ORIGINAL ARTICLE

Towards developing high-fidelity simulated learning environment training modules in audiology

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ABSTRACT

Introduction: This discussion paper reviews and synthesises the literature on simulated learning environment (SLE) from allied health sciences, medical and nursing in general and audiology specifically. The focus of the paper is on discussing the use of high-fidelity (HF) SLE and describing the challenges for developing a HF SLE for clinical audiology training.

Methods: Through the review of the literature, this paper discusses seven questions, (i) What is SLE? (ii) What are the types of SLEs? (iii) How is SLE classified? (iv) What is HF SLE? (v) What types of SLEs are available in audiology and their level of fidelity? (vi) What are the components needed for developing HF SLE? (vii) What are the possible types of HF SLEs that are suitable for audiology training? Publications were identified by structured searches from three major databases PubMed, Web of Knowledge and PsychInfo and from the reference lists of relevant articles. The authors discussed and mapped the levels of fidelity of SLE audiology training modules from the literature and the learning domains involved in the clinical audiology courses. Results: The discussion paper has highlighted that most of the existing SLE audiology training modules consist of either low- or medium-fidelity types of simulators. Those components needed to achieve a HF SLE for audiology training are also highlighted.

Conclusion: Overall, this review recommends that the combined approach of different levels and types of SLE could be used to obtain a HF SLE training module in audiology training.

KEY WORDS:
Simulated learning environment, simulator training, computer-based simulation, audiology simulator training, simulated learning program, High-fidelity simulation, High-fidelity audiology, simulated training

INTRODUCTION

The increasing awareness of hearing, hearing impairments and related treatments and interventions have resulted in increased demands on quality professional audiological services. A quality professional audiological service is contributed by many factors; however, it mainly reflects the quality of higher education training received by the respective audiologists. In view of providing quality educational audiology training throughout the world, most of the institutions involved face the same challenges for providing sufficient and quality supervised clinical experience, either in the university audiology clinics or external hearing care centres.[1,2]

Audiology education varies worldwide, with some countries offering programs at the undergraduate level and some at postgraduate levels.[3] Despite the differences in the levels of the degree, all audiology programmes worldwide consist of a core clinical training module that is normally divided into basic clinical training and advanced clinical training.[4] Basic clinical training requires students to apply their theoretical knowledge and efficiently to perform routine audiological procedures including case history taking, speech audiometry, acoustic immittance and pure-tone audiometry procedures. Advanced clinical training typically involves non-routine procedures, such as hearing aid clinics, auditory-evoked potentials cases and irregular cases, such as auditory neuropathy spectrum disorders or auditory processing disorders. Traditionally, the teaching and learning activities for both routine and non-routine audiological procedures and cases may require the student to, (i) attend a demonstration session, (ii) perform the procedure among colleagues and, (iii) attend observation sessions for real clinical cases in addition to their normal instructional course lectures. Students will then be assessed in a practical examination and/or with the practical report. Once completed, audiology students will proceed to their actual clinical placement where they will be seeing audiology patients under clinical supervision (in certain circumstances and institutions, advanced non-routine procedures may be learned concurrently with their clinical placements). This standard training methodology creates problems, especially for some students who may still not be competent, particularly when they are still at the beginning of their clinical placement. This is considered as acceptable in teaching and learning because the competency development varies between students.[5] Some students may achieve the learning goal early, while some students may take more time than their colleagues to achieve the same learning goal. Without a proper pre-clinical training, there is possibility that

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the students' incompetent clinical skill may affect the quality of audiological services and reduce the level of patient comfort.[6] Sending students who are just at the beginning of their clinical placement also creates an issue, such as variations in the quality of the basic training between audiology centres.[1] This leads to different learning exposures among students and thus leads to differences in developing their clinical skills based on the required learning goal.

Researchers and audiology academic instructors have now turned their interest to integrating the simulated learning environment (SLE) training within the existing clinical audiology curriculum.[7] This technique has been widely used in many fields, such as in the field of aviation for training pilots, medical and nursing and allied health sciences, including audiology. SLE is operationally defined as a training module that attempts to mimic reality. In a recent systematic review, SLE audiology training has been shown to provide a positive outcome for the students.[7] Because of the importance of integrating the SLE training into the audiology curriculum, this paper discusses seven questions with the aims of (i) providing general information about SLE in audiology and, (ii) highlighting the use of high-fidelity (HF) SLE in other fields and discussing the challenges to develop a HF SLE training in audiology for basic or advanced clinical training (involving a comprehensive module of history-taking, acoustic immittance, otoscopic examination, speech audiometry, pure-tone audiometry with other necessary advanced assessments). Therefore, this paper deals with seven questions, (i) What is SLE? (ii) What are the types of SLEs? (iii) How is SLE classified? (iv) What is HF SLE? (v) What types of SLEs are available in audiology and their level of fidelity? (vi) What are the components needed for developing HF SLE? (vii) What are the possible types of HF SLEs that are suitable for audiology training?

