DEVELOPMENT OF AN INTERACTIVE E-CONTENT MODULE ON CLINICAL MASKING CONCEPTS FOR UNDERGRADUATE AUDIOLOGY STUDENTS

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JUNE, 2026

CERTIFICATE

This is to certify that this dissertation entitled "**Development of an Interactive E-Content Module on Clinical Masking Concepts for Undergraduate Audiology Students**" is a bonafide work submitted as part of fulfilment of the degree of Master of Science (Audiology) of the student with Registration Number **P01II24S023013**. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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This is to certify that this dissertation entitled "**Development of an Interactive E-Content Module on Clinical Masking Concepts for Undergraduate Audiology Students**" is the result of my own study under the guidance of Mr. Saravanan P, Assistant Professor of Audiology, Centre for Hearing Sciences and co-guidance of Mr. Karthik Venkat Sridaran, Speech Technologist, Centre for Rehabilitation Engineering, Acoustics and Bio-medical engineering, All India Institute of Speech and Hearing, Mysuru and has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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ABSTRACT

Clinical masking is a foundational yet cognitively demanding procedure in diagnostic audiology that undergraduate students consistently identify as one of the most difficult topics to learn. Despite strong evidence for the effectiveness of simulation-based and interactive e-learning in audiology education, no dedicated, validated, interactive digital module on clinical masking existed prior to this study. The present study developed, validated, and evaluated a ten-module interactive e-content module on clinical masking concepts for undergraduate Bachelor of Audiology and Speech Language Pathology (B. ASLP) students at the All India Institute of Speech and Hearing (AIISH), Mysuru. The module was systematically designed to progress from foundational definitions and terminological grounding through to case-based clinical reasoning, incorporating multimedia elements, animated audiograms, formative quizzes with a 70% mastery gate, and embedded summative assessments. Three experienced audiologists validated the module content using a 5-point Likert scale; all parameters across all 10 modules were rated 4 or 5 by at least 2 of the 3 raters, demonstrating strong content validity. Effectiveness was evaluated using a baseline/post-training test design with 35 undergraduate audiology students. Since the baseline scores did not follow a normal distribution (p = .005), the non-parametric test, the Wilcoxon signed-rank test, was used to compare baseline and post-training scores. A statistically significant and practically large improvement was observed, with median scores increasing from 17 (IQR = 4) to 36 (IQR = 5) out of 52, and all 35 participants demonstrated individual improvement. Student perceptions were overwhelmingly positive across all 20 survey items (Median = 5.00 per item; combined Strongly Agree and Agree rate = 96.9%). The findings confirm that the interactive e-content module is a valid, effective, and highly acceptable instructional resource for improving undergraduate audiology students' knowledge and applied understanding of clinical masking.

Keywords: *clinical masking, e-learning, audiology education, interactive module, simulation-based learning, undergraduate training*

CHAPTER I

INTRODUCTION

Pure tone audiometry (PTA) is the gold standard and most widely used behavioural hearing assessment procedure in clinical audiology for determining an individual's hearing sensitivity across different frequencies. The test involves presenting calibrated pure tones via air-conduction and bone-conduction transducers to identify the softest intensity at which a person can consistently detect sound (Martin & Clark, 2015). The PTA is an integral component of audiological diagnosis which gives information of the type, degree and configuration of hearing loss to guide medical referral, rehabilitation planning, hearing aid fitting and auditory management decisions (Gelfand, 2009). Pure tone audiometry is the basis of routine hearing assessment in hospitals, clinics, educational and hearing conservation programmes because of its reliability, simplicity and clinical value.

Pure-tone audiometry requires the careful interpretation of air- and bone-conduction thresholds to assess the integrity of the auditory system. Air-conduction testing evaluates the complete auditory pathway from the outer ear through the middle and inner ear to the auditory nerve, while bone-conduction testing bypasses the outer and middle ear, testing cochlear function directly (Hall & Mueller, 1997). Comparison between these thresholds enables the clinician to differentiate conductive, sensorineural, and mixed hearing losses. However, accurate threshold estimation can become challenging in cases involving unilateral hearing loss, asymmetrical hearing sensitivity, or significant air-bone gaps, where sound presented to one ear may be detected by the opposite ear through cross-hearing. Such situations increase the risk of obtaining inaccurate audiometric findings if ear-specific responses are not ensured.

Clinical masking is an essential component of pure-tone audiometry used to obtain accurate ear-specific thresholds by preventing the non-test ear from detecting the test signal presented to the test ear (Martin & Clark, 2015; Yacullo, 2009). Clinical masking is the process by which the audibility of one sound is reduced by the presence of another sound (ANSI,1996), or, in other words, the threshold of audibility for one sound is raised by the presence of another (Hood, 1960). In clinical audiology, masking is achieved by presenting an appropriate masking noise to the non-test ear while evaluating hearing sensitivity in the test ear. The masking procedure ensures that the obtained thresholds truly reflect the ear's auditory sensitivity rather than responses from the opposite ear through cross-hearing. The need for masking arises because sound presented at higher intensities may cross over to the contralateral ear, particularly during bone-conduction testing or in cases of significant ear asymmetry.

Proper masking is especially important in air-conduction, bone-conduction, and speech audiometry of unilateral, asymmetrical, and mixed hearing losses (Hood, 1960). Appropriate masking procedures are essential to obtain audiometric thresholds that reflect the poorer ear's response and to avoid shadow audiograms, inaccurate threshold estimation, and possible misdiagnosis. Such inaccuracies may influence differential diagnosis, fitting of hearing aids, medical referral and planning of rehabilitation (Martin & Clark, 2015). Hence, there are several concepts that need to be understood by the audiologist for effective utilization of masking like interaural attenuation, crossover, occlusion effect, masking dilemma and plateau method. Accurate masking relies on conceptual understanding and procedural decision-making and is therefore viewed as one of the more complex but clinically relevant skills in diagnostic audiology (Margolis, 2010). Thus, knowledge of masking principles is important in diagnostic audiology to ensure accuracy and validity of the audiometric results.

Poor masking may lead to misdiagnosis, such as misclassification of the type and degree of hearing loss, which has implications for management decisions, such as hearing aid fitting or medical referral (Martin & Clark, 2015). It is a complex but vital skill that requires a solid understanding of interaural attenuation, the plateau method, and a balance between under- and over-masking (Margolis, 2010).

Clinical masking needs a good grasp of acoustics, sound pathways, and auditory masking, which involves multiple calculations and the integration of patient data to inform decision-making (Skinner et al., 2023). Audiologists must know when and how to mask and check masked thresholds. Even with the complexity of the skill, it remains unclear why it takes up to 3 years to learn (Turner, 2004; Valente, 2009). Masking concepts are often difficult for undergraduate audiology students to learn. The main concepts reported as challenging are interaural attenuation, when masking is needed, correctly using the plateau method, over-masking or under-masking, and the choice of masking noise. Learning clinical masking requires integration of theory and practice, knowledge and judgment. As in traditional teaching, lectures with static diagrams and pictures may be insufficient to promote the clinical application and deep understanding (Margolis, 2010).

Lecture-based instruction tends to focus heavily on formulas and static examples, often leading to negative classroom experiences and a lack of cohesion in teaching methods. Many students report needing "cheat sheets" and independent practice to truly understand masking, and that confidence takes more than six months to develop.

Interactive e-learning has been shown to have significant advantages in health sciences education, including enhanced engagement, understanding and retention of concepts. Digital modules incorporating animations, simulations and active learning techniques provide tailored learning experiences and improved skills development compared with passive approaches. In audiology, simulation-based and interactive e-learning approaches have been increasingly used to improve clinical training and decision-making skills. Studies involving virtual audiometry training, paediatric audiology simulations, and clinical skill development have reported positive outcomes, including improvements in learners' understanding, confidence, and clinical reasoning (Bakhos et al., 2020; Tomlin et al., 2023; Wilson et al., 2020).

Hemanth and Manjula (2018) developed a computer-based training program for audiological evaluation and observed significant improvements in students' knowledge and clinical skills following simulation-based training. Masking was integrated into the software as part of an audiological assessment, but was not specifically designed to address the conceptual and procedural problems of clinical masking. The study extends the work by developing an interactive e-content module focused solely on clinical masking. The module incorporates structured teaching, interactive activities, and case-based learning to improve conceptual understanding and clinical decision-making skills (Hemanth & Manjula, 2018). Digital modules that include animations, simulations, and active learning strategies provide personalised learning experiences and opportunities for repeated practice and may be particularly useful in teaching complex concepts such as clinical masking.

There are advances in interactive and simulation-based training in audiology, but there is no e-content module dedicated to clinical concepts of masking. Such resources can be developed to bridge the gap between theoretical learning and practical application in the clinical setting, thus improving students' clinical competence and confidence.

1.1 Need for the study

In audiology, clinical masking is essential for obtaining accurate ear-specific thresholds and scores in both pure-tone and speech audiometry. So accurate application of masking is crucial for reliable diagnosis, differential identification of hearing loss, and appropriate rehabilitation planning (Martin & Clark, 2015; Yacullo, 2009). However, multiple studies have shown that masking is one of the most difficult concepts for undergraduate audiology students to understand and implement effectively (Margolis, 2010;

Skinner et al, 2023).

One of the main reasons for the difficulty in learning clinical masking is its sophisticated nature. Concepts of interaural attenuation and cross-hearing are essential to understand when masking is needed, but can be difficult for students to grasp. Skinner et al. (2023) reported that over 80% of audiology students found learning masking challenging and required significant time and effort. Students reported the following learning barriers: excessive theoretical instruction, a lack of a consistent instructional approach, and few opportunities for clinical application. Hence, there is a need for innovative instructional methods that bridge the gap between theory and clinical application. The study also emphasised that interactive strategies such as simulations, practice exercises, and applied clinical examples benefited learners most. The masking process, and especially the plateau method, involves step-by-step reasoning and decision-making and may be difficult for undergraduate students to master (Hood, 1960). Overmasking and undermasking are common errors that can result in misinterpretation of audiograms and inappropriate clinical decisions (Gelfand, 2009).

Classroom lectures, textbook illustrations, and PowerPoint presentations are common traditional teaching methods, but may not be sufficient to describe the dynamic nature of masking. These methods are mostly passive and do not allow students to actively participate in the masking process, practice calculations, or test their knowledge in applied clinical scenarios. Turner (2004) reported that the lack of clinical exposure during undergraduate training further limits the students' ability to gain confidence and proficiency in performing masking procedures independently.

Interactive and simulation-based e-learning methods have been successfully applied in audiology to areas such as paediatric audiology decision-making, virtual audiometry training and clinical skills development, and have positively affected learners' understanding, confidence and clinical reasoning skills (Bakhos et al., 2020; Tomlin et al., 2023; Wilson et al., 2020). To date, there are no such resources specifically for clinical masking. Most existing resources are largely static and descriptive, with limited scope for interactivity or case-based learning. Therefore, students may not be well-trained in the proper use of masking in real clinical practice.

Tomlin et al. (2023) explored the effectiveness of an e-learning simulation module designed to improve the clinical decision-making skills in audiology training. The study compared the outcomes between students taught using traditional problem-based learning (PBL) and those using the newly developed e-simulation focused on paediatric infant diagnostic testing. The findings suggested that the e-simulation was similar to PBL in terms of learning outcomes and offered additional benefits such as flexibility, consistency, and increased engagement. The authors concluded that e-simulation provides a sustainable and effective alternative for clinical education, especially in contexts where clinical placements are limited. These findings suggest that e-learning simulations are valuable tools for teaching complex audiology concepts, such as clinical masking, where traditional instruction alone may not be sufficient.

In addition, the move towards Outcome-Based Education (OBE) in health sciences emphasises theoretical knowledge and the development of analytical and application skills. Masking is a very good example of a concept that calls for higher-order thinking, as students have to analyse test conditions, evaluate cross-hearing risks and apply stepwise procedures in real time. Therefore, an interactive e-content module will be very useful for providing individualised learning, immediate feedback, and repeated practice, all of which are vital for understanding complex clinical procedures (Cook et al., 2010; Ruiz et al., 2006).

The growing complexity of the audiological assessment process has shown the need for teaching methods that encourage active learning, clinical reasoning and repeated practice, rather than passive absorption of theoretical knowledge. Students must apply principles of audition, perform numerical calculations, and make decisions in real time when interpreting audiometric data in the clinical mask. The traditional lecture approach to teaching may not satisfy such higher-order demands of cognition.

Evidence from health professions education support the use of simulation-based interactive learning strategies to develop complex clinical skills. Cook et al. (2010) found that computer-based simulation had a large positive effect on students' clinical knowledge and performance in the health professions, particularly in procedural decision-making. Cook and Triola (2009) also state that virtual patient simulations allow students to apply theoretical concepts in real clinical situations, which in turn enhances their clinical reasoning and problem-solving skills.

Theories of education also support the use of multimedia and interactive teaching techniques. According to the cognitive theory of multimedia learning (Mayer, 2009), information is learned more efficiently when visual and auditory elements are presented in an organized and integrated way. This is especially true in clinical masking, where students must simultaneously interpret audiometric data, calculate masking levels, and follow protocol. Ericsson (2004) also noted that expertise is achieved through deliberate practice, which requires repeated performance, immediate feedback, and gradual skill improvement. This view was supported by McGaghie et al. (2011), who showed that education based on deliberate practice stimulation leads to better and more durable learning than traditional instructional methods.

Simulation-based and interactive learning methods have proved effective; however, there are no structured e-learning resources in audiology education that address the clinical concepts of masking. Thus, the development and validation of an interactive e-content module can be an effective method to enhance audiology undergraduate students' knowledge, clinical reasoning, and implementation of masking procedures in practice. Errors in the masking procedure can directly affect the diagnostic result. Therefore, an interactive e-content module needs to be developed and validated to address the concepts of clinical masking explicitly. Such a module can enhance conceptual clarity, application skills and student self-confidence in clinical practice. Finally, this module will lead to better audiological diagnosis and better patient care outcomes.

1.2 Aim of the study

The present study aimed to develop and validate an interactive e-content module on clinical masking concepts for undergraduate audiology students.

1.3 Objectives of the study

1. To design and develop an interactive e-content module addressing theoretical and practical aspects of clinical masking.
2. To validate the content and instructional design of the module through expert review.
3. To evaluate the module's effectiveness in improving knowledge and applying masking concepts among undergraduate audiology students.

CHAPTER II

REVIEW OF LITERATURE

Clinical masking is an important procedure in diagnostic audiology. The masking is defined as the process of presenting an appropriate noise to the non-test ear (NTE) to mask any stimulus presented to the test ear (TE) so that the NTE cannot detect it, thereby ensuring that audiometric thresholds are ear-specific and diagnostically valid (Hood, 1960; Martin & Clark, 2015). The acoustic basis of masking is the phenomenon of cross-hearing, in which the test signal presented to one ear can transcranially reach the contralateral cochlea when its intensity exceeds the interaural attenuation (IA) for that transducer type and stimulus modality (Gelfand, 2009). If cross-hearing occurs and is not recognised or corrected, the audiologist may record responses from the NTE instead of the TE, leading to audiometric data that are not representative of the true hearing status of the ear being tested.

The clinical implications of masking errors are serious and directly relevant to the patient. Under-masking, i.e., presenting too little noise to prevent cross-hearing in the NTE, leads either to spuriously elevated thresholds or to the recording of responses to the NTE as responses to the TE. This may lead to the development of shadow audiograms in cases of profound unilateral hearing loss, to bilateral hearing loss being misinterpreted as unilateral hearing loss, and to the type and degree of hearing loss being misclassified in cases of mixed hearing impairment (Gelfand, 2009; Martin & Clark, 2015). Conversely, overmasking occurs when the noise level is so high that it is transmitted to the TE by bone conduction, thereby increasing the true threshold. The TE threshold is higher than it really is, leading to an overestimation of hearing loss (Hood, 1960; Yacullo, 2009). Both errors could lead to incorrect diagnostic interpretation, poor discrimination between conductive and sensorineural hearing loss, and, in turn, suboptimal patient management, including inappropriate hearing aid prescription, unnecessary physician referral, or withholding necessary treatments

(Gelfand, 2009; Margolis, 2010; Martin & Clark, 2015).

2.1 Challenges in Learning Clinical Masking Among Audiology Students

Masking is an important part of diagnostic audiology. It is, however, one of the hardest concepts for audiology students to learn, understand and apply with confidence and accuracy. Masking presents multidimensional learning challenges, including conceptual complexity, procedural demands, instructional deficits and limited opportunities for supervised clinical application during undergraduate and graduate training.

The most comprehensive investigation of student perceptions of learning clinical masking to date was conducted by Skinner et al. (2023), who administered a cross-sectional online survey to 424 Doctor of Audiology (AuD) students and recent graduates across the United States. The survey explored the perceived effort, challenge, and instructional experiences associated with learning clinical masking. A large majority of respondents rated masking as challenging and effortful to learn, and reported that clinical confidence in performing masking procedures took more than 6 months to develop after formal instruction was completed. Qualitative thematic analysis of open-ended responses identified four dominant themes characterising students' experiences with learning masking: a persistently negative classroom experience; a lack of consensus or significant variation in teaching approaches across programs; an excessive focus on formulaic rules and mathematical procedures at the expense of conceptual and clinical understanding; and a small set of individually driven positive learning strategies, including independent practice, peer collaboration, and the use of informal clinical aids such as masking cheat sheets. Participants consistently identified simulation exercises, lab-based practicals and clinic-based learning as the most useful instructional modalities, indicating a clear preference for active, applied learning over passive didactic instruction.

The conceptual basis of clinical masking presents particular challenges to undergraduate learners. Students frequently report difficulty understanding the physics of cross-hearing and interaural attenuation, the reasons IA values differ between transducer types and test modalities, and how to apply these principles to determine when masking is needed for a given audiometric configuration (Gelfand, 2009; Skinner et al., 2023). The determination of initial masking levels requires the integration of multiple audiometric data points and the accurate application of formulaic procedures, whereas the plateau method requires stepwise iterative reasoning and real-time tracking of the threshold, skills that require a level of clinical reasoning not fully developed in the early stages of audiology training (Margolis, 2010). Errors are common. Over- and under-masking have been reported as common errors among students and trainee audiologists and have the clinical consequences described above.

Margolis (2010) highlighted the complexity of clinical masking and emphasised the importance of developing strong clinical reasoning skills for accurate masking decisions. However, traditional methods of teaching masking have often relied heavily on memorising masking rules, formulas, and decision trees, with limited emphasis on developing a conceptual understanding of cross-hearing, cochlear sensitivity, and interaural transmission. The lack of a conceptual framework may result in students mechanically performing masking procedures and having difficulties adjusting their decisions to atypical audiometric configurations. Clinical simulations and worked case examples are instructional approaches that blend conceptual understanding and procedural knowledge and have been suggested to improve clinical competence in masking (Margolis, 2010; Skinner et al., 2023).

Turner (2004) investigated the masking dilemmas that arise in the presence of asymmetric hearing loss, and identified them as real clinical uncertainty, even for experienced audiologists. The findings point to the need for educational strategies that allow students to experience a broad and representative range of clinical audiometric scenarios, including complex and atypical configurations. The study supported the claim that exposure to simple textbook audiograms does not result in mastery of clinical masking. Realistic cases, with broad, diverse practice, cultivate flexible clinical judgment.

According to the clinical masking protocol documents, the plateau method is generally considered the gold standard method of clinical masking protocols (Martin, 1994). However, many practicing audiologists use masking procedures that are inconsistent or unstandardized. These findings highlight the importance of developing a strong foundation of masking during undergraduate training, as deficiencies in masking knowledge and application may be carried into clinical practice. The study further emphasises the importance of effective teaching strategies in enhancing appropriate, standardised masking procedures among audiology students.

2.2 Simulation-Based and E-Learning Approaches in Audiology Education

2.2.1 Systematic Evidence for Simulation in Audiology

The systematic evidence base for simulation-based learning within audiology has increased significantly over the last decade. The first systematic review specific to simulated learning environments (SLEs) in audiology education was conducted by Dzulkarnain et al. (2015). They searched fifteen databases. Four studies satisfied our inclusion criteria. Three out of 4 reported positive results, with SLE groups having higher post-training scores than traditional training groups or significantly higher scores than non-training control groups. The review concluded that SLEs have the potential to increase knowledge and procedural skills in audiology students, whilst acknowledging the small number of high-quality studies available and the need for further empirical investigation.

Alanazi and Nicholson (2023) then conducted a more extensive systematic review of the use of simulation in audiology education. They searched seven databases for peer-reviewed publications from 2000 to 2023. The review examined the evidence for the impact of simulation on students' knowledge, skills, self-confidence, and satisfaction. The findings confirmed that simulation-based training in audiology consistently produced positive effects across all four domains, with the strongest evidence of benefits in self-confidence and procedural skill acquisition. The authors concluded that simulation was most effective when used in combination with other teaching methods in a blended learning approach and when students had the opportunity to practice skills and receive structured feedback on their performance repeatedly. The review also noted the growing evidence base, but a limited range of audiology topics for which dedicated simulation tools had been developed, and that complex procedural topics, such as clinical masking, remained underserved.

Kanji and Watermeyer (2024) conducted a scoping review of the literature on simulation-based methods for teaching communication and counselling skills in clinical audiology education, drawing on 17 published studies. Simulation was found to offer positive learning experiences and meaningful opportunities for practice to students developing communication competencies. Most studies used standardised patients and quantitative outcome measures. The review was less focused on the usefulness of interpersonal skills than technical procedures, but did confirm the broader principle that simulation-based learning is a useful, scalable method for developing clinical skills in audiology education, especially where clinical placements are limited or variable.

Bowers et al. (2026) investigated audiology students' perceptions of a near-peer simulated patient program to improve clinical communication and counselling skills. The study explored students’ perceptions of the simulation experience and its contribution to their confidence, clinical preparedness and professional skills development. Results suggested that the involvement of near-peer simulated patients offered a safe, authentic learning environment that improved students’ communication skills and promoted reflective clinical practice. The study also underscored the importance of simulation-based learning as a valuable educational approach to improve student engagement and preparedness for real clinical encounters in audiology training.

2.2.2 Technology-Based Simulation Tools for Audiometric Training

Several technology-based simulation tools have been developed and evaluated for use in audiology training. Bakhos et al. (2020) conducted a controlled study comparing conventional training with an immersive virtual reality (VR) training system among 29 first-year audiology students in France. The VR system simulated an audiometric testing environment and provided interactive training in otoscopy, pure tone audiometry, speech audiometry, and masking. Students in the VR training group saw a mean increase in knowledge score of 21.1 percentage points following training, compared to 6.9 percentage points in the traditional training group, a significant and clinically meaningful difference. Satisfaction ratings post-training were excellent in 100% of VR-trained students, compared with 74% of traditionally trained students, and self-confidence ratings were higher in the VR group. Crucially, the VR training module included a specific component on masking for speech audiometry, providing feedback on masking decisions within the simulated audiometric environment. These results showed that technology-based simulation is not only feasible but also superior to traditional methods for training students in audiometric procedures, including masking procedures.

Kwak et al. (2024) evaluated the effectiveness of a virtual reality-based pure-tone audiometry training program among experienced audiologists and undergraduate audiology students. This training program was part of the VR training curriculum to mask it. The study demonstrated the feasibility of VR-based audiometry training and its high acceptance among both novice students and experienced practitioners, as evidenced by high ratings of perceived usefulness and perceived ease of use within groups. The study showed the unique value of VR in allowing learners to practice masking procedures in a realistic simulated environment without the risk to real patients. The study concluded that VR training is a supplement, not a complete substitute for traditional training. The authors noted the absence of VR tools dedicated to masking and suggested that more focused simulation tools in this area should be developed.

Gerdes et al. (2025) developed and evaluated a web-based audiometer simulation tool for training graduate-level students in hearing screening procedures, including pure tone audiometry. The simulation was based on a commercial audiometer and tympanometer and guided learners through procedures at varying levels of difficulty, with contextual help. Student perceptions of the simulation tool demonstrated significantly greater confidence in performing hearing screening procedures, interpreting otoscopy findings, and explaining the audiometric process to patients than control students. The open-ended qualitative responses consistently identified the hands-on, self-paced nature of the simulation as the most valued aspect, which supports the finding that student-centred, interactive digital tools are especially effective in developing procedural confidence in audiology trainees.

Other web-based virtual audiometry platforms have been developed as an online simulation education for audiometry training. Calandruccio and Weidman (2022) developed a web-based virtual clinical audiometer simulation platform to educate undergraduate and graduate students on hearing screening protocols and pure-tone audiometry using fictional yet realistic patient profiles. The platform was built using standard web technologies, allowing students to practice audiometric procedures with a virtual audiometer in any web browser, providing flexibility without specialised hardware. Pedagogical principles of graduated difficulty, embedded feedback, and representation of diverse clinical populations were used in the program's design. The proposed tool is a scalable clinical training tool for students of audiology and speech-language pathology.

Audiometric decision-making has been used in virtual patient simulation. de Araújo et al. (2023) explored user satisfaction with an audiometric simulation interface and the self-perception of the impact of computer simulation on clinical practice. The study found that, in general, audiologists and audiology students were satisfied with the simulator's interface and reported that working with the virtual patient simulation had a positive effect on clinical confidence and procedural thinking. The results of this study provide further evidence that audiometric simulators can be effective tools for reinforcement and expansion of clinical training in audiology when designed with sufficient fidelity and usability.

Hemanth and Manjula (2018) developed and validated a computer-based audiological evaluation training software in simulated mode for undergraduate audiology students at AIISH. The software allowed students to practice pure-tone and speech audiometry, as well as masking procedures, on simulated clinical cases and provided immediate feedback on their performance. Evaluation of the software showed significant improvements in students' knowledge and psychomotor skills post-training, as well as a decrease in the time required to complete audiological evaluations. Students also expressed positive attitudes towards the software's usefulness as a learning tool. The results of the current study suggest that simulation-based digital resources may be beneficial in audiology education and have the potential to improve conceptual understanding and clinical competence.

2.2.3 E-Learning Simulation for Clinical Decision-Making in Audiology

Beyond procedural training, e-learning modules have demonstrated effectiveness for developing clinical decision-making skills in audiology. Tomlin et al. (2023) developed and evaluated an e-learning simulation module designed specifically to teach clinical decision-making in the context of paediatric infant diagnostic testing. The study compared outcomes between students taught using traditional problem-based learning (PBL) and those who completed the e-simulation module. Results showed that e-simulation achieved student skill-acquisition outcomes similar to PBL, with significant added benefits in scalability, consistency of content delivery, and flexibility of access. The students' qualitative feedback was positive, and the authors concluded that e-simulation is a sustainable and educationally effective alternative for teaching complex clinical decision-making in audiology, particularly when clinical placements are scarce or inconsistent. The authors explicitly recommended that similar e-simulation modules be developed for other complex audiology topics that require integrated clinical decision-making, of which clinical masking is one of the most prominent examples.

Reed et al. (2021) explored the use of simulation training to develop auditory brainstem response (ABR) testing skills in graduate audiology students. The study found that students who participated in simulation-based ABR training demonstrated significantly improved skills in waveform identification and threshold estimation compared with those who received only traditional didactic instruction. This study was notable for applying simulation training to a specific, technically demanding audiology procedure, analogous in several respects to clinical masking, including its complexity, the difficulty students experience in learning it, and the clinical consequences of errors. The positive outcomes of simulation-based ABR training provide a strong precedent for the development of analogous simulation-based resources targeting clinical masking.

Wilson et al. (2020) investigated student perceptions of two SLEs used in paediatric audiology training and found that students reported high satisfaction with both simulation modalities, valuing the opportunity to practice clinical skills in a safe environment, to receive structured feedback, and to apply theoretical knowledge in realistic clinical contexts. Students reported that simulation experiences were especially valuable in preparing them for real clinical placements, supporting the notion that well-designed simulation closes the gap between classroom learning and supervised clinical practice. These findings are directly applicable to the development of interactive e-content modules for clinical masking, as they also seek to provide a structured, feedback-rich learning environment that prepares students for the clinical application of masking procedures.

Mehrez et al. (2024) compared e-learning and in-person teaching methods in the Clinical Aspects of Audiology course among Syrian postgraduate audiology students. The study investigated the effectiveness of online learning for audiology education and students' learning experience with two instructional methods. The results demonstrated that e-learning was a flexible and accessible way of teaching and was as effective as traditional classroom teaching. The authors highlighted the promise of e-learning methods to support audiology education, especially in circumstances where access to conventional face-to-face education is restricted. The findings contribute to the emerging role of digital learning strategies in improving the accessibility and continuity of audiology training.

2.3 Gaps in the Literature and Challenges in E-Learning for Clinical Masking

The growing research evidence base for simulation-based and interactive e-learning in audiology education reveals a critical, as-yet-unaddressed gap: no published, validated interactive e-content module dedicated to clinical masking concepts has been identified in the audiology education literature. Existing simulation tools and e-learning platforms in audiology have addressed a range of clinical content areas, including audiometry, ABR, tympanometry, paediatric diagnostic decision-making, and communication counselling skills. However, clinical masking, despite being one of the most foundational, most procedurally complex, and most commonly misunderstood procedures in diagnostic audiology, remains without a dedicated interactive digital learning resource.

The absence of such a resource is particularly striking given the consistently documented difficulty students experience in learning clinical masking (Skinner et al., 2023; Margolis, 2010; Turner, 2004), and the explicit and repeated calls in the literature for the development of simulation-based and interactive instructional tools targeting this area. Based on the strong preference for applied, practice-based learning among the students surveyed, Skinner et al. (2023) concluded their survey study with a specific recommendation for developing interactive, scenario-based digital resources for masking education. The present study takes this recommendation forward by developing and validating a specific interactive e-content module on clinical masking for undergraduate audiology students.

A related challenge is the quality of the design of existing educational resources on clinical masking. The principles of masking are covered extensively didactically in traditional audiology texts such as those of Yacullo (2009) and Valente (2009). However, it is a static, passive medium by nature, without interactivity, self-assessment and adaptive feedback. Masking is taught as one of many audiometric procedures on typical audiometric learning platforms, but without the depth, structured progression, and content specificity needed to achieve true clinical competency. Margolis (2010) specifically criticised the didactic-only approach as insufficient for developing the level of understanding necessary for accurate clinical masking and called for instructional resources that engage learners in actively applying masking principles to realistic clinical scenarios.

The challenges of instructional design in developing a successful e-content module for clinical masking are unique. The iterative, multistep nature of the plateau method, the variability in masking requirements across audiometric configurations, and the mathematical precision required for initial masking level calculations all necessitate careful scaffolding of content from basic concepts to advanced clinical applications. The importance of alignment of content with explicit learning objectives, formative assessment with immediate corrective feedback, scaffolding from simple to complex and cognitive load management through clear and well-structured presentation of content has been repeatedly emphasised by authors of literature on e-learning design in health professions education (Cook et al., 2010; Mayer, 2009). These design principles must be applied with special diligence to clinical masking, given the inherent complexity and high clinical stakes of the content.

The challenges of motivation and engagement in self-directed e-learning contexts are also relevant for the development of a masking e-content module. Other learners are less engaged in online self-directed learning environments without the social accountability of a face-to-face classroom (Means et al., 2013). One design strategy to address engagement, self-regulation and clinical safety considerations simultaneously for clinical masking is the use of minimum competency thresholds as progression gates within the module. The sequential, mastery-based nature of the content means that foundational concepts must be fully understood before more complex material can be meaningfully engaged. Evidence from gamification research in health professions education further supports the use of progress tracking, immediate feedback, and scenario-based learning as effective motivational tools within interactive e-learning modules (Khoshnoodifar et al., 2023).

Finally, the design of a clinical masking e-content module for the Indian audiology training context must address the broader issue of ensuring that e-learning resources are contextually relevant, institutionally accessible, and technically compatible with available infrastructure. Some modules may require specialised software, proprietary hardware, or high-bandwidth internet access, which may not be available in all institutional settings. The design approach presented in this study, which uses an institutionally hosted module with a user-friendly graphical interface that works with standard web browsers and is accessible via local institutional networks, directly addresses these contextual access challenges and makes the resource available for widespread and fair use within the Indian audiology training environment.

In summary, a large volume of literature demonstrates the critical importance of clinical masking for audiological diagnosis, the well-documented and ongoing challenges faced by students in learning this procedure, the proven efficacy of simulation-based and interactive e-learning for audiology education and the total absence of a dedicated, validated, interactive e-content module on clinical masking. The present study thus fills an established, evidence-based gap in audiology educational resources, with direct implications for the quality of undergraduate masking training and, ultimately, the accuracy of audiological diagnosis and patient care outcomes.

CHAPTER III

METHOD

The present study involved developing, validating, and evaluating an interactive e-content module on clinical masking concepts for undergraduate audiology students. The development of the interactive e-content module was carried out in three phases: preparation of content on various concepts in clinical masking, validation and evaluation of the developed content, and assessment of the module's effectiveness.

3.1 Participants

35 undergraduate audiology students participated in the study. Specifically, students enrolled in a Bachelor of Audiology and Speech Language Pathology (B. ASLP) were included, as by this stage in the curriculum, they had completed the foundational theory classes on clinical masking. All participants had a minimum theoretical background in clinical masking procedures. Participants were selected using purposive sampling, a method that deliberately includes students who meet the criterion of having completed relevant coursework.

3.1.1 Participant Selection Criteria

Inclusion Criteria

- Undergraduate audiology students.
- Students who have completed the theory paper already, including the clinical masking concept.
- Students who were available for all sessions of the training module and assessments.

Exclusion Criteria

- Students who have not completed foundational coursework in clinical masking.
- Students who have received prior advanced training in masking concepts beyond the standard undergraduate curriculum.

- Students who have already undergone extensive clinical practice in masking procedures.
- Students who have previously participated in a similar training program or study.

3.2 Ethical considerations

Ethical approval was obtained prior to the commencement of the study, and all procedures were in accordance with the AIISH ethical guidelines, "Ethical Principles for 8 Bio-Behavioural Research Involving Human Subjects" (2023). Written informed consent was obtained from all the participants before data collection. The participants were informed about the study's purpose, the procedures involved, the potential benefits, and their rights as participants. Participation was completely voluntary, and participants were free to withdraw from the study at any time. The copy of the ethical approval is given in Appendix 1

3.3 Procedure

The development of the interactive e-content module involved the following phases:

Phase 1: Content preparation of various concepts in clinical masking,

Phase 2: Validation and evaluation of the content,

Phase 3: Evaluation of the effectiveness of the module

3.3.1. Phase 1: Content preparation of various concepts in clinical masking

The content is divided into 10 modules covering the concepts of the clinical masking procedure during pure-tone and speech audiometry. Which includes:

Module 1: Introduction to clinical masking:

In Module 1, students were introduced to clinical masking and its importance in diagnostic audiology. Students will learn why masking is essential for obtaining accurate ear-specific hearing thresholds or speech-perception measurements.

Module 2: Terminologies used in clinical masking

Module 2 helps familiarise the students with essential terminologies such as test ear, non-test ear, masker, maskee, interaural attenuation, presentation level, ipsilateral masking, contralateral masking, effective masking level, minimum masking level, initial masking level, maximum masking level, cross over, cross hearing, shadow curve, over-masking, and under-masking. The use of standardised terms will help learners communicate clinical findings effectively. This foundation supports the understanding of advanced masking concepts in later modules.

Module 3: Concepts of crossover and cross hearing, interaural attenuations and occlusion effect

Module 3 explains how test signals can cross over to the non-test ear and the role of interaural attenuation in this process. This helps study the phenomenon of cross-hearing and its effect on the accuracy of audiometric findings. The occlusion effect is also described with demonstrations to show its clinical impact.

Module 4: When to mask

Module 4 facilitates learning the clinical rules governing when masking is required in air-conduction, bone-conduction, and speech audiometry. The module includes decision-making formulas and shortcuts to simplify the process. Learners identify situations in which failure to mask may lead to misdiagnosis.

Module 5: How much to mask

Module 5 focuses on calculating the initial, minimum, and maximum masking levels required during the plateau/ maximum masking method to determine the correct amount of masking. Learners are guided through formulas and worked-out examples.

Module 6: Audiogram symbols, patient instructions, and audiometer setup during masking

Module 6 introduced the concepts to teach students how to use audiogram symbols correctly when recording masked thresholds and to give clear instructions to patients during masking procedures. The module also deals with how to set up the audiometer appropriately for different masking situations.

Module 7: Clinical masking procedures for pure tone masking:

Module 7 presented step-by-step masking procedures for measuring air- and bone-conduction thresholds. It also explained the application of the plateau method and maximum masking level method in clinical practice using simulated audiograms. Guided examples were included to reinforce correct masking procedures and improve clinical understanding.

Module 8: Clinical masking procedures for speech audiometry

Module 8 introduced the learners to masking procedures for speech recognition threshold (SRT) and speech identification scores (SIS) testing. The module demonstrates appropriate types of masking noise and the methods of masking, including the plateau and maximum masking level method. Case-based examples will illustrate correct application in clinical contexts.

Module 9: Common errors during the clinical masking procedure

Module 9 helps students learn to identify and avoid common mistakes, such as failure to mask when required, poor patient instructions, under-masking, over-masking, incorrect use of interaural attenuation, ignoring the occlusion effect, errors in the plateau method, audiometer setup errors, documentation errors, masking dilemma, etc. The consequences of these errors are illustrated using examples. Practical tips are provided to help learners apply masking more accurately in clinical practice.

Module 10: Clinical case-based examples for practice:

Module 10, the final module, provides learners with case-based exercises to apply all the concepts learned in previous modules. Learners must work through simulated patient cases with varying types and degrees of hearing loss and decide when and how to mask. This allows them to refine their clinical reasoning and decision-making skills.

The contents within each section are developed based on the existing literature on the various concepts of clinical masking. Learning objectives are developed for each module, and the content is designed to align as closely as possible with them. All modules are developed in Microsoft PowerPoint (2019) and include pictographs, diagrams, text and animated graphics. Interactive activities such as illustrations and appropriate examples, matching, selecting the odd one out, and dropdown selection are included. The images included in the modules were generated using AI tools such as Gemini and ChatGPT, while some were sourced from Google and selected from materials available under Creative Commons licenses. The scripts of all modules are written in simple, clear and consistent sentences to facilitate easy understanding. Furthermore, the audio script is recorded as a voice-over. The videos incorporated in the module were created and edited using Canva and Microsoft Clipchamp. A Google form with instant feedback was used at the end of each module to assess the students' understanding of each concept. The fourth, fifth, seventh and tenth modules were divided into submodules to divide lengthy content into short sections. This offered a systematic approach to developing high-quality e-content to enhance learner engagement and skill development. The format includes multimedia tools and interactive assessments to enable personalised and inclusive learning experiences. This study analysed learner outcomes, usability, and content relevance across audiologists.

Development of the digital platform:

The application has been divided into Front–End Screen and Back-End database. When the user opens the web address, it navigates to the dissertation title page. When the user clicks Begin, it navigates to the front-end page, which is developed using Microsoft Visual Studio 2022 Enterprise Version (Licensed), purchased by AIISH, Mysuru, and installed on CRAB, COE. The application layout is divided into two Panes: the main learning content (Video) is displayed in the left-hand pane. While all other modules are listed on the right-hand pane. Each module has been divided into separate sections, with a corresponding questionnaire (Google Forms). The application design required the participants to watch the complete video before progressing to any related formative assessment activities. The major feature of the application is that the quiz is unlocked only after the user has watched the video content in its entirety. Other video playback features, such as play, pause, and forward, were under user control. Special attention was paid to ensure the digital platform was appealing and user-friendly. Legible fonts and high contrast visuals were used. This application enabled access to modules across various desktops, laptops, and Tabs by ensuring flexibility and inclusivity.

The application's back-end is hosted in a MySQL database. This database contains all the information related to the application. Utmost care has been taken to make sure this database is not accessible to users. The entire module is hosted in the dedicated AIISH Server, which can be accessed within and from outside networks using the web address https://emauds.aiishtools.co.in.

3.3.2. Phase 2: Validation and evaluation of the content

Three experienced audiologists conducted the content validation of the materials developed for each module. The following aspects were evaluated using a 5-point Likert scale (1- Strongly Disagree/Very Poor, 2- Disagree/ Poor, 3- Neutral/ Average, 4- Agree/Good, 5- Strongly Agree/Very Good): accuracy, appropriateness for the target audience and learning level, relevance, clarity, completeness, structure, alignment with learning objectives, engagement, use of examples, and language accuracy. The expert validation process ensured that the module content was educationally appropriate, clinically relevant, and effective for facilitating learning.

3.3.3. Phase 3: Evaluation of the effectiveness of the module

The effectiveness of the developed e-content module on clinical masking was evaluated using a baseline/post-training test experimental design. This approach is widely recognised for its ability to measure learning outcomes by comparing participants' knowledge levels before and after the intervention. A comprehensive assessment tool was designed using Google Forms with 52 questions to evaluate learning across multiple knowledge and skill domains. The questionnaire was not only Multiple-Choice Questions (MCQs). It contained a variety of question types, including 38 MCQ with a single answer, 7 MCQ with multiple answers, 6 True or False, and 1 Matching the following, which provided a wider coverage and deeper testing of student competence. The Google Form is attached in Appendix 2

- Conceptual knowledge: measured with true/false and fill-in-the-blank statements, covering theoretical concepts such as crossover, interaural attenuation, and the plateau method.
- Clinical reasoning: assessed by matching questions and short case vignettes requiring application of rules for when to mask.
- Problem-solving and practical competence: assessed by calculation-based questions and case-based scenarios requiring learners to determine appropriate masking levels and identify possible errors (over-masking, under-masking, or masking dilemma).

All participants were provided with a baseline test prior to accessing the module to establish a baseline measure of knowledge and skills. A post- training test was administered with the same set of questions after completion of all modules to compare baseline and post-training scores. The difference between baseline test and post-training performance was analysed to quantify knowledge gain attributable to the e-content module.

The module incorporated formative assessments at the end of each module to improve active engagement. Progression through the modules will depend on passing the quizzes embedded in each module with a minimum mastery score (e.g. 70%). Students who did not meet the criterion were encouraged to review the material and retake the quiz before progression. The mastery-based progression system ensured that learners developed a strong understanding of foundational concepts before proceeding to more advanced topics.

Qualitative feedback was also obtained via a structured questionnaire on content clarity, ease of navigation, usefulness of interactive elements and perceived confidence in application of masking principles. These measures together provided a holistic assessment of the educational effectiveness and practical applicability of the developed e-content module to improve undergraduate audiology students' understanding of clinical masking. Along with the quantitative comparison, the qualitative evaluation provided insight into the strengths and weaknesses of students' learning. Thereafter, it helped in the evaluation of the effectiveness of the e-content module in improving the understanding of clinical masking in undergraduate students of audiology from the educational and practical perspectives.

A structured student survey was used to evaluate the perceptions after the completion of the developed e-content module. The survey link was located at the end of the module and gathered anonymously to promote unbiased, honest feedback. The survey comprised closed-ended items to measure parameters such as content accuracy, clarity, organisation, interactivity, and overall satisfaction, and open-ended questions to elicit free-text comments. The combination of quantitative ratings and qualitative comments provides both quantitative data and rich insight into students' experiences. The feedback was systematically analysed and used to identify the module's strengths, address limitations and guide future refinements, ensuring that the module's strengths are maintained, limitations are addressed, and future refinements are guided, ensuring that the resource remains learner-centred and pedagogically effective.

3.4 Data analysis

Data obtained from the study were analysed using IBM SPSS Statistics (Version 26.0). Descriptive statistics were used to summarise participant performance and feedback responses. For the baseline and post-training scores, measures of central tendency and dispersion, including mean, standard deviation, median, and interquartile range, were calculated. Before the comparison analysis, the distributions of baseline and post-training scores were examined using the Shapiro-Wilk test of normality. As baseline scores did not meet the assumption of normality, a nonparametric test was used for hypothesis testing. The Wilcoxon signed-rank test was used to compare baseline and post-training test scores and determine the effectiveness of the interactive e-content module on clinical masking concepts.

In addition to statistical significance testing, the magnitude of the intervention effect was estimated using the effect size r, calculated from the Wilcoxon signed-rank test statistics as $r = |Z|/\sqrt{N}$. Effect size values were interpreted according to Cohen's (1988) guidelines. Statistical significance was established at an alpha level of 0.05.

For content validation, expert ratings were analysed descriptively. A module component was considered acceptable if at least two of the three expert raters rated it 4 or 5 on the 5-point Likert scale (1- Strongly Disagree/Very Poor, 2- Disagree/ Poor, 3- Neutral/ Average, 4- Agree/Good, 5- Strongly Agree/Very Good). Student perception feedback data were analysed using frequencies, percentages, and median scores to describe participants' views regarding the content, organisation, usability, interactivity, and overall effectiveness of the developed module.

CHAPTER IV

RESULTS

The present study aimed to develop, validate, and evaluate the effectiveness of an interactive e-content module on clinical masking concepts for undergraduate audiology students. Data were collected from thirty-five Bachelor of Audiology and Speech Language Pathology (B. ASLP) students. All participants received a baseline test, the e-content modules and a post-training test. The e-content modules consisted of 10 modules covering all concepts of clinical masking in pure-tone and speech audiometry.

4.1. Phase 1: Development of the Interactive e-Content Module

The e-content module on clinical masking was developed based on literature findings and learning needs identified among undergraduate audiology students. Basic concepts, such as interaural attenuation, cross-over, cross-hearing, and indications for masking, are often included in undergraduate training but were included here to provide continuity and reinforce conceptual understanding. Greater attention was paid to clinically difficult areas commonly described in the literature, such as effective masking, the plateau method, under-masking, over-masking, the masking dilemma, and the interpretation of complex clinical masking situations. In line with these learning needs, the e-content module was systematically structured into several learning modules that comprise theoretical explanations, demonstrations, clinical case scenarios, and formative assessments.

The e-content module was developed into 10 structured modules that address both the theoretical foundations and the practical applications of clinical masking in audiological assessment. The content was developed through a systematic instructional design process that begins with introductory concepts and progresses to complex case-based applications. Each module was anchored to explicit learning objectives derived from a comprehensive review of the clinical masking literature.

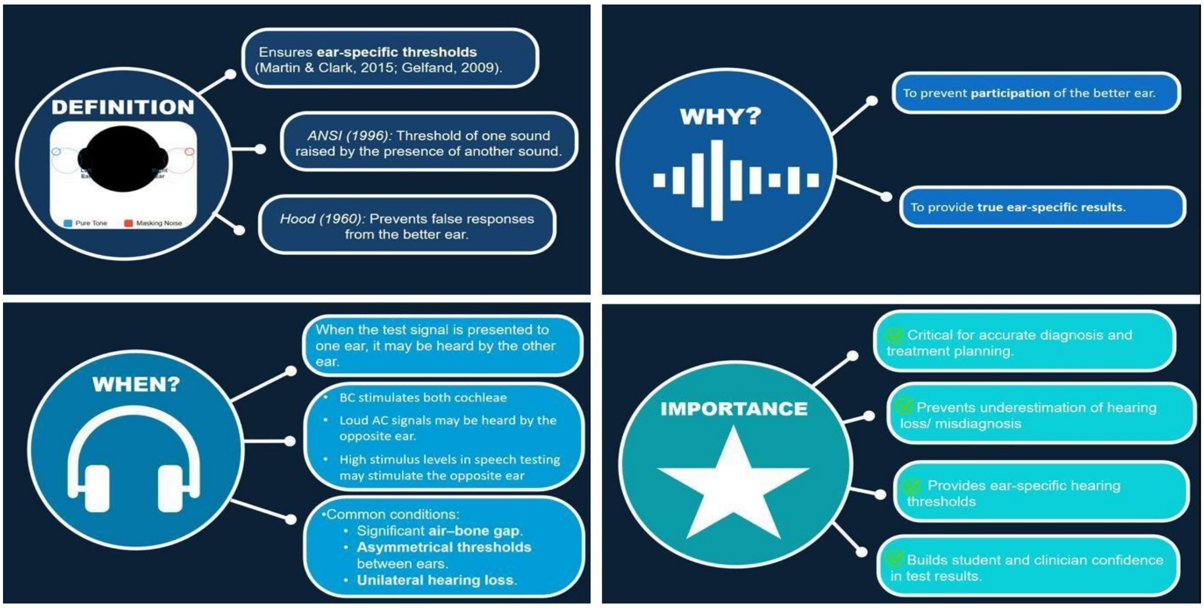
The e-content module on clinical masking included baseline and post-training summative assessment sections embedded within the module's structure, created in Google Forms. To provide an overview, a few representative slides from each module are presented in Figures 4.1-4.10 below.

Module 1: Introduction to Clinical Masking

The module introduced the concept of clinical masking, its need, and its importance in diagnostic audiology. The content included the definition of masking and examples illustrating the consequences of failing to apply masking when required. At the end of the module, a 10-question Google Form was added for the post-assessment of the learning through the e-content module. The average post-assessment score was 84.6%.

Figure 4.1

Sample slides from Module 1: Introduction to Clinical Masking.

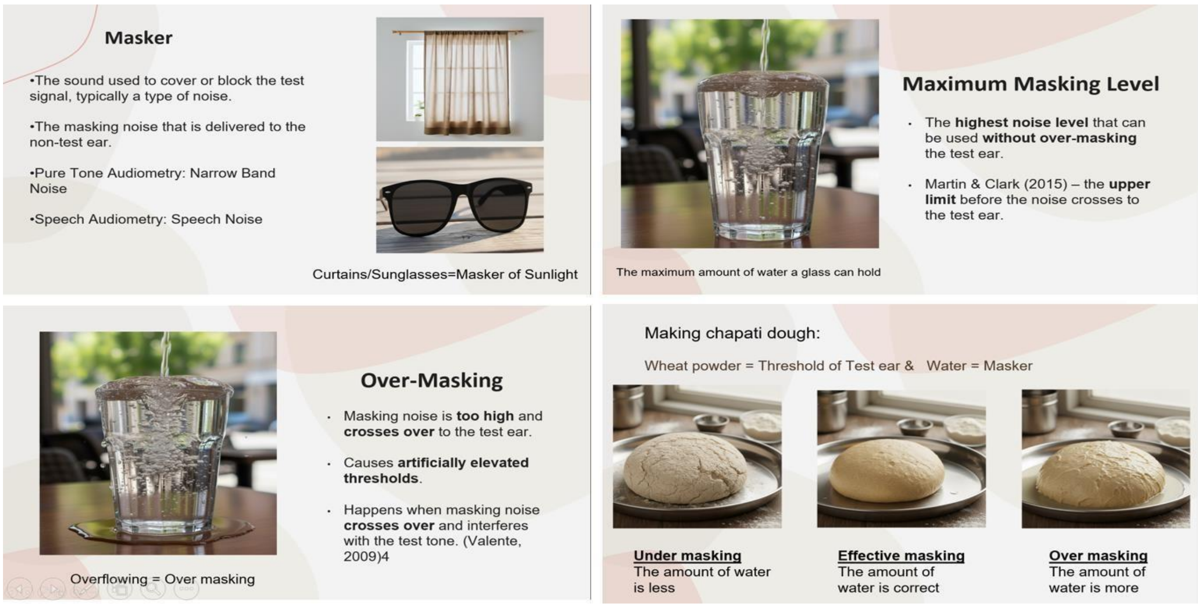


Module 2: Terminologies in Clinical Masking

The module introduced the key terminologies used in clinical masking. Concepts such as test ear, non-test ear, presentation level, interaural attenuation, crossover, cross-hearing, shadow curve, masking levels, over-masking, and under-masking were explained with examples and visual analogies to establish a foundation for subsequent modules. The learners' mean post-assessment score was 91.4%.

Figure 4.2

Sample slides from Module 2: Terminologies in Clinical Masking.

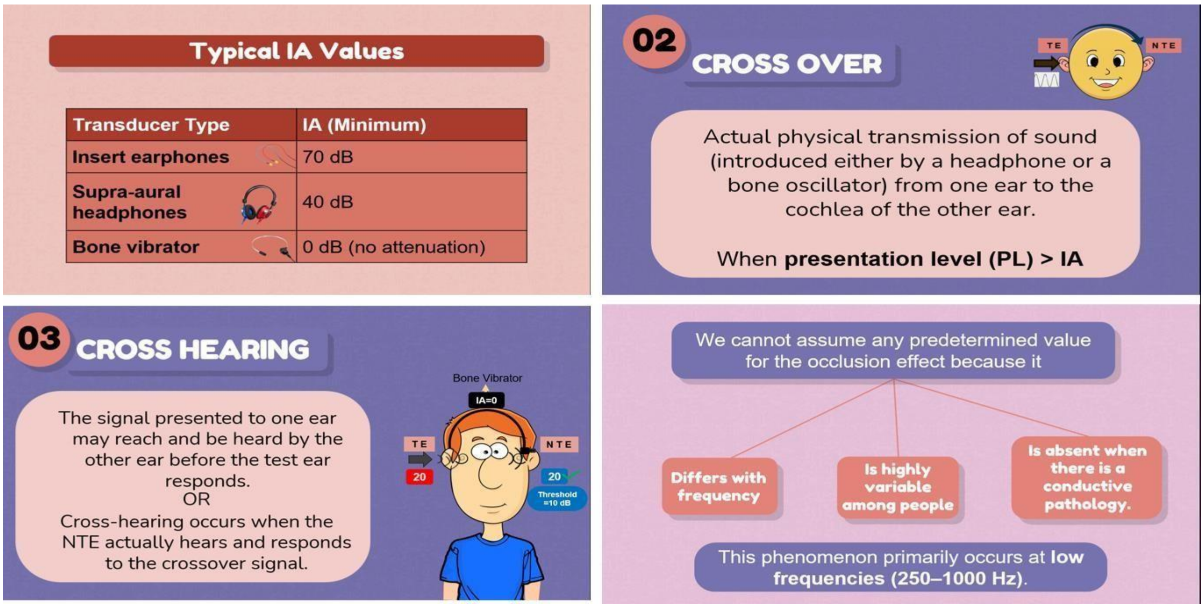


Module 3: Concepts of Cross-Over and Cross-Hearing, Interaural Attenuations and Occlusion Effect

The module explained the concepts of crossover, cross-hearing, interaural attenuation, and the occlusion effect. Illustrations and examples were included to demonstrate how these concepts influence masking decisions and audiometric results. Learners achieved an average post-assessment score of 87.4%.

Figure 4.3

Sample slides from Module 3: Concepts of Cross-Over and Cross-Hearing, Interaural Attenuations and Occlusion Effect.

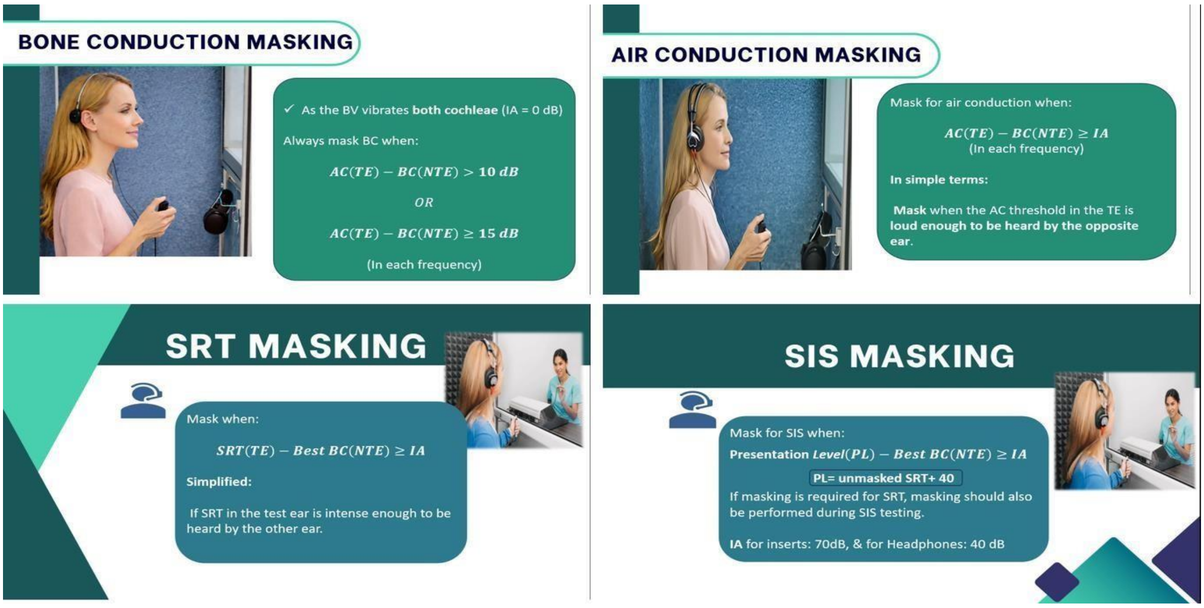


Module 4: When to Mask

The module described the clinical conditions under which masking is required during air-conduction, bone-conduction, and speech audiometry. Decision-making rules and examples were included to help learners identify situations requiring masking. Participants obtained a mean score of 81.7% on the module post-assessment, indicating satisfactory understanding of the module content.

Figure 4.4

Sample slides from Module 4: When to Mask.

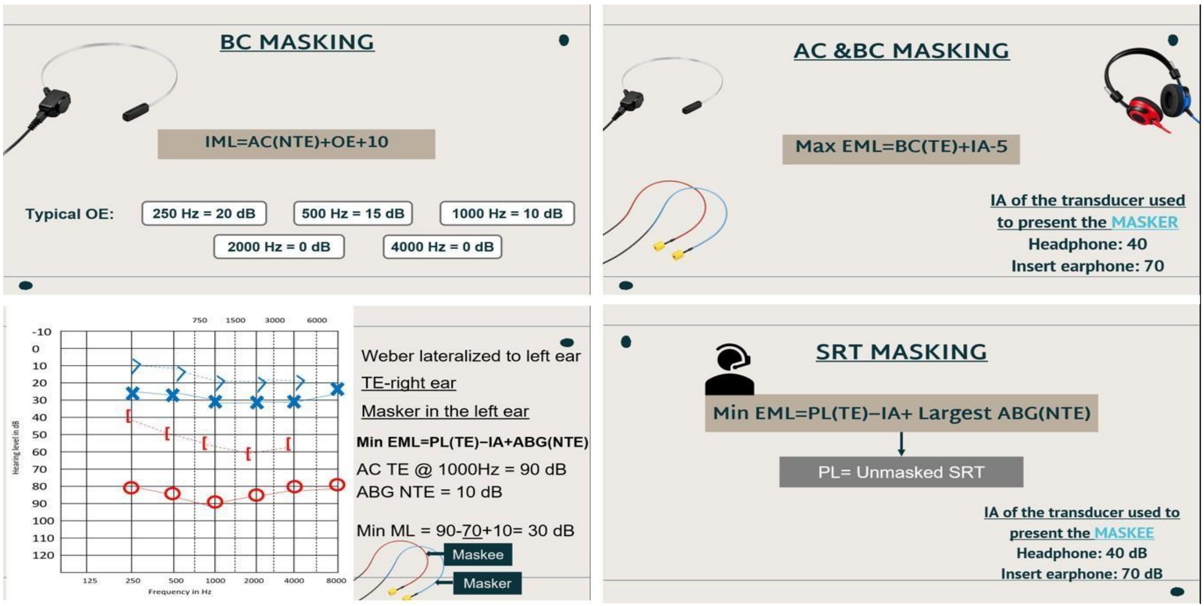


Module 5: How Much to Mask

The module covered how to determine the appropriate amount of masking during audiometric testing. Formulae and worked examples were used to explain procedures for calculating, minimum, initial and maximum masking levels. The average post-assessment score for the 10 questions was 78.3%, suggesting good comprehension of the main ideas.

Figure 4.5

Sample slides from Module 5: How Much to Mask.

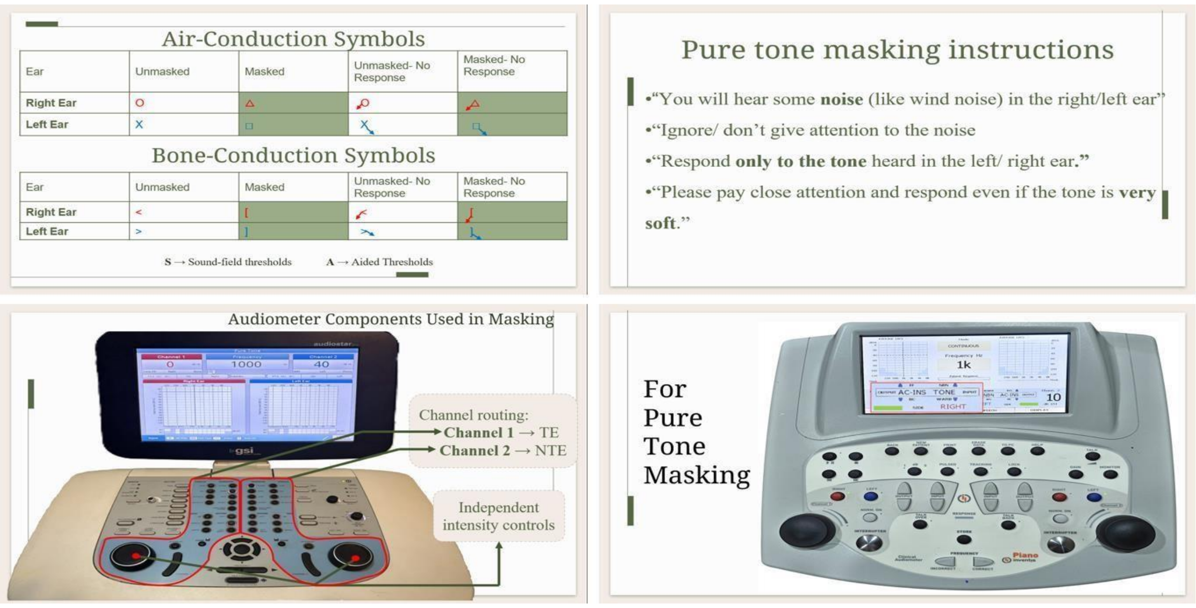


Module 6: Audiogram Symbols, Patient Instructions, and Audiometer Setup During Masking

The module introduced the audiogram symbols for plotting masked thresholds and documenting masking procedures. Content also included instructions to patients and the audiometer setup necessary for effective masking. The average score on the post-assessment was 86.3%, indicating a good level of understanding of the module concepts.

Figure 4.6

Sample slides from Module 6: Audiogram Symbols, Patient Instructions and Audiometer Setup During Masking.

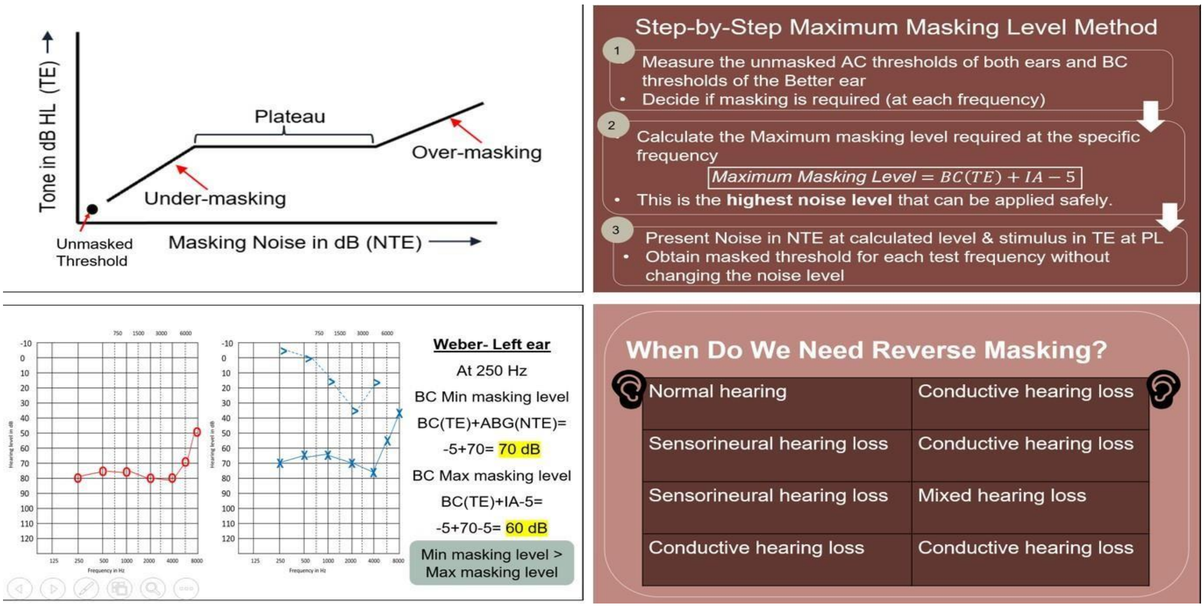


Module 7: Clinical Masking Procedures for Pure-Tone Audiometry

The module presented the step-by-step procedures used for masking during air- and bone-conduction audiometry. Simulated audiograms and guided examples were included to demonstrate the application of the plateau method and maximum masking level method. The mean score of 84.9% indicated that most learners understood and applied the module's concepts.

Figure 4.7

Sample slides from Module 7: Clinical Masking Procedures for Pure-Tone Audiometry.

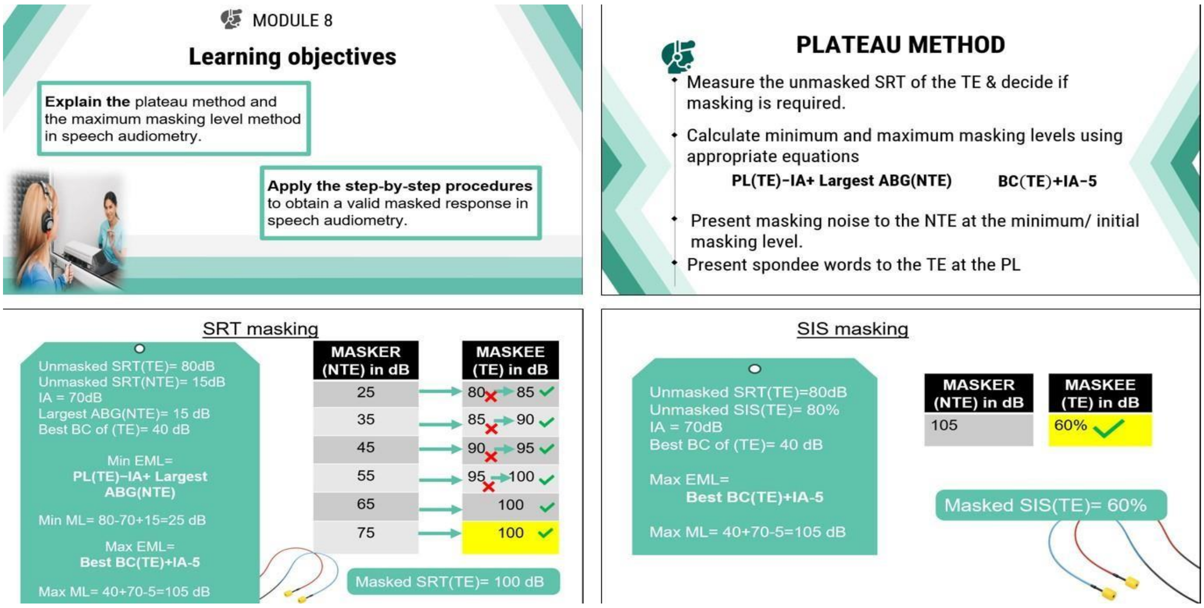


Module 8: Clinical Masking Procedures for Speech Audiometry

The module described masking procedures used during speech recognition threshold (SRT) and speech identification score (SIS) testing. Clinical examples were provided to demonstrate the appropriate use of masking noise and masking methods during speech audiometry. The average post-assessment score was 87.7%.

Figure 4.8

Sample slides from Module 8: Clinical Masking Procedures for Speech Audiometry.

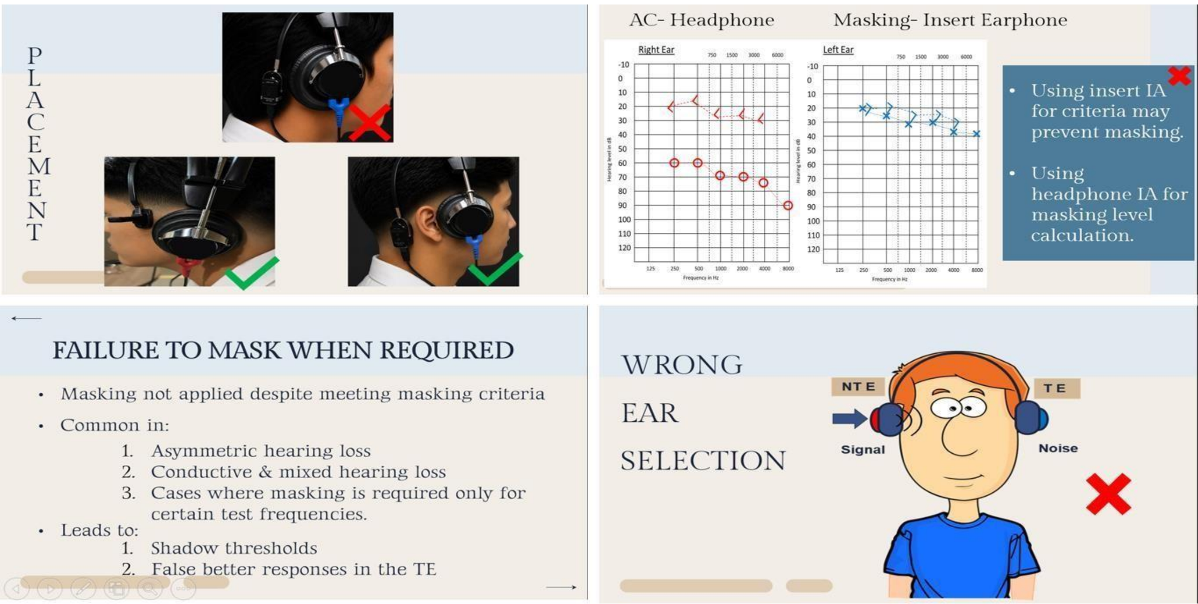


Module 9: Common Errors During the Clinical Masking Procedure

The module discussed common errors encountered during masking procedures, including under-masking, over-masking, incorrect masking decisions, use of occlusion effect, incorrect audiometer setup, poor patient instructions, errors in masking methods, masking dilemma, and documentation errors. Examples were provided to illustrate the clinical consequences of these errors and methods to avoid them. The average score on the post-assessment was 86.9%.

Figure 4.9

Sample slides from Module 9: Common Errors During the Clinical Masking Procedure.

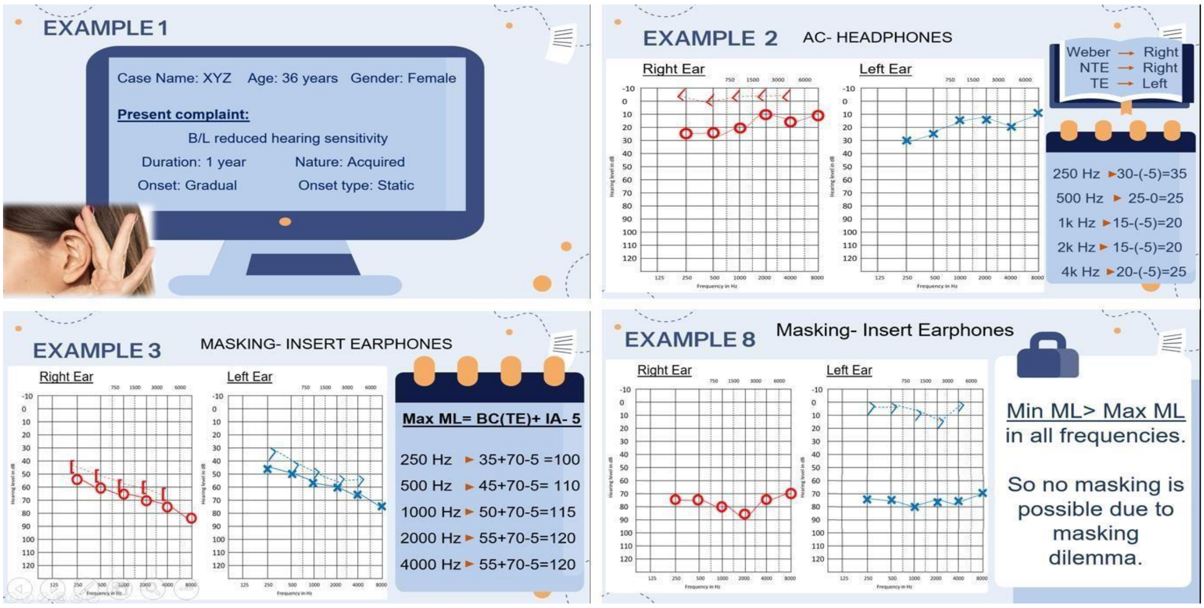


Module 10: Clinical Case-Based Examples for Practice

The module provided simulated clinical cases with different hearing loss configurations to apply masking concepts and procedures. Learners were required to analyse each case and make appropriate masking decisions, thereby strengthening clinical reasoning and problem-solving skills. The average score obtained on the post-assessment was 84.6%.

Figure 4.10

Sample slides from Module 10: Clinical Case-Based Examples for Practice.



The structure and content of the e-learning module are given in Table 4.1

Table 4.1

List of modules, topics covered, and duration of each module.

Module No.	Title of the Module	Content Covered	Duration of the content
Module 1	Introduction to Clinical Masking	• Definition of masking, • Importance of masking, and • Why and when masking is required	7 minutes
Module 2	Terminologies in Clinical Masking	• Test ear, • Non-test ear, • Masker, • Maskee, • Presentation level, • Interaural attenuation, • Effective masking level, • Minimum masking level, • Maximum masking level, • Overmasking, and • Undermasking	12 minutes
Module 3	Concepts of Crossover and	• Crossover,	

<table>
<tr><th>Module No.</th><th colspan="2">Title of the Module</th><th>Content Covered</th><th>Duration of the content</th><th></th></tr>
<tr><td></td><td colspan="2">Cross-Hearing, Interaural Attenuation and Occlusion Effect</td><td>• Cross-hearing,
• Interaural attenuation, and
• Occlusion effect,</td><td>10 minutes</td><td></td></tr>
<tr><td rowspan="2">Module 4</td><td rowspan="2">When to Mask</td><td>Part A</td><td>• Criteria for air conduction masking,
• Criteria for bone conduction masking, and
• Audiogram examples</td><td>12 minutes</td><td rowspan="2">16 minutes</td></tr>
<tr><td>Part B</td><td>• Criteria for speech masking, and
• Audiogram examples</td><td>4 minutes</td></tr>
<tr><td rowspan="2">Module 5</td><td rowspan="2">How Much to Mask</td><td>Part A</td><td>• Pure tone masking:
• Calculation of Minimum masking level,
• Calculation of the initial masking level,
• Calculation of the maximum masking level, and
• Audiogram examples</td><td>12 minutes</td><td rowspan="2">18 minutes</td></tr>
<tr><td>Part B</td><td>• Speech masking:
• Calculation of Minimum masking level,
• Calculation of the initial masking level,
• Calculation of the maximum masking level, and
• Audiogram examples</td><td>6 minutes</td></tr>
<tr><td>Module 6</td><td colspan="2">Audiogram Symbols, Patient Instructions and Audiometer Setup During Masking</td><td>• Audiogram symbols,
• Patient instructions, and
• Audiometer setup,</td><td>10 minutes</td><td></td></tr>
<tr><td rowspan="3">Module 7</td><td rowspan="3">Clinical Masking Procedures for Pure-Tone Audiometry</td><td>Part A</td><td>• Plateau method, and
• Audiogram examples</td><td>13 minutes</td><td rowspan="3">22 minutes</td></tr>
<tr><td>Part B</td><td>• Maximum masking level method, and
• Audiogram examples</td><td>3 minutes</td></tr>
<tr><td>Part C</td><td>• Masking dilemma
• Reverse Masking, and
• Audiogram examples</td><td>6 minutes</td></tr>
<tr><td>Module 8</td><td colspan="2">Clinical Masking Procedures for Speech Audiometry</td><td>• Plateau method,
• Maximum masking level method, and</td><td>9 minutes</td><td></td></tr>
</table>

Module No.	Title of the Module		Content Covered	Duration of the content	
			• Audiogram examples		
Module 9	Common Errors During the Clinical Masking Procedure		• Failure to mask, • Poor patient instructions, • Undermasking, • Overmasking, • Incorrect use of IA, • Ignoring the occlusion effect, • Plateau method errors, • Audiometer setup errors, and • Masking dilemma	16 minutes	
Module 10	Clinical Case-Based Examples for Practice	Part A	• Simulated audiograms, • Explanation about masking decision-making, clinical reasoning, masking interpretation, and prevention of masking errors in a simulated case	9 minutes	17 minutes
		Part B		8 minutes	

The complete module was hosted on a dedicated institutional server at the All India Institute of Speech and Hearing (AIISH), Mysuru, accessible within the institution via a local IP address. To provide a visual representation of the developed application interface and module layout, screenshots of the application are presented in Figures 4.11, 4.12, and 4.13 and 4.14 below.

Figure 4.11

Home Page of the application.

Figure 4.12

Main Navigation Interface of the application.

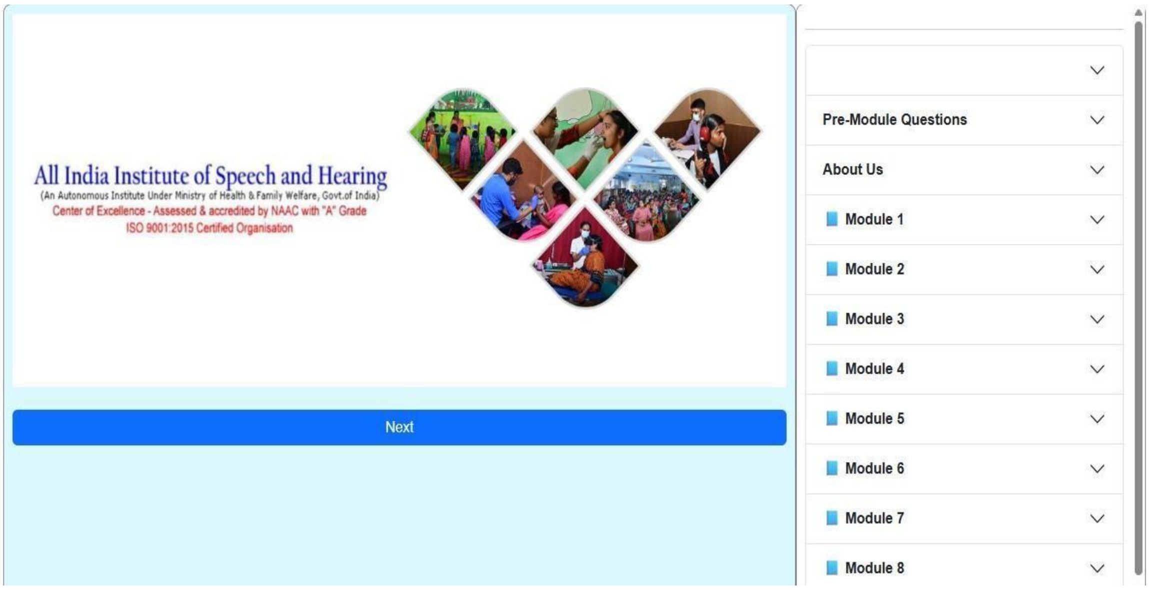


Figure 4.13

Module 1 interface of the application.

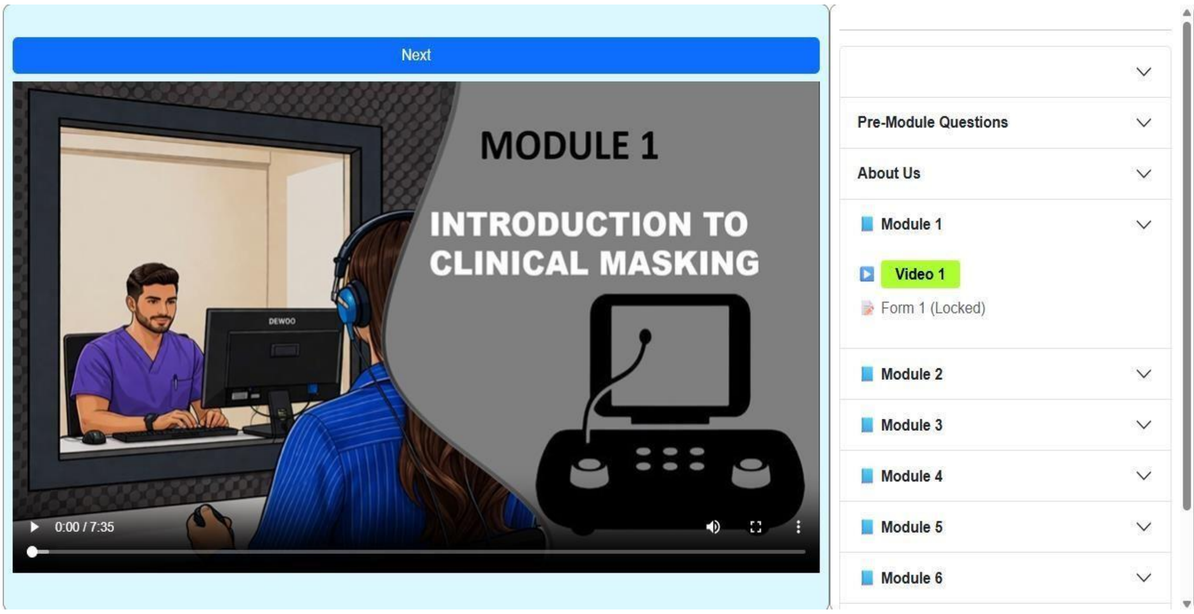
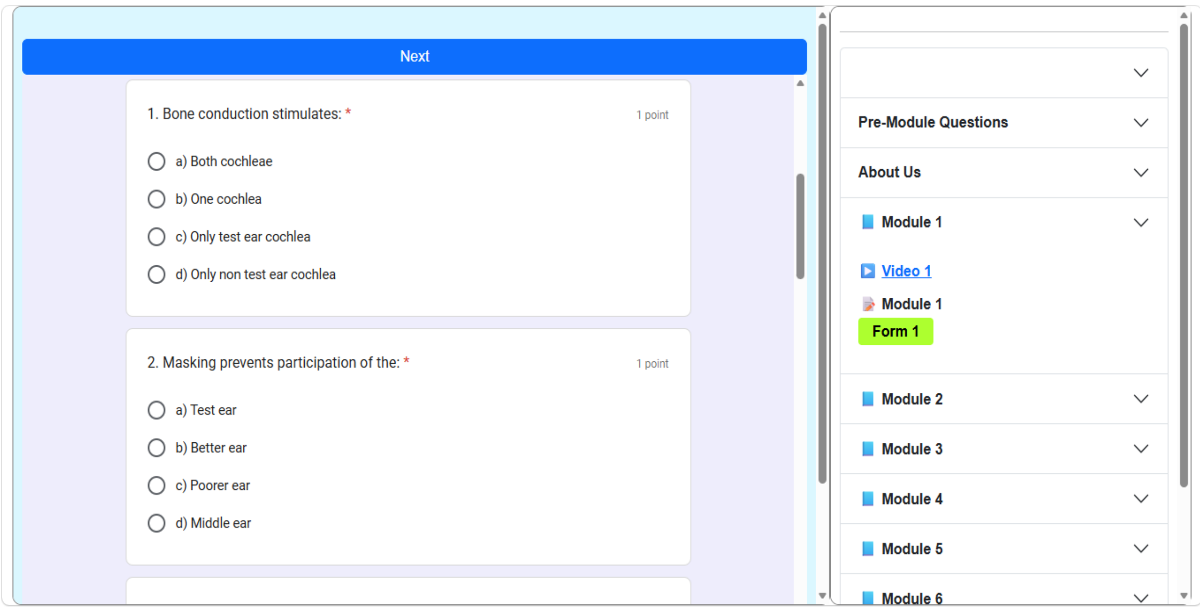


Figure 4.14

Embedded Module 1 post assessment.



4.2 Phase 2: Content Validation Through Expert Review

3 experienced audiologists validated the content. The ten modules were rated independently by each rater on a 5-point Likert scale (1 = Strongly Disagree/Very Poor to 5 =

Strongly Agree/Excellent) on ten different parameters including (1) Accuracy, (2) Appropriateness for the target audience and learning level, (3) Relevance, (4) Clarity, (5) Completeness, (6) Structure, (7) Alignment with learning objectives, (8) Engagement, (9) Use of Examples and (10) Language Accuracy. An item was considered content-valid if at least two of the three raters (i.e., $\geq 2/3$) assigned a rating of 4 or 5. All evaluated parameters across the ten modules were rated 4 or 5 by at least two of the three expert raters, demonstrating strong expert agreement on the quality and appropriateness of the module content and instructional design.

Expert feedback from all three raters indicated that the module was relevant to the target learner group and that the use of interactive elements, embedded examples, and structured assessments was appropriate for the complexity of clinical masking concepts.

4.3 Phase 3: Evaluation of Module Effectiveness

To evaluate the effectiveness of the developed e-content module, baseline and post-training assessments were conducted to assess learning outcomes. Before the inferential statistical analysis, the normality of the distributions of baseline and post-training scores was tested using the Shapiro-Wilk test. Results revealed that the baseline scores were significantly non-normal ($p = .005$). Post-training scores were normally distributed ($p = .058$). Hence, the non-parametric Wilcoxon signed-rank test was used to compare baseline and post-training scores.

Baseline and Post-training Performance

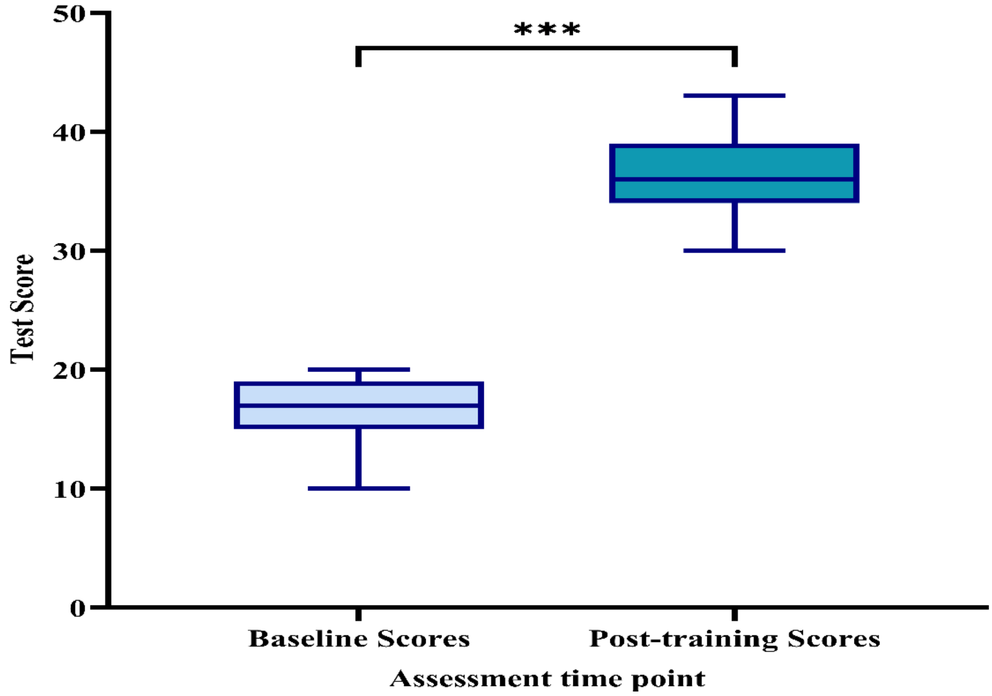
Descriptive statistics for baseline and post-training scores are presented in Table 3. Before engaging with the e-content module, participants obtained a mean baseline score of 16.46 (SD = 2.84, Median = 17.00, Interquartile Range =4) out of a maximum possible score of 52, reflecting limited baseline knowledge of clinical masking concepts. Following completion of all ten modules, mean post-training scores increased substantially to 36.29 (SD

= 3.67, Median = 36.00, Interquartile Range =5), representing a mean gain of 19.83 marks.

A Wilcoxon signed-rank test was performed to evaluate the significance of the difference between baseline and post-training scores. The results, presented in Table 4, showed a statistically significant improvement in performance after completion of the e-content module ($Z = -5.164$, $p < .001$). For all 35 participants, the post-training score was higher than the baseline. This means there were no negative ranks and no ties. The effect size was calculated as $r = |Z| / \sqrt{N} = 5.164 / \sqrt{35} = .87$, which suggested a large effect (Cohen, 1988). These findings confirm that the interactive e-content module resulted in a statistically significant and practically meaningful improvement in students' knowledge and application of clinical masking concepts.

Figure 4.15

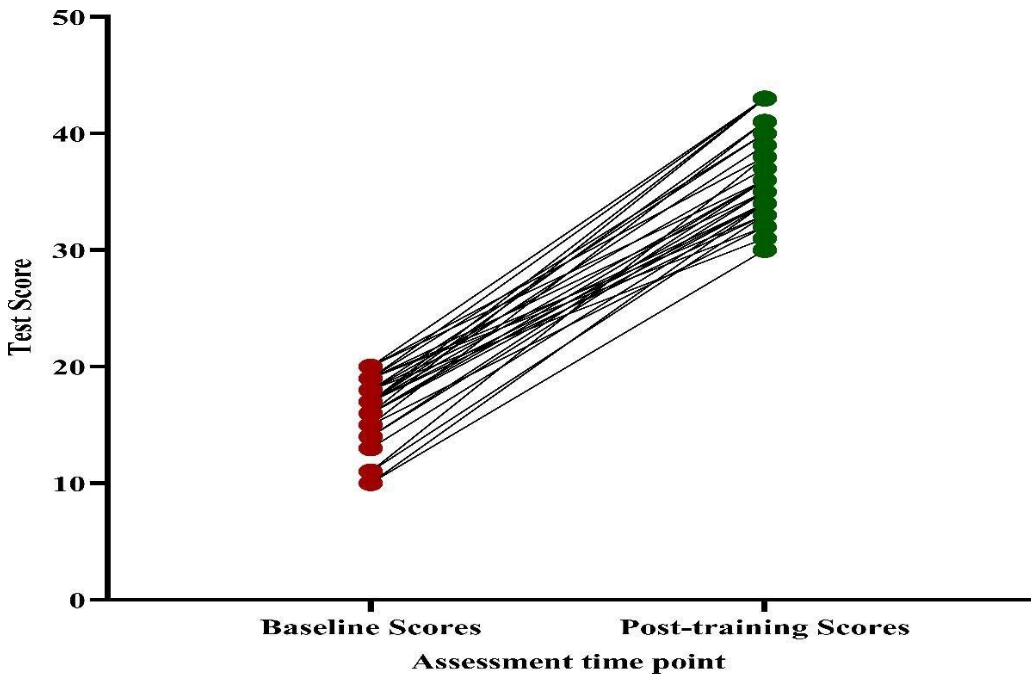
Box-and-whisker plots of baseline and post-training scores.



Note. Box-and-whisker plots. All 35 participants showed improvement. Horizontal lines within boxes represent medians; boxes span the interquartile range. *** p < .001

Figure 4.16

Paired Dot Plot of individual baseline and post-training scores.



It is clear from Figure 4.15 that all students improved their post-training scores compared to their baseline scores.

4.4 Phase 4: Student Perception and Feedback Survey

All 35 participants completed the Student Perception and Feedback Survey, a 20-item instrument measured on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) after completing the e-content module. The survey assessed students' perceptions of the accuracy of the content, clarity of explanations, ease of navigation, interactivity, clinical relevance, engagement and overall satisfaction. Descriptive statistics for ordinal Likert data were mainly median and percentage scores. Frequencies and percentages of all response categories, along with the median, are presented in Table 4.2. The percentages of responses for each question are shown in Figure 4.17.

Table 4.2

Frequency Distribution of Responses to the Student Perception and Feedback Survey (n = 35)

Item	Survey Statement	Median	SA n (%)
Q1	The content of the e-module was accurate and free from errors.	5	30 (85.71%)
Q2	The learning objectives were clearly stated and aligned with the module content.	5	33 (94.29%)
Q3	The module content was clinically relevant to audiology practice.	5	33 (94.29%)
Q4	The explanations of masking concepts were presented clearly and at an appropriate level.	5	21 (60.00%)
Q5	The module was easy to navigate and user-friendly.	5	23 (65.71%)
Q6	The interactive elements (e.g., drag-and-drop, simulations) enhanced my learning.	5	20 (57.14%)
Q7	The examples and case studies were helpful in understanding the concepts.	5	23 (65.71%)
Q8	The audio-visual quality (graphics, animations, narration) was appropriate and engaging.	5	33 (94.29%)
Q9	The module kept me engaged throughout the learning process.	5	33 (94.29%)
Q10	The embedded quizzes and assessments were helpful in reinforcing learning.	5	28 (80.00%)
Q11	The feedback provided after each quiz was clear and informative.	5	29 (82.86%)
Q12	The content was well-organised and logically sequenced.	5	32 (91.43%)
Q13	The length of each module was appropriate for the volume of content covered.	5	29 (82.86%)
Q14	The language used in the module was clear and easy to understand.	5	32 (91.43%)
Q15	The self-paced format of the module allowed me to learn at my own convenience.	5	32 (91.43%)

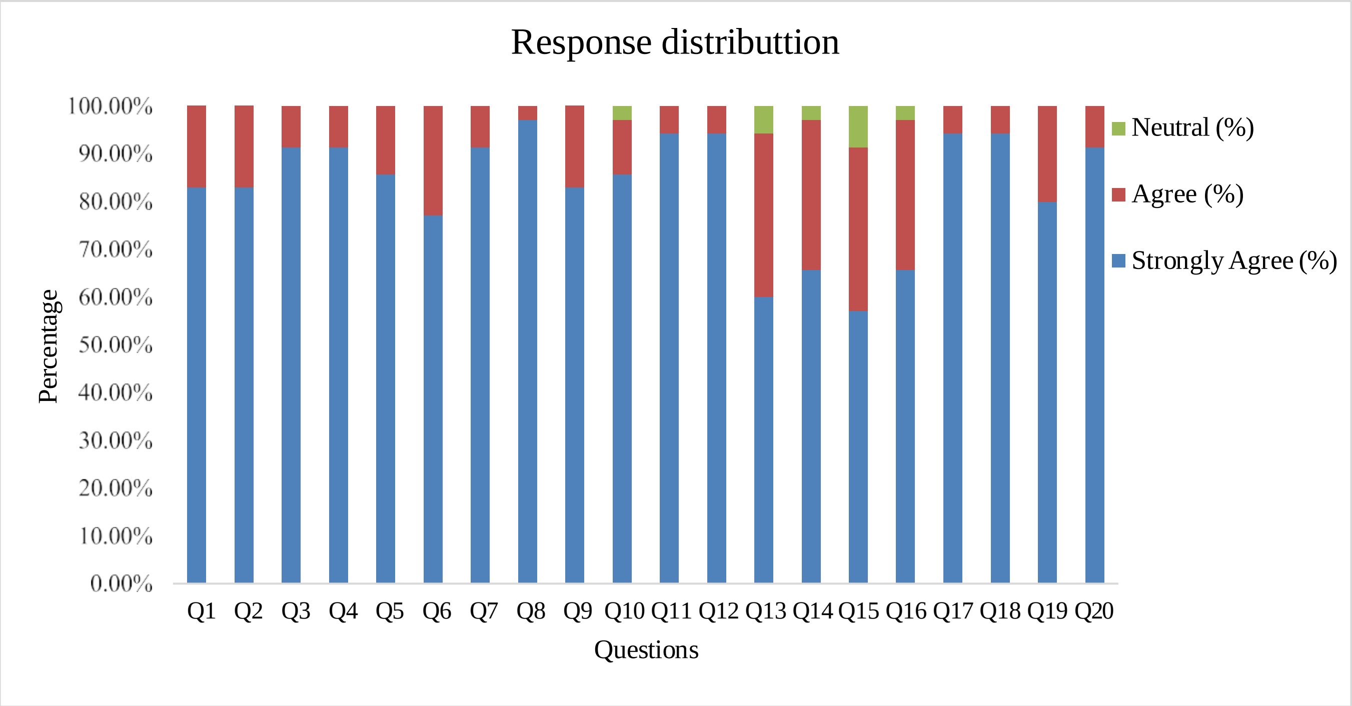
Item	Survey Statement	Median	SA n (%)
Q16	The module improved my conceptual understanding of clinical masking.	5	30 (85.71%)
Q17	The module improved my ability to apply masking principles in clinical scenarios.	5	27 (77.14%)
Q18	My confidence in performing clinical masking procedures has improved after using this module.	5	32 (91.43%)
Q19	Overall, I am satisfied with the e-content module.	5	34 (97.14%)
Q20	I would recommend this module to other audiology students.	5	29 (82.86%)

Note. SA = Strongly Agree. Values represent frequency counts and row percentages in parentheses. Total n = 35 participants.

Table 4.2 shows that students' perceptions of the e-content module were overwhelmingly positive across all 20 survey items. The mean rating across all items was 4.82 (out of 5.00), and the median rating for each item was 5.00 (Strongly Agree), indicating that the modal response across the entire survey was the highest possible endorsement.

Figure 4.17

Percentage Distribution of Responses to the Student Perception and Feedback Survey (n = 35).



Note. Stacked bar chart showing the percentage distribution of Strongly Agree, Agree, and Neutral responses across all 20 survey items (n = 35). No Disagree or Strongly Disagree responses were recorded for any item.

In summary, the results of the present study are discussed in relation to each objective. Regarding Objective 1, a dynamic e-content module was successfully developed, comprising ten structured modules with multimedia, interactivity, formative quizzes with adaptive mastery progression, and embedded summative assessments. For Objective 2, the expert content validation provided strong evidence of content validity, as all 10 modules were rated 4 or 5 by at least 2 of the 3 expert raters. The module resulted in a large and statistically significant increase in students' knowledge and application skills regarding Objective 3 (Wilcoxon Z = −5.164, p < .001, r = .87), with mean scores increasing from 16.46 to 36.29 out of 52. Overall mean ratings of 4.82 (Median = 5.00) across all 20 items demonstrated strongly favourable student perceptions with a combined Strongly Agree and Agree rate of 96.9%, confirming high levels of acceptability, engagement and perceived clinical utility of the module.

CHAPTER V

DISCUSSION

The present study aimed to develop, validate and evaluate an interactive e-content module on clinical masking concepts in audiology for undergraduate audiology students. Clinical masking has been an ongoing challenge in audiology education, as it requires students to integrate theory, numerical calculations, and clinical decision-making in audiometric assessment. Many audiology students found masking difficult to learn and effortful, and many required months of practice before they felt confident using it clinically (Skinner et al., 2023). Likewise, Margolis (2010) highlighted that successful masking is not just memorising formulas and procedures, but also an understanding of concepts and the ability to reason clinically. Even experienced clinicians may find masking decisions challenging in the presence of complex audiometric configurations (Turner, 2004).

To address these learning challenges, the current study developed an interactive e-content module comprising 10 sequential learning units that cover both theoretical and practical aspects of clinical masking. The material was organised from fundamental concepts and terminology to advanced clinical applications and case-based problem-solving. Such a progression was designed to support systematic learning, enabling students to build on prior knowledge while gradually developing the clinical reasoning required for accurate masking decisions. The module design is consistent with the principles of scaffolded learning, which emphasise connecting new knowledge to existing understanding and promoting the progressive elaboration of concepts (Bruner, 1960; Vygotsky, 1978).

The concepts of interaural attenuation, crossover and cross-hearing, the occlusion effect, masking level calculations, the plateau method, over-masking and under-masking, and case-based error identification were chosen on the basis of convergent evidence that these represent the greatest sources of student difficulty. Students identified the plateau method and masking level calculations as areas where independent practice and repeated exposure were most needed before competence was achieved (Skinner et al., 2023). Indeed, even experienced clinicians face genuine uncertainty in making masking decisions for configurations of asymmetric hearing loss, as Turner (2004) observed. Organising content around exactly these high-difficulty areas meant that the instructional effort was targeted to where the learning need was greatest, rather than being uniformly distributed across both easier and more demanding content.

The embedded interactive features in the module, animated clinical audiograms, case vignettes with simulated patient audiometric data and scenario-based formative quizzes are in line with the constructivist teaching principles, and allow active knowledge construction in authentic problem contexts, instead of passive reception of information (Cook & Triola, 2009). The simultaneous display of audio narration with visual clinical content is consistent with Mayer's (2009) cognitive theory of multimedia learning, which shows that the use of dual sensory channels for presenting information greatly improves understanding and retention compared with single-channel presentations. This is especially relevant for masking, where integrating spatial and procedural reasoning with numerical calculation is necessary. Importantly, the rationale for mastery-based progression was grounded in principles of competency-based education and in evidence from deliberate practice research that criterion-referenced progression produces greater and more durable learning gains than time-based pacing (McGaghie et al., 2011; Ericsson, 2004).

Specifically, students were required to score 70% or higher on each embedded formative quiz to progress to the next module. This is particularly important in clinical masking, where each layer of concepts is a foundation for the next. Clinically and pedagogically, it is important to ensure that there is genuine competence at each level before moving on to more complex material. Results for content validity showed the module to be clinically accurate, academically appropriate and well aligned with the stated learning objectives.

All 10 parameters in all 10 modules met the criteria for a rating of 4 or 5 by 2 out of 3 raters. The consistently favourable ratings across modules suggest that the content was perceived as accurate, relevant and appropriate for undergraduate audiology students. Such expert endorsement is critical in the clinical masking context where inappropriate instructional content can directly reinforce the very errors the module sought to address, e.g., incorrect initial masking level calculations or incorrect application of the plateau method. The high scores for Accuracy and Alignment with Learning Objectives support the module's claims that it teaches what it claims to teach, with the technical accuracy required for clinical audiometric education. The equally positive expert ratings for Engagement and Use of Examples indicated that the clinical scenarios, animated audiogram demonstrations, and worked calculation examples embedded in the module were deemed pedagogically relevant and appropriately contextualised. This aligns with Skinner et al. (2023), who found from the learner perspective that applied clinical examples and scenario-based exercises were the most valued instructional strategies for audiology students learning masking, far above passive didactic approaches.

One of the most clinically informative findings of the study was the low baseline median score of 17 out of 52 (approximately 32%). The results of the present study provide evidence that undergraduate audiology students who had completed the didactic masking component of the Bachelor of Audiology and Speech Language Pathology (B. ASLP) curriculum entered the study with a limited understanding of masking principles. This baseline finding is consistent with Skinner et al.'s (2023) observations that students in several audiology programmes reported a need for extensive independent practice and repeated self-directed exposure before feeling competent in masking, suggesting that standard classroom instruction alone rarely prepares students adequately. Margolis (2010) has provided theoretical explanations for this pattern. When instruction emphasises formulaic rules and step-by-step decision trees but does not develop the conceptual framework of cross-hearing physics and interaural transmission, students can follow procedures in familiar contexts but struggle with flexible reasoning when presented with unfamiliar audiometric configurations. The poor baseline performance identified in the present study provides direct empirical evidence of this gap and supports the need for a dedicated interactive resource that addresses the conceptual and applied understanding specific to masking.

A Wilcoxon signed-rank test indicated a statistically significant and practically large improvement from baseline scores (*Median* = 17.00) to post-training (*Median* = 36.00) following the module. All 35 participants showed individual improvement, and no negative ranks or ties were recorded. Cook et al. (2008) reported a large pooled effect size compared with no instruction in a meta-analysis of internet-based learning across 201 eligible studies in health professions education. Different metrics of effect size and study designs limit direct comparisons, but the magnitude of improvement seen in the present study was large. Similar benefits have been reported in audiology education through simulation-based digital learning. Hemanth and Manjula (2018) developed a computer-based audiological evaluation training software and reported significant improvements in students' knowledge and clinical skills following training with simulated audiological cases. Although their software addressed a broad range of audiological assessment procedures, the present module focused specifically on clinical masking. Both studies demonstrate the educational value of interactive technology-enhanced learning environments in improving student learning outcomes and clinical competence.

Moreover, the assessment tool was developed in a multi-format design that included MCQs with single answers, MCQs with multiple answers, true/false, matching, calculation-based MCQs, and case-based scenario MCQs, ensuring that the improvement in the post-training test was due to true learning at different cognitive levels, rather than superficial factual recall. This design aligns with the levels of remembering, understanding, applying, and analysing in Bloom's revised taxonomy (Anderson & Krathwohl, 2001). The inclusion of calculation-based and case-based items was especially important for a topic such as clinical masking, where the ability to derive masking levels accurately and reason through complex audiometric configurations is the ultimate clinical goal. The fact that all 35 participants demonstrated improvement in performance, regardless of baseline score, suggests that the module was effective for students with very little prior masking knowledge and students who had retained some knowledge from prior educational instruction.

Tomlin et al. (2023) evaluated an e-simulation module for paediatric audiological decision making and concluded that e-simulation produced learning outcomes in applied clinical reasoning equivalent to those achieved through problem-based learning. This is relevant here as the case-based scenario items also required integrative reasoning rather than simple knowledge retrieval. Furthermore, Bakhos et al. (2020) showed that immersive simulation-based audiology training enhanced not only procedural knowledge but also learner confidence, providing additional support for the value of interactive digital instruction in the development of higher-order clinical skills in audiology education.

Student perceptions of the module were overwhelmingly positive across the 20 survey items, with a median score of 5.00 per item. No Disagree or Strongly Disagree responses to any item indicated a high level of learner satisfaction and perceived educational value. The positive learner feedback observed in the present study is consistent with evidence suggesting that interactive and clinically relevant learning materials enhance learner engagement and perceived educational value (Cook et al., 2010; Means et al., 2013). The relevance of these findings is particularly evident in clinical masking, where students have previously reported frustration with instructional approaches perceived as insufficiently connected to authentic clinical practice (Skinner et al., 2023). The high ratings for clinical relevance suggest that case-based, scenario-driven instruction in the module may have successfully bridged the perceived gap between theory and clinical application, thereby reducing disengagement with traditional masking instruction. The positive learner perceptions observed in the present study are also consistent with findings reported by Hemanth and Manjula (2018), who found that students viewed a computer-based audiological evaluation training software favourably and perceived it as a useful learning resource. Together, these findings suggest that interactive digital learning tools are well accepted by audiology students and can enhance both engagement and learning.

CHAPTER VI

SUMMARY AND CONCLUSION

The present study successfully developed, validated, and evaluated an interactive e-content module on clinical masking concepts for undergraduate audiology students. The module achieved excellent content validity (≥ 4/5 rating by at least 2 of 3 expert raters across all parameters and modules), produced a statistically significant and large improvement in masking knowledge and applied understanding (Wilcoxon $Z = -5.164$, $p < .001$, $r = .87$), with all 35 participants demonstrating individual knowledge gain, and was received with high satisfaction by learners across all dimensions of evaluation (Median = 5.00 on all 20 survey items; combined Strongly Agree/Agree rate = 96.9%).

The findings of the present study demonstrated that the developed e-content module is a valid, effective, and clinically grounded instructional resource. Furthermore, the module addresses a longstanding, well-documented gap in digital educational resources on clinical masking in audiology. The findings demonstrate that interactive, evidence-based e-content modules can effectively enhance both conceptual understanding and applied clinical reasoning among undergraduate students. The results also indicate that such digital learning resources are feasible to implement and are highly valued by learners within the Indian audiology education context. The module has great potential for incorporation into undergraduate audiology curricula as a scalable, adjunct to traditional instruction. This resource has wider implications for the accuracy of audiological diagnoses and the quality of patient care for people with hearing disorders, ensuring students develop a principled, transferable understanding of the principles of clinical masking before and alongside supervised clinical practice.

Implications of the Study

The findings of the current study have important implications for education, clinical training, and curriculum development. From an educational perspective, the module offers a structured, self-paced, interactive platform for undergraduate audiology students to learn a concept that has traditionally been difficult, low in confidence, and inconsistently taught. The module is hosted on the AIISH institutional server and can be accessed through any standard web browser on any device. The modular design makes it easy to integrate into the Bachelor of Audiology and Speech Language Pathology (B. ASLP) curriculum as a pre-clinical preparation tool, a self-directed revision tool or as a structured blended learning component alongside practical sessions.

The module's outcome-based structure, with explicit learning objectives aligned to each module and mastery-based progression gates to ensure minimum competency standards, is well aligned with the Outcome-Based Education framework, increasingly adopted in Indian health sciences programmes. The module’s focus on case-based reasoning, the application of procedures, and the identification of errors is relevant to the competencies required for accurate, independent masking in audiometric practice, which may have downstream effects on diagnostic accuracy and patient outcomes (Yacullo, 2009). From a curriculum development perspective, the module was conceptualised as a reusable digital learning object that could be used in existing audiology curricula and perhaps adapted by other audiology training institutions in India.

Limitations of the Study

There are some limitations of the present study. First, the absence of a randomised control group means that, although the magnitude and consistency of the baseline to post-training test gains strongly implicate the module as the primary cause of improvement, a contribution from test-retest familiarity effects cannot be completely ruled out. One practical and ethical concern in research on educational interventions in institutional settings is withholding a potentially beneficial resource from a control group.

Secondly, the sample comprised 35 undergraduate students from a single institution; the results may not be generalisable to other audiology institutions with different curricula, student demographics, and clinical training contexts.

Third, the same set of questions was used for baseline and post-training testing, which may introduce a practice effect. Future studies should include alternate-form assessments to more rigorously delineate true knowledge acquisition from familiarity effects.

Future Directions

Future studies should address these limitations by adopting a randomised or quasi-experimental design that allows for direct comparison with traditional instruction and by assessing knowledge retention longitudinally at longer follow-up periods. Larger, more diverse student cohorts across multiple sites would improve external validity and generalise the findings to other audiology training programmes in India and elsewhere. From an instructional design perspective, the module would benefit from future iterations that include virtual patient simulation environments for real-time interaction with the audiometer and adaptive learning pathways that tailor content pacing and complexity to the learner’s performance profile (Means et al., 2013). The creation of comparable interactive e-content modules for other procedurally intensive topics in the audiology curriculum, such as vestibular assessment and advanced hearing aid programming, would further the institutional precedent set by the present study and contribute to a growing body of validated digital learning resources for the speech and hearing sciences.

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APPENDIX 1

All India Institute of Speech and Hearing
(An autonomous Institute under the
Ministry of Health and Family Welfare, Govt. of India)
Center of Excellence - Assessed & Accredited by NAAC with 'A' Grade
ISO 9001:2015 Implemented Institute
Manasagangothri, Mysuru-570006

ಅಖಿಲ ಭಾರತ ವಾಕ್ ಮತ್ತು ಶ್ರವಣ ಸಂಸ್ಥೆ
ಮಾನಸಗಂಗೋತ್ರಿ, ಮೈಸೂರು–570006
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मानसगंगोत्री, मैसूरु - 570 006

INSTITUTE REVIEW BOARD (IRB) APPROVAL FOR BIO-BEHAVIOURAL RESEARCH PROPOSAL INVOLVING HUMAN SUBJECTS AT AIISH

AIISH Institute Review Board (IRB)

Ref: SH/IRB/M.4/AUD.11/2025-26 **Date: 06.01.2026**

Title of the Dissertation	: Development Of An Interactive E-Content Module On Clinical Masking Concepts For Undergraduate Audiology Students
Name of the Investigator	: Hiba K M
Guide	: Mr. Saravanan P
Co-Guide (if any)	: Mr. Karthik Venkat Sridaran
Proposed Duration of the Project	: 08 months
Source of funding	: Non-funded Master's dissertation
Estimated budget	: Nil
Reference Number of the Project	: Nil
Date on which the IRB meeting was held	: 02.01.2026

A clear statement of the decision reached IRB meeting (In the vent of the proposal is not approved, a statement of reasons for the same must be indicated) : **APPROVED**

Advice & suggestions (if any) : NIL

Signature & Name of the Member Secretary-IRB
Dr. Animesh Barman
Professor of Audiology
All India Institute of Speech and Hearing, Mysore-570006

सदस्य सचिव / Member Secretary
संस्थागत समीक्षा बोर्ड
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अखिल भारतीय वाक् श्रवण संस्थान
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APPENDIX 2

Clinical Masking

Please read each question carefully and select the most appropriate answer. Some questions may require **calculation or interpretation of clinical masking concepts**.

Note: Some questions may have **multiple correct answers**. For such questions, you must **select all the correct options**. Marks will be awarded **only if all correct answers are selected**.

Please attempt **all questions independently**.

* Indicates required question

Email *

____

1. Reverse masking is primarily used when: *

Mark only one oval.

- A. Plateau is wide
- B. IA is high
- C. Weber findings are misleading
- D. No ABG is present

2. Which condition results in no plateau? *

Mark only one oval.

- IA >
- ABG IA

= ABG IA

< ABG

IA >> ABG

3. When there is risk for cross-hearing, masker must be presented to the *

____

Tick all that apply.

- Non-test ear by BC
- Test ear by AC
- Non-test ear by Headphones
- Non-test ear by inserts
- All of the above

4. At 500 Hz, the following values are obtained: *

BC (TE) = 15 dB HL
ABG (NTE) = 60 dB
IA = 40 dB

Interpret the situation.

Mark only one oval.

- Plateau possible
- Overmasking
- Masking dilemma
- Under-masking

5. Cross-hearing is a possibility during pure-tone air conduction tests when: *

Mark only one oval.

- AC (Test Ear) – IA< BC (Non Test Ear)
- AC (Test ear) – IA ≤ BC (Non-test ear)

AC (Test ear) – IA≥ BC (Non-test ear)

AC (Test ear) - IA > BC (Non-test ear)

6. Interaural attenuation for BC is generally considered to be: *

Mark only one oval.

0 dB

> 10 dB

≥ 10dB

10 dB

7. To increase interaural attenuation when masking, one should use: *

Mark only one oval.

Speech masker

Supra-aural headphone

Circum-aural headphone

Insert earphone

BC masker

8. The primary way by which cross-hearing for AC takes place is by: *

Mark only one oval.

Leakage from test ear to the non-test ear

AC headphone vibration transmission

Bone conduction through the skull

Cartilage conduction

Direct cochlear stimulation by airborne sound

9. When performing speech audiometry, you must: *

Mark only one oval.

- Use masking when the level of the speech materials is greater than the IA for an air-conducted signal
- always masks for word recognition scores since it is presented at a supra-threshold level
- uses a white noise masker
- Calculate the PTA and use that as your level to present the masking tone
- Present speech noise to the Non-test ear whenever the signal can be heard in the Non-test ear

10. You will need to mask more often for SIS testing than SRT because: *

Mark only one oval.

- SIS testing uses broadband speech signals
- SIS words are presented at suprathreshold levels
- A masking dilemma will always occur if you do not
- SRT words are presented at high levels
- Interaural attenuation is smaller for SIS stimulus than tones

11. If the air-conduction threshold in both ears is 60 dB HL, the bone-conduction threshold in the right ear is 5 dB HL. Considering an inter-aural attenuation value of 60 dB, the maximum masking level would be ___dB HL *

Mark only one oval.

- 60
- 65
- 120

0

12. During air-conduction testing with supra-aural headphones, AC(Test Ear) = 90

* dB and BC(Non-test ear) = 40 dB at 250 Hz which is the Best BC of Non test ear. SRT of test ear is 80. which statement is correct?

Tick all that apply.

- Masking is not required
- AC masking is required
- BC masking is required
- SRT masking is required
- SIS masking is required

13. During air-conduction testing with insert earphones, AC(Test Ear) = 100 dB at 8000 Hz. Which statement is correct? *

Mark only one oval.

- Masking is usually not done
- AC masking can be done; BC Masking cannot be done
- AC masking cannot be done; only BC masking can be done
- Only Speech masking can be done
- All masking can be done

14. A patient has the following values at 500 Hz: *

BC (Test Ear) = 15 dB
ABG (Non Test Ear) = 25 dB

Occlusion effect= 15dB

Minimum effective masking level for BC masking will be:

Mark only one oval.

- 25 dB

30 dB

35 dB

40 dB

15. During BC masking, ABG in the Non Test Ear is 5 dB at 1000 Hz. What is the equation find minimum masking level? *

Mark only one oval.

BC(Test Ear) + ABG(Non Test Ear)

Presentation Level – IA + Smallest ABG

BC(Test Ear) + IA – 5

BC(Test Ear) + Occlusion Effect

16. Which statement best explains why BC masking is almost always required? *

Tick all that apply.

BC interaural attenuation is 0 dB
BC stimulates only one cochlea
BC has high interaural attenuation
BC signals cannot cross the skull
BC stimulates both the cochlea

17. Which clinical condition most commonly produces a **masking dilemma**? *

Mark only one oval.

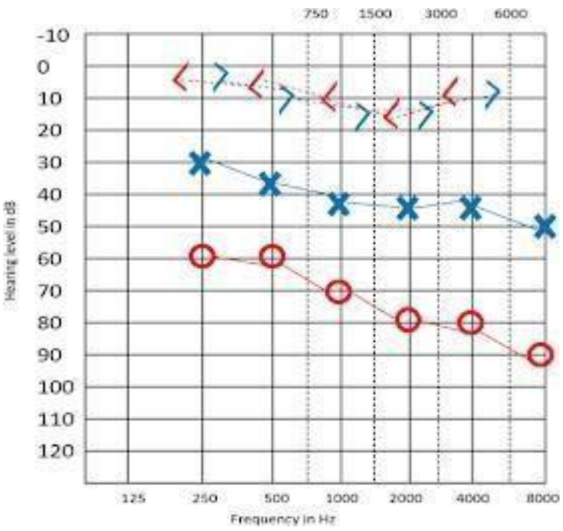
Bilateral severe Sensorineural hearing loss

Bilateral conductive hearing loss with large ABG

Unilateral conductive hearing loss with large ABG

Unilateral severe Sensorineural hearing loss

18. Maximum masking level at 2kHz for AC masking using insert earphone is: *



Mark only one oval.

- 75 dB
- 80 dB
- 85 dB
- 90 dB

19. Which statement correctly describes the plateau region? *

Mark only one oval.

- Noise increases and the threshold improves
- Noise remains unchanged but the threshold increases
- Noise increases but the threshold remains unchanged
- Noise decreases while the threshold remains constant

20. Which masking procedure can use the plateau method? *

Tick all that apply.

AC masking
SIS masking
BC masking
SRT masking

21. Which of the following best explains why plateau verification is not typically performed during masking for Speech Intelligibility Score testing? *

Mark only one oval.

Speech stimuli are broadband signals that cannot produce plateau effects

Speech Intelligibility Score testing does not involve determination of threshold

Interaural attenuation for speech is always greater than masking noise

Masking noise used in speech audiometry prevents overmasking automatically

22. During bone conduction masking, ignoring the occlusion effect may result in: *

Mark only one oval.

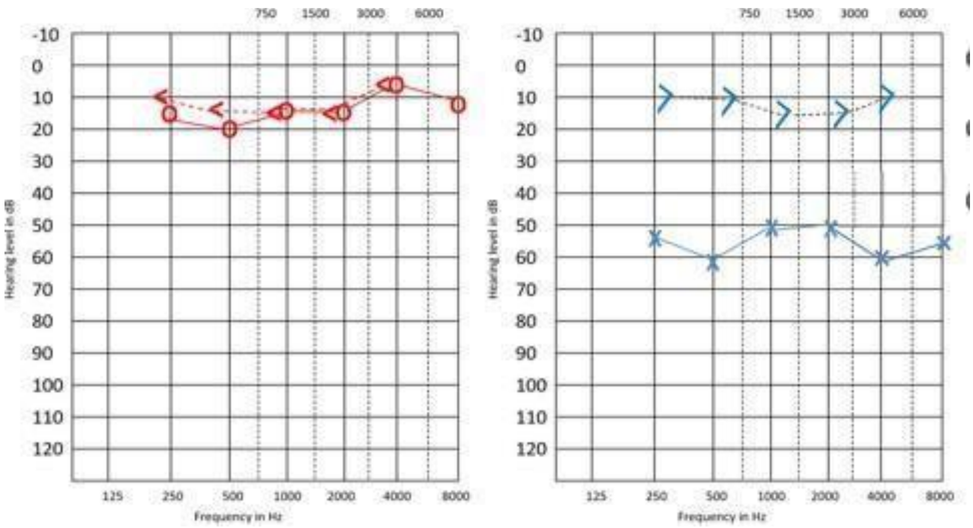
Over-masking

Under-masking

Plateau widening

Reduced IA

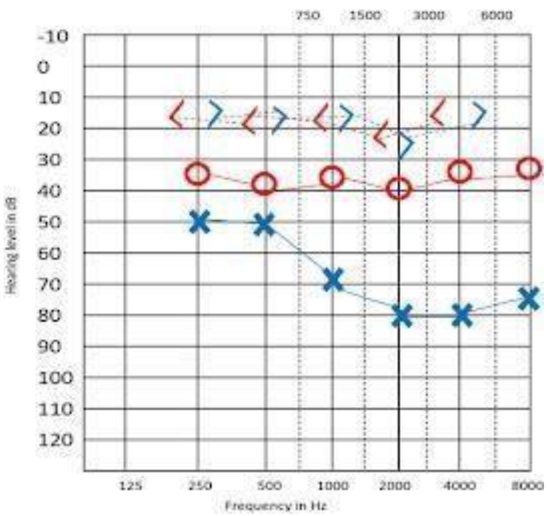
23. This is an audiogram obtained without masking, in which AC thresholds were measured with headphones. And Weber lateralized to the right in all frequencies. Choose the correct statement about pure tone masking. *



Mark only one oval.

- Both AC& BC masking must be done in the right ear
- BC masking must be done in the right ear
- Both AC& BC masking must be done in the left ear BC
- masking must be done in the left ear

24. Find the minimum and maximum masking levels to determine the masked AC thresholds in the left ear at 4KHz using headphones. *



Mark only one oval.

- Minimum- 60 dB, Maximum- 80 dB

Minimum- 45 dB, Maximum- 85 dB

Minimum- 55 dB, Maximum- 70 dB

Minimum- 50 dB, Maximum- 75 dB

25. Crossover refers to *

Mark only one oval.

Perception of sound in the opposite ear cochlea

Transmission of sound to the opposite cochlea

Masking noise crossing ears

Threshold shift

26. A shadow curve occurs when *

Tick all that apply.

False thresholds are recorded

Non-test ear responds to the test signal

Poorer ear responds to the test signal

None of the above

27. Under-masking can create a false *

Mark only one oval.

Speech scores

Air–bone gap

Bone conduction threshold

All of the Above

28. Bone conduction masking is required when *

Mark only one oval.

- AC(TE) – BC(NTE) ≥10 dB
- AC(TE) – BC(NTE) = 10
- AC(TE) – BC(NTE) > 10 dB
- BC(TE) – AC(NTE) ≤ 10 dB

29. Air conduction masking with headphones is required when *

Mark only one oval.

- AC(TE) – BC(NTE) ≥ 40 dB
- AC(TE) – BC(NTE) ≤ 40 dB
- AC(TE) – BC(NTE) ≥ 70 dB
- AC(TE) – BC(NTE) ≤ 70 dB

30. At 500 Hz, the following values are obtained: *

BC (Test Ear) = 10 dB HL

ABG (Non-Test Ear) = 50 dB

IA = 40 dB

Calculate the minimum and maximum masking levels for BC and identify the situation.

Mark only one oval.

- Min = 60 dB, Max = 45 dB → Masking dilemma
- Min = 55 dB, Max = 45 dB → Plateau possible
- Min = 60 dB, Max = 50 dB → Plateau possible
- Min = 50 dB, Max = 45 dB → No dilemma

31. Masking is usually required in *

Tick all that apply.

Symmetrical hearing loss
Asymmetrical hearing loss
Normal hearing sensitivity
Large Air bone gap
Unilateral hearing loss

32. Minimum masking level for AC is *

Mark only one oval.

BC(Test Ear) + IA - ABG (Non-Test Ear)

AC(Test Ear) – IA + ABG (Non-Test Ear)

AC(Test Ear) + IA - ABG (Non-Test Ear)

BC(Test Ear) – IA+ ABG (Non-Test Ear)

33. The plateau method is also called *

Mark only one oval.

Maximum masking method

Threshold shift method

Reverse masking method

Cross-hearing method

34. In which condition is over-masking of pure-tone likely? *

Mark only one oval.

Effective masking level Non Test Ear ≤ BC Test Ear +IA

Effective masking level Non Test Ear > BC Test Ear +IA

Effective masking level Non Test Ear ≥ BC Test Ear +IA

Effective masking level Non Test Ear < BC Test Ear – IA

35. At **1000 Hz**, the following values are obtained using **supra-aural headphones**: *

AC (Test Ear) = 95 dB HL

BC (Test Ear) = 15 dB HL

BC (Non-Test Ear) = 10 dB HL

AC (Non-Test Ear) = 30 dB

IA = 40 dB

What is the minimum masking level for BC masking?

Mark only one oval.

30 dBHL

60 dB HL

35 dB HL

50 dB HL

36. During air-conduction testing using **supra-aural headphones**, the following values are obtained at **2000 Hz**: *

AC (Right ear) = 85 dB

BC (Left ear) = 30 dB

Which statement is correct?

Tick all that apply.

AC Masking is not required in the right ear

AC masking is required in the right ear

☐ AC masking is required in the left ear ☐ BC masking is required in the left ear ☐ BC masking is required in the right ear ☐ Masking is required in both ears

37. Over-masking causes thresholds to appear better than the true thresholds. *

Mark only one oval.

- True
- False

38. A masking dilemma occurs when the minimum masking level is greater than the maximum masking level. *

Mark only one oval.

- True
- False

39. A patient shows bilateral conductive hearing loss with large air-bone gaps in both ears. While masking for BC testing, increasing the masking noise results in continuous threshold shifts with no plateau. What is the most likely situation? *

Mark only one oval.

- Under-masking
- Over- masking
- Masking dilemma
- Reverse masking

40. Occlusion effect mainly affects high-frequency air conduction thresholds. *

Mark only one oval.

True

False

41. Crossover and cross-hearing are the same phenomenon. *

Mark only one oval.

True

False

42. Reverse masking is not used when usual masking procedures give confusing results. *

Mark only one oval.

True

False

43. In reverse masking, masking noise is given to: *

Mark only one oval.

Test ear

Better ear always

Non-lateralized ear

Both ears

44. IA in 'BCTest Ear+ IA-5' refers to *

Mark only one oval.

IA of the noise

IA of the transducer used to present speech

IA of the transducer used to present the pure tone IA of

the transducer used to present noise

45. Match the frequency with the typical occlusion effect value. *

Frequency	Occlusion Effect
1. 250 Hz	A. 5 dB
2. 500 Hz	B. 0 dB
3. 1000 Hz	C. 15 dB
4. 2000 Hz	D. 20 dB
5. 4000 Hz	E. 10 dB

Mark only one oval.

1-B, 2-A, 3-E, 4-C, 5-D

1-C, 2-E, 3-B, 4-A, 5-D

1-D, 2-A, 3-B, 4-E, 5-C

1-E, 2-D, 3-A, 4-C, 5-B

1-D, 2-C, 3-E, 4-A, 5-B

46. A 30-year-old patient shows inconsistent audiogram results where Weber lateralization does not match the audiogram. Which masking technique can help clarify the responding ear? *

Mark only one oval.

Plateau masking

Maximum masking level method

Reverse masking

Peripheral masking

47. Bone conduction testing stimulates only the cochlea of the test ear. *

Mark only one oval.

True

False

48. Factors affecting plateau width *

Mark only one oval.

Type of transducer used

ABG of the Non-Test Ear (NTE)

Degree of Asymmetry Between Ears

Type of masking noise used

49. If the AC of Test Ear is 50 dB and IA is 40 dB, what should be the BC of Non-Test Ear so that AC masking is required? *

Mark only one oval.

10 dB

20 dB

30 dB

40 dB

50. During masking in pure tone audiometry raising masking noise in the non-test ear causes an increase in threshold in the test ear indicates *

Mark only one oval.

- Over masking
- Under masking
- Plateau achieved
- Under or over masking

51. If the AC Test Ear is 60 dB and IA is 40 dB, what should be the BC Non Test Ear so that AC masking is not required? *

Mark only one oval.

- 0 dB
- 10 dB
- 20 dB
- 30 dB

52. Calculate minimum effective masking level and Maximum effective masking level for AC when using headphones in individual with AC (RE) =45 dB, BC (RE) =0 dB, AC (LE) =50 dB *

Mark only one oval.

- 50 dB and 70 dB
- 65 dB and 40 dB
- 70 dB and 30 dB
- 55 dB and 35 dB