure the effective use of equipment for learners in the classroom.’

Morris (2017) also recognises the importance of students feeling involved and their views being recognised. S20 summarised ‘I don’t want to wear old GA again, but I don’t mind to wear the new one because it [is] much better than old one’. Gregory (1998), identifies ALDs being too obtrusive and bulky as a reason for students rejecting their radio aids. This is reflected in reasons given by students for not wanting to wear their GA box.

By streaming, students are connecting without the need for additional equipment[44]. Phonak (2022), describes their streamer[45] as enhancing ‘your entertainment experience’ which similarly applies to the classroom. Initial findings of students using Phonak Airstream is that they benefit from using student microphones as background noise, including other student voices are reduced. S50 explained how

[42] Data on confidence was only collected in December.
[43] An additional 44 students joined the study in December 2022.
[44] Edumics and Cochlear Mini Mics were attached to the wired Group aid box.
[45] Phonak TV Connector

without the microphones, their own and their peers' voices are quieter and less intelligible. These finds have also been identified by deaf TAs using the streamers. TA3 'I can hear who is talking. It is great because it blocks out the background noise.' Cole (2020) describes our ears as 'the doorway to the brain.' Thus it is essential that students get the greatest access to sound to enable their brain to interpret it. Furthermore Thibodeau (2010) highlights while ALDs provide an advantage to accessing the teacher's voice, it impacts their ability to access their peers. Whereas WGAS gives students access to both.

5.5. School Audiology

School Audiology	Support available
Educational Audiologist	Check on connectivity and use of WGAS through annual review assessments and set targets on use for annual reviews.
Audiology Team	Support staff with WGAS and show students how to connect following upgrade.
Onsite Technicians	Keep WGAS running, check connectivity and pre-empt problems.

5.5.1 WGAS Management

T2 explained how [they] 'felt more confident about knowing what to check should there be any problems.' T9 highlighted, 'I could do with 1:1 instruction' going through all the individual equipment. Over 40 years ago, when WGA was designed, Ross (1973) recognised 'that teaching staff should have an informed commitment to the use of any classroom amplification system' Thus, for any system to work, those that use it need to understand the benefits as well as how to use it.

Furthermore, the empowerment of staff and students, through building confidence, adjusting and ensuring WGAS works optimally has been achieved through an onsite Educational Audiologist (Ed Aud) and Audiology team. Frontrow (2013) summarises, 'the best way to ensure all students' needs are met auditorily, educationally, and socially is to support them with properly designed classroom amplification. While BATOD (2018) identifies providing appropriate support for the

deaf child as a key part of the Ed Aud role, Ash (2021) focuses on the provision of audiology training and support.' NDCS (2017) summarises how this can all be achieved through consultation with users and close liaison between health and education services.'

TA9 shared 'Great support from Audiology!' Observations highlighted that participants who actively asked questions and sought support were more confident in using WGAS. Similarly, those interactions have helped to identify trends and troubleshoot issues. Throughout this study, it has been clear that for the project to succeed it has needed to be carefully managed to enable WGAS to run and necessary changes to be made. Wilson (2011) highlighted how SFS contributed to 'small but significant improvements in student listening,' particularly in classrooms with good acoustics. Similarly, Atkin (2017) highlights the importance of rebroadcasting being carefully managed to prevent it impacting on the transparency of the signal received by the listener. The need for careful positioning of the streamers has been identified as well as staff training and support in the classrooms. Feedback from staff has also shown that they want support from Audiology to understand WGAS and use it optimally.

5.5.2 Staff empowerment

With WGAS, everyone can move around the classroom. T13 observed the benefit of 'not [being] tethered by a wire' as movement around the classroom. Similarly, T14 explained how they are more aware of when to use their microphone as 'I can hear the sound I'm making which I didn't do when wearing the WGA microphone as I couldn't hear myself'. This illustrates that, teachers are reflecting on their teaching style, voice level and noise on WGAS. Support to talk more quietly has been given. Body language has also been observed to relax when using WGAS (T13). Rekkedal (2014) highlights how positive attitudes towards assistive technology are essential for successful implementation. Johnson (2015) highlighted the importance of working with student to guide their teachers 'in using

the device properly and consistently'. Further research on how to support teachers to enable them to feel confident to troubleshoot and sort concerns.

5.6 Strengths and limitations of the study

WGAS was phased in over 6 months due to multiple factors including budgeting, personal amplification upgrades, implementation time and Audiology staffing were While this time was needed to add the equipment, train staff and make adjustments, it meant that participants had different amounts of time using the equipment before they were surveyed. The July 2022 questionnaires sometimes highlighted issues which had been solved when the later (December 2022) questionnaires were completed. For example, one student stopped streaming because she found the sound too loud when streaming. However, adjustment to the amplifiers resolved the issue. Therefore, the researcher was able to use action research feedback to help solve or reflect on issues.

Questionnaires were handwritten by students to enable them to be completed easily. However, quality varied depending on the support given to aid understanding the questions, for example, misunderstanding the term GA and taking it to mean WGA rather than WGAS. The uptake of questionnaires was higher in the main school and lower in the sixth form. A future study might include an online questionnaire, with QR code for sixth form, annually or when adaptations are made to WGAS. Marschark (2002) highlights the importance of training with staff and students and this has been reflected in the study.

5.7 Implications for future studies.

While progress has been seen within the research in terms of WGAS being implemented and used, further investigations measuring confidence levels of WGAS users as it embeds, particularly the impact of training on user confidence would be beneficial. For WGAS to work optimally staff and students need full engagement with the system, understand the benefits and feel confident in using it especially what to do if something goes wrong or where to get support as well as

identifying when students are connected. Johnson (2015) highlights the importance of teachers managing equipment effectively and making sure the devices are comfortable to wear, convenient to use, and implement a monitoring and management plan to ensure they function consistently'. Further research into the use of student microphones and their impact on participation, student access and lesson engagement to follow up concerns about delays between speakers. Also how speech-in-noise testing could be used to illustrate the greater SNR of WGAS in the classrooms and student connection.

6. Conclusion

This study's intention was to explore the wireless benefits of WGAS, particularly how wireless microphones and streaming technology enhance their learning environment. Data was collected over a six-month period as the wireless adaptations were implemented.

Over a quarter of students and staff were included in the study. Their responses were collected through questionnaires and interviews as well as observational data. Through action research, participant voice has informed the research, enabling concerns to be raised, reflected on and solved within the research. Marschark (2002) highlights the importance of 'making best use of all available information to optimise the educational opportunities for deaf students'. Staff benefitting from hearing student voices more easily in addition to students finding the microphones useful to cue them into listen were unexpected benefits.

Furthermore, the wireless adaptations to WGAS were conclusively successful in enhancing pupil auditory access in the classrooms. Everyone students (96.42%), Teachers (71.43%) and TAs (100%) found WGAS to be overall positive, particularly the benefit of wireless streaming and microphone connectivity. Improved sound quality and greater access to sound were highlighted as benefits of WGAS streaming. TA3 observed how students were more attentive and engaged when connected wirelessly.

In addition, the microphones enabled both students to hear their peers and staff better, and staff to hear and understand the students more easily. Ofsted (2021) highlighted the importance of students having positive relationships with staff and feeling included by peers. WGAS enables students to hear their peers and be heard themselves. Thus, as these users move through the school, confidence should increase and enable WGAS to embed further. Staff engagement and use of onsite Audiology to keep WGAS working optimally has been identified as essential. Marschark (2002) highlights our challenge for the future is to bring formal investigations with research in situ. Thus, WGAS with the wireless adaptations has the capacity to evolve as technology progresses while continuing to enable every student to hear themselves and their peers as well as the teacher.

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Appendix I: History of the Mary Hare Group aid

Year	Feature	Comments
1992	Teacher control panel, headphones worn by students, wired microphones worn by the teacher	• Teachers could see whose box was connected to WGA via the teacher control unit which showed the names of the students and if they were connected to WGA. • This gave reassurance to staff to know that the students were connected. However, over time some students have worked out that it is only showing that the box is connected. The HAs could be without battery, switched off or the wire not connected to the HAs. • Group aid boxes with microphones worn around the student's neck. • Wired connections between box and student and box and control unit. (Bellinger, 1992)
2012	Smaller Group aid boxes, ear level connectivity and bilateral cochlear implant connectivity	• Group aid update reduced the size of the boxes, making the system more compact and discrete. • Enabled pupils to continue wearing their HAs in lessons rather than having to remove them to wear the Group aid personal headphones. • Thus, enabling them to benefit from the latest HAs technology at the time, such as Phonak Naida SoundRecover technology and to improve the SNR of the Group aid as well as reducing the number of ear infections. • Cochlear implants were then able to connect both their processors. (School, 2011)
2022	WGAS using streaming technology and wireless infrared microphones.	• Wireless (2.4GHz) proprietary streaming technologies connecting students to WGAS. • Individual wireless microphones for all students and staff.

Appendix II: Precursors to WGAS

Issue	Reason
Small scale adaptations to WGA	• Each department within the school had a different teacher microphones.
Lack of movement around the classroom.	• The WGA was attached to the desks in the classrooms and laboratories in the main school.
WGA not in every classroom	• Practical subjects did not have WGA system.
Coronavirus period/ Lack of cohesion	• Teachers were not only moving classrooms to teach but also needing to work out how to use the different WGA systems, have a temporary one or none at all. This lack of cohesion meant that the Group aid system was used more effectively in some areas of the school and less well in others.
Aging system	• Increasing breakdowns in WGA which needed a technician to maintain.
Difficulties obtaining parts	• Supply chain issues on leads as Connevans stops selling them.
Processor and hearing aid upgrades with no direct input socket	• Advanced Bionics launched their new processors using new wireless methods (RogerDirect and Airstream Wireless Technology) and this has been rolled out by NHS Cochlear implant teams since 2021. • Phonak Marvel Hearing aids with their lack of direct input connectivity was initially a huge worry to a system which was hardwired. • The Cochlear Nucleus 7 (CP900) was launched without direct input in 2017 (Batista, 2017).
No breakaway neck cords	• Student GA boxes had neck cords without breakaway connections.

Appendix III: Progress since the introduction of WGAS:

- Training of teachers
- Time has been spent with all year groups in the classroom to help the students connect to the system
- Students have been systematically upgraded using the Royal Berkshire Audiology outreach clinic at Mary Hare
- Issues with equipment has been troubleshot for example Phonak Marvel HAs will stop streaming if they get saturated with moisture. This has led to a school initiative on the use of dryboxes and the problem addressed.
- New Naida Paradise HAs have been acquired through Royal Berkshire and an upgrade rollout has been successful.
- Annual review assessments have been used to give students pupil voice and enable targeted support to be put in to help students. This includes upgrading HAs, teaching students how to connect in the classroom, discussing the benefits of ear level connection as well as the merits of looking after personal amplification
- Learning walks have been carried out by leadership with agreed targets from Audiology. Their focus has been on identify issues and supporting use of equipment within the classroom.

Appendix IV: WGAS Questionnaire

Group Aid Questionnaire Dec 2022

Name:…… Form:……

1. What personal amplification do you use? Hearing aid/Cochlear Implant or BAHA?
2. What is the make and model of your equipment?
3. Have you got new hearing aids or processors recently?
4. If you have, how did you connect to the Group Aid before?
5. How do you connect now?
6. How easy do you find connecting to the Group Aid and why?
7. Do you have any difficulties connecting to the Group Aid?
8. How could these be solved?
9. How do the microphones compare to the Group Aid box?
10. What are the benefits of the microphones?
11. What are the challenges?
12. How could they be solved?
13. How confident are you with using the new group aid?

Appendix V: Ethics Approval

University of Hertfordshire UH

SOCIAL SCIENCES, ARTS AND HUMANITIES ECDA

ETHICS APPROVAL NOTIFICATION

TO	**Lynn Gambles**
CC	**Dr Joy Rosenberg**
FROM	**Dr Brendan Lavor, Social Sciences, Arts and Humanities ECDA Vice Chair**
DATE	**20/01/2013**

Protocol number: SHE/PGT/UH/05794

Title of study: Exploring the impact of group aid technology, and follow-up adaptations, on students in the classroom

Your application for ethics approval has been accepted and approved with the following conditions by the ECDA for your School and includes work undertaken for this study by the named additional workers below:

No additional workers named

General conditions of approval:

Ethics approval has been granted subject to the standard conditions below:

Permissions: Any necessary permissions for the use of premises/location and accessing participants for your study must be obtained in writing prior to any data collection commencing. Failure to obtain adequate permissions may be considered a breach of this protocol.

External communications: Ensure you quote the UH protocol number and the name of the approving Committee on all paperwork, including recruitment advertisements/online requests, for this study.

Invasive procedures: If your research involves invasive procedures you are required to complete and submit an EC7 Protocol Monitoring Form, and copies of your completed consent paperwork to this ECDA once your study is complete.

Submission: Students must include this Approval Notification with their submission.

Validity:

This approval is valid:

From: 20/01/2023

To: 28/02/2023

Please note:

Failure to comply with the conditions of approval will be considered a breach of protocol and may result in disciplinary action which could include academic penalties.
Additional documentation requested as a condition of this approval protocol may be submitted via your supervisor to the Ethics Clerks as it becomes available. All documentation relating to this study, including the information/documents noted in the conditions above, must be available for your supervisor at the time of submitting your work so that they are able to confirm that you have complied with this protocol.

Should you amend any aspect of your research or wish to apply for an extension to your study you will need your supervisor's approval (if you are a student) and must complete and submit form EC2.
Approval applies specifically to the research study/methodology and timings as detailed in your Form EC1A. In cases where the amendments to the original study are deemed to be substantial, a new Form EC1A may need to be completed prior to the study being undertaken.

Failure to report adverse circumstance/s may be considered misconduct.
Should adverse circumstances arise during this study such as physical reaction/harm, mental/emotional harm, intrusion of privacy or breach of confidentiality this must be reported to the approving Committee immediately.

Appendix VI: EC3 Ethics Participant Consent form (over 18)

University of Hertfordshire UH Ethics Committee

ETHICS COMMITTEE FOR STUDIES INVOLVING THE USE OF HUMAN PARTICIPANTS ('ETHICS COMMITTEE')

FORM EC3
CONSENT FORM FOR STUDIES INVOLVING HUMAN PARTICIPANTS

I, the undersigned *[please give your name here*, *in BLOCK CAPITALS]*

……
of *[please give contact details here, sufficient to enable the investigator to get in touch with you, such as a postal or email address]*

…..……
hereby freely agree to take part in the study entitled ***Exploring the Impact of Wireless Group Aid (WGAS) Technology on learners in the classroom***

(UH Protocol number SHE/PGT/UH/0579)

1 I confirm that I have been given a Participant Information Sheet (a copy of which is attached to this form) giving particulars of the study, including its aim(s), methods and design, the names and contact details of key people and, as appropriate, the risks and potential benefits, how the information collected will be stored and for how long, and any plans for follow-up studies that might involve further approaches to participants. I have also been informed of how my personal information on this form will be stored and for how long. I have been given details of my involvement in the study. I have been told that in the event of any significant change to the aim(s) or design of the study I will be informed, and asked to renew my consent to participate in it.

2 I have been assured that I may withdraw from the study at any time without disadvantage or having to give a reason.

3 In giving my consent to participate in this study, I understand that voice, video or photo-recording will take place and I have been informed of how/whether this recording will be transmitted/displayed.

4 I have been told how information relating to me (data obtained in the course of the study, and data provided by me about myself) will be handled: how it will be kept secure, who will have access to it, and how it will or may be used.

5 I understand that if there is any revelation of unlawful activity or any indication of non-medical circumstances that would or has put others at risk, the University may refer the matter to the appropriate authorities.

Signature of participant……..…Date……

Signature of (principal) investigator: LMGambles Date:…February 2023

Name of (principal) investigator *Lynn Gambles*

Appendix VII: EC4 Ethics Participant Consent form (under 18)

University of Hertfordshire UH Ethics Committee

Exploring the impact of group aid technology, and follow-up adaptations, on learners and staff in the classroom

UNIVERSITY OF HERTFORDSHIRE
ETHICS COMMITTEE FOR STUDIES INVOLVING THE USE OF HUMAN PARTICIPANTS ('ETHICS COMMITTEE')

FORM EC4
CONSENT FORM FOR STUDIES INVOLVING HUMAN PARTICIPANTS
FOR USE WHERE THE PROPOSED PARTICIPANTS ARE MINORS, OR ARE OTHERWISE UNABLE TO GIVE INFORMED CONSENT ON THEIR OWN BEHALF

I, the undersigned *[please give your name here, in BLOCK CAPITALS]*

……
of *[please give contact details here, sufficient to enable the investigator to get in touch with you, such as a postal or email address]*

……
hereby freely give approval for *[please give name of participant here, in BLOCK CAPITALS]*

.....
to take part in the study entitled ***Exploring the Impact of Wireless Group Aid (WGAS) Technology on learners in the classroom***

.....

(UH Protocol number SHE/PGT/UH/05794)

1 I confirm that I have been given a Participant Information Sheet (a copy of which is attached to this form) giving particulars of the study, including its aim(s), methods and design, the names and contact details of key people and, as appropriate, the risks and potential benefits, how the information collected will be stored and for how long, and any plans for follow-up studies that might involve further approaches to participants. I have also been informed of how my personal information on this form will be stored and for how long. I have been given details of his/her involvement in the study. I have been told that in the event of any significant change to the aim(s) or design of the study I will be informed, and asked to renew my consent for him/her to participate in it.

2 I have been assured that he/she may withdraw from the study, and that I may withdraw my permission for him/her to continue to be involved in the study, at any time without disadvantage to him/her or to myself, or having to give a reason.

3 In giving my consent to participate in this study, I understand that voice, video or photo-recording will take place and I have been informed of how/whether this recording will be transmitted/displayed.

4 I have been given information about the risks of his/her suffering harm or adverse effects and I agree to complete any required health screening questionnaire in advance of the study. I have been told about the aftercare and support that will be offered to him/her in the event of this happening, and I have been assured that all such aftercare or support would be provided at no cost to him/her, or to myself. In signing this consent form I accept that medical attention might be sought for him/her, should circumstances require this.

5 I have been told how information relating to him/her (data obtained in the course of the study, and data provided by me, or by him/her, about him/herself) will be handled: how it will be kept secure, who will have access to it, and how it will or may be used.

8 I have been told that I may at some time in the future be contacted again in connection with this or another study.

9 I declare that I am an appropriate person to give consent on his/her behalf, and that I am aware of my responsibility for protecting his/her interests.

Signature of person giving consent

……Date……

Relationship to participant

.....

Signature of (principal) investigator

…….....Date

Name of (principal) investigaror *[in BLOCK CAPITALS please]*

LYNN GAMBLES..... .....

Appendix VIII: EC6 Ethics Participation Information Document

University of Hertfordshire UH Ethics Committee

UNIVERSITY OF HERTFORDSHIRE

ETHICS COMMITTEE FOR STUDIES INVOLVING THE USE OF HUMAN PARTICIPANTS
('ETHICS COMMITTEE')

FORM EC6: PARTICIPANT INFORMATION SHEET

1 **Title of study**

Exploring the Impact of Wireless Group Aid (WGAS) Technology on learners in the classroom

2 **Introduction**

You are being invited to take part in a study. Before you decide whether to do so, it is important that you understand the study that is being undertaken and what your involvement will include. Please take the time to read the following information carefully and discuss it with others if you wish. Do not hesitate to ask us anything that is not clear or for any further information you would like to help you make your decision. Please do take your time to decide whether or not you wish to take part. The University's regulation, UPR RE01, 'Studies Involving the Use of Human Participants' can be accessed via this link:

https://www.herts.ac.uk/about-us/governance/university-policies-and-regulations-uprs/uprs
(after accessing this website, scroll down to Letter S where you will find the regulation)

Thank you for reading this.

3 **What is the purpose of this study?**

This research study aims to explore in more details the new developments to the group aid system from the perspectives of students using the system and staff who are learning to deliver using the system, particularly the use of individual microphones and ear level connectivity. There has been a lack of research into the benefits of group aid systems and the benefits to students of hearing all of their peers as well as the teacher. The aim is show how wireless technology can enhance the learning experience for students and staff in the classroom. Consequently, improving access for all. It will also identify where training opportunities and next steps in implementing the system.

4 **Do I have to take part?**

It is completely up to you whether or not you decide to take part in this study. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. Agreeing to join the study does not mean that you have to complete it. You are free to withdraw at any stage without giving a reason. A decision to withdraw at any time, or a decision not to take part at all, will not affect any treatment/care that you may receive (should this be relevant).

5 **Are there any age or other restrictions that may prevent me from participating?**

There are no age restrictions but you will need to be a student or staff member of Mary Hare school

6 **How long will my part in the study take?**

I just need permission to access your records, the questionnaires and filming have been completed as part of my job role at Mary Hare. Any further questionnaire will also be collected as part of my job role. The questionnaires will take less than 10 mins to complete.

7 **What will happen to me if I take part?**

Nothing the filming and questionnaires have already been completed as part of my job role at Mary Hare. If further questionnaires are given out to be completed support will be given to complete them. I am just asking permission to access the questionnaires and film.

8 **What are the possible disadvantages, risks or side effects of taking part?**

(Note: if appropriate for this particular study, you will be asked to agree to any required health screening questionnaire in advance of the study. Please also note that circumstances may arise that could result in the need for you to withdraw from the study; should such circumstances occur, the investigator will discuss the matter with you.)

There are no risks or disadvantages in taking part in this research study

9 **What are the possible benefits of taking part?**

As this data is collected as part of my job role, it is designed to support and improve the learning experience in the classroom. Your participation will be appreciated and will help to establish how the group aid system and the new developments are working and the benefits of the wireless connection and access to the hand help mics.

10 **How will my taking part in this study be kept confidential?**

Any personal information you give will be stored securing on the school devices that are secure, and password protected. Questionnaire will be anonymized. Following the completion of the research study in May 2023, all data (interview transcripts, personal information and answers to the survey questions) will be annonomised where possible. Some data may be used to further enhance the project. All data will be securely stored on Mary Hare sharepoint which is secure.

11 **Audio-visual material**

The MS Teams recordings from the 1:1 interviews and small group discussions will be done by Mary Hare marketing department and only students with permission for filming will be filmed. All the data from the questionnaires and interviews will be collated and analysed using school and university approved software. Any information that could identify you will be anonymised to protect your privacy. Once I have completed the research study, the collated data from the surveys and interviews will be shared with Mary Hare leadership who are looking at the importance of the group aid and the benefits for use.

12 **What will happen to the data collected within this study?**

- The data collected will be stored electronically, in a password-protected environment, for 6 months following the submission of the research study to the university, after which time it will be destroyed under secure conditions;

- The data collected will be stored electronically by **Lynn Gambles** for a duration of 6 months following the submission of the research study to the university, after which time it will be destroyed under secure conditions unless it is being used to continue the project.;

- The data will be anonymised prior to storage.

- Students will only be filmed if their parents have already completed a consent form to give Mary Hare school permission to film their child.

13 **Will the data be required for use in further studies?**

- The results of the study and/or the data collected (in anonymised form) may be deposited in an open access repository.

14 **Who has reviewed this study?**

This study has been reviewed by:

- Mary Hare research committee
- The University of Hertfordshire Social Sciences, Arts and Humanities Ethics Committee with Delegated Authority

The UH protocol number is SHE/PGT/UH/05794

15 **Factors that might put others at risk**

Please note that if, during the study, any medical conditions or non-medical circumstances such as unlawful activity become apparent that might or had put others at risk, the University may refer the matter to the appropriate authorities and, under such circumstances, you will be withdrawn from the study.

16 **Who can I contact if I have any questions?**

If you would like further information or would like to discuss any details personally, please get in touch with me, by phone or by email:

Lynn Gambles
Work Phone:01635 244296
Email: l.gambles@maryhare.org.uk

Although we hope it is not the case, if you have any complaints or concerns about any aspect of the way you have been approached or treated during the course of this study, please write to the University's Secretary and Registrar at the following address:

Secretary and Registrar
University of Hertfordshire
College Lane
Hatfield
Herts
AL10 9AB

Thank you very much for reading this information and giving consideration to taking part in this study.

Appendix IX: Mary Hare Research Application Form

Application form for research at Mary Hare School

Section A: Brief details of the Application

1a Title of Project: Exploring the impact of group aid technology, and follow-up adaptations, on learners and staff in the classroom – changed to **Exploring the impact of wireless group aid technology on learners in the classroom**

2a Name of Principal Investigator(s) (please attach a statement of their qualifications and priorexperience, which are relevant to the proposed project): Lynn Gambles

3a E-mail address: l.gambles@maryhare.org.uk

4a Telephone: 01635 244296

5a Name of research institution/university: Mary Hare School/ University of Hertfordshire

6a Has your research been approved by an appropriate ethics committee?(please attach the letter of approval) It is under review with University of Hertfordshire and was approved in January 2023. Joy Rosenberg is the supervisor who also works for Mary Hare.

7a Are you receiving a grant for this research?
If not, how is it being funded? No it is part of my work commitment as head of Audiology at Mary Hare

Section B: Abstract of Project

1b What is the purpose of the investigation? How is it intended to benefit the participant? The project to give us greater information to ensure the group aid is developed too its full potential. Students and staff will gain as this will help shape the project, give them a voice and enable the system to be improved and enhanced for them.

2b Give details of the proposed research protocol including equipment to be used and anysafeguards or precautions to be taken. Include a statement of the findings of

any risk analysis undertaken with regard to the participant's safety and well-being.

Questionnaire will be given to students in June and December 2022. Video footage of students talking about the group aid system was collected in June 2022 and interviews were conducted in June and December 2022. All interviews were recorded. Student interviews had another adult present.

3b What will be the duration and frequency of the procedures?

The project will involve collecting information form staff and students on the group aid project. This feedback will enable the students and staff to share their views but it will also help trouble shoot issues with the project and identify further training needed for staff and students. Students completed a questionnaire in either June or December 2022 in class. Further observations and interviews were conducted in June and December 2022.

4b Any further relevant information

This research will be used as a Masters Dissertation Project but this is primarily to collect data for the school and the development of the group aid system. The aim is to provide evidence and research to validate the group aid system. This research will support tribunals as well.

Section C: Information on participants in the study

1c How many participants will be involved? Students and staff within the school.

The research is using data collected as part of my job role as Head of Audiology. 56 students, 14 teachers and 12 TAs/ Technicians have been included. All have Mary Hare consent and have completed a Univ of Hertfordshire Ethics form too. A list is held in school.

2c What is the age group and sex of the participants?

Students in years 7-14 have been included in the study.

3c What are your recruitment criteria? Students and staff using the new group aid system.

- Students with a hearing loss/ degree of deafness
- Secondary school age
- Attend Mary Hare School
- Use a Group aid system in their lessons
- Use an auditory Aural communication method in their studies
- Use personal amplification (hearing aids, cochlear implants, BAHAs or a combination.
- Hearing loss as a demographic in table/ Degrees of deafness, would examples be useful/ average hearing loss etc.
- Have changed over to wireless connectivity

(please provide):

(i) A copy of the information sheet and consent form to be sent to parents
(ii) A copy of the information sheet and consent form given to participants

Please note that information on data protection, withdrawal from the research andcomplaints procedure is compulsory and should be included in the consent forms.

4c What reward will be given to participants in the study eg book voucher, small token?
None

5c Would you consider making a contribution, monetary or otherwise, to the Mary HareCharity, for allowing the research to take place? This project is for Mary Hare and has received donations from the manufacturers involved.

6c What steps, if any, will be taken to safeguard the confidentiality of the results of theinvestigation? All data will be stored electronically at Mary Hare or locked away in school.

7c Any further relevant information

While the school has invested in the equipment, discounts and free equipment have been provided from Cochlear Uk, Advanced Bionics, Phonak and Frontrow.