What is SLE?

The terms simulations, SLE, simulated learning program and simulated training have been used interchangeably in the healthcare education literature.[1,8,9] While there is no standard term, SLE has been used for the purpose of this paper of describing different levels and types of SLEs available in audiology, specifically. SLE aims to substitute the whole or a part of the real clinical working environment. SLE could be used for clinical training by linking the existing knowledge the student has learned in lectures or through practical sessions and extending their experience through the "experiential learning".[9] It is anticipated that with SLE, students will expand their knowledge, gain new experiences, receive feedback, and reflect and relate what they have learned from the SLE into true clinical environments.

What are the types of SLE?

SLE training can be conducted in several ways and requires different modules that may or may not require specific training devices and tools. Among the SLE types described previously are, (i) integrated mannequins simulators[10,11], (ii) computer-based simulations (CBS)[12,13], (iii) virtual reality[14,15], (iv) an integrated virtual reality with a haptic system[16,17], (iv) part-task trainers[18], (v) multimedia[19] and, (vii) standardised or simulated patients.[20–22] Table I provides definitions of these training tools based on descriptions from Cant and Cooper (2010)[23], and Maran and Glavin (2003)[9] for reviews.

How is SLE classified?

Fidelity reflects how closely the respective SLE training is to the actual clinical training environment and tasks. In general, fidelity is categorised into three levels, (i) low fidelity (LF), (ii) medium fidelity (MF) and, (iii) high fidelity (HF).[9] LF SLE consist of entry-level clinical tasks that minimally reflect actual patient behavioural and physiological responses.[9] LF SLE would not involve any device or mannequin to simulate the respective behavioural and physiological activities. Examples of LF SLE include the teaching of clinical skills via role-playing, demonstrations or through case studies. MF may involve mannequins or certain computer-based devices; however, it may be lacking in terms of the reactions in producing realistic sensations and physiology responses. As in audiology, the SLE may be lacking in producing certain scenarios in the testing, for example, pediatric diagnostic cases that occasionally may involve a difficult child who is maybe crying or moving during the test that may not be provided with a very basic CBS software. HF SLE, as the focus of this paper, is a high-end technology SLE that consists of training modules that are closer to reality, because they simulate both the behavioural and physiological activities of the patients.

What is HF SLE?

HF SLE is a module consisting of any method of SLE that could simulate the actual training very closely to reality. Among the training modules classified as HF being used in the field of medicine, allied health, dentistry and nursing are, (i) computerised-based mannequins,[24-29] (ii) integrated virtual reality haptic systems,[16,17,30] (iii) Standardised or simulated patient[31-33] or (iv) a combination of these approaches.

Computerised mannequins have been used in medical, physiotherapy and nursing education with great success.[25,34-37] The use of a mannequin could substitute for the patient's anatomical landmarks and would closely represent the real-case scenario for the students. This allows the students to practice their clinical psychomotor skills with a simulated mannequin. The computerised system within the mannequin generates physiology responses, such as pulses, heart sounds, breath sounds and pupil responses to light, and shows blood circulation within the system.

Virtual-reality, on the other hand, substitutes patients with a virtual patient and therefore a patient-client interaction could be accomplished through the 3D virtual system. Virtual-reality simulates not only the patient, but also the clinical environment and at the same time creates an illusion for the student that they are engaging directly with the patient in that virtual environment. The integrated haptic system would generate the feelings of touch and the resistance that would create an illusion as if the student were performing a procedure on a real patient.[16] Virtual reality allows the student to implement their decision-making and analytical skills to the pre-programmed cases in the system.[9] The sensation of haptic can be produced to trigger false alarms to the student, to simulate physiological responses such as breathing and to simulate patient sensations of touch to the clinician.[9] Among them all, virtual-reality has been successfully used for training manual dental dexterity,[30] oral implant surgery[16] and assessments in stroke patients.[17]

The use of HF SLE in medicine and nursing has shown that the techniques are more superior than the LF and MF SLE[25,38] while there is also a finding that shows no differences between the SLEs training with different levels of fidelity.[22,24] The HF SLE is perceived by the student as improving knowledge, critical thinking, competency in practical skills, confidence and the integration of knowledge and practice.[27-29,39-41] These results suggest similar findings could be obtained for SLE training in the field of audiology if HF SLE training were developed and implemented.

What types of SLE are available in audiology and their fidelity?

Various types of SLE tools have been developed since the 1970s for audiology and its related fields. These SLE tools are used for basic clinical training: for example, basic audiometry,[2,42-46] otoscopic examination,[47] case history and clinical feedback[2,22] or for advanced clinical training involving non-routine testing such as auditory brainstem response[48] and to enhance inter-personal and communication skills through audiologic counselling.[49-50] Table II summarises all papers identified from the database searches that describe, summarise the developments or implement the SLE training methods in audiology. As shown in Table II, there are thirteen studies using SLE in the field of audiology with two using LF SLE, eight using MF SLE and only three using an HF SLE module. Four different types of SLE were identified out of the ten SLE reports. These SLE training tools included CBS, standardised patient, part-task trainer and multimedia packages. The only modules that can be considered as having a HF module are the case-history taking and feedback module using a simulated-patient by Hughes et al.[22] and the audiology counselling module by Naeve-Velguth et al.[49] and English et al.[50] The use of HF-standardised patient in these studies is useful for history taking, clinical feedback and counselling; however, as highlighted in the introduction to this paper, clinical audiology training involves not only these three components, but other basic and advanced audiological assessments, such as pure-tone audiometry, otoscopic examination, speech audiometry and acoustic immittance with other necessary advanced audiological applications. Thus, having a comprehensive HF SLE is therefore essential for representing the real clinical scenario.

What are the components needed for developing HF SLE?

At least three relevant aspects must be considered by the instructors before considering the use of a HF SLE as one of the teaching and learning strategies, as highlighted by Bradley[53] and Issenberg and Scalese.[54] These aspects are as follows, (i) the identification of the learning goal and mapping teaching and learning methods according to the learning goal, (ii) incorporated feedback in the SLE modules and, (iii) appropriate and validated assessment methods. These will be further explained in subsequent sections.

Identifying the learning goal

As highlighted by Issenberg and Scalese,[54] the use of SLE must be driven by the learning goal of the courses and the expected learning outcomes. The development and acquisition of SLE must be tailored to the learning goal; as opposed to the approach of developing the SLE devices/modules first and then later determining the learning goals. SLE, on the other hand, serves as the teaching and learning strategies to achieve the learning goals and the course expected learning outcomes.

The premises for identifying the learning needs among educationists lie within the basic teaching and learning taxonomy. The basic teaching-and-learning taxonomy was first described by Bloom et al.[55] and is widely known as Bloom's Taxonomy. Bloom's taxonomy may assist instructors in applying appropriate instructional strategies towards each of the learning domains involved. The principle underlying this taxonomy is that knowledge transfer is not limited to simple information recall and comprises two major domains including the cognitive (referring to intellectual ability and knowledge) and affective domains (referring to emotional or student attitudes towards the subjects).[55,56] The cognitive domains are further classified into different cognitive levels to show differing complexity levels of lower- and higher-order thinking based on the requirements of the courses. The cognitive process is described in six different levels, from the 'remember' (level 1), 'understand' (level 2), 'application' (level 3), 'analysis' (level 4), 'evaluation' (level 5), and 'to create' (level 6).[56] Since the 1990s, the psychomotor learning domains (referring to physical skills) and social learning domains (referring to social interactions, communication and soft skills) have been highlighted as among the important components in teaching and learning.[57,58]

Table III summarises seven types of the most common clinical tests for clinical training used in the audiology clinics with their learning goals, possible teaching and learning domains and levels of cognitive process.[59] The level of the cognitive process was mapped based on the revised Bloom's Taxonomy.[56] The learning domain from Table III was reviewed and mapped by three evaluators (AAAD, SR, MB). From Table III, most of the clinical skills required for the clinical audiology courses consist of learning goals governed by the cognitive, affective, psychomotor and social learning domains. Because of this, an HF SLE should incorporate these four learning domains in the modules to achieve the learning goals. As an example, the SLE training for pure-tone audiometry involves cognitive, affective, psychomotor and social learning domains, thus requiring the HF SLE to emphasise these four domains. Specifically, for pure-tone audiometry training, the HF SLE should cover the following learning goals and learning domain/s: the student is able, (i) to clearly instruct a patient prior to the pure-tone audiometry testing (cognitive, affective and social domains), (ii) to select correct transducers and accurately place the transducer on the patient (cognitive, affective and psychomotor), (iii) to accurately determine hearing thresholds for air conduction and bone conduction using appropriate methods (cognitive, affective and psychomotor), (iv) to identify the needs for masking (cognitive), (v) to accurately perform air conduction and bone conduction masking (cognitive and psychomotor) and, (vi) to interpret audiograms and correlate their findings with the other test batteries (cognitive).

Therefore, HF SLE should serve as an avenue for student-client interactions to enhance their verbal communication skills, and an avenue for the use of critical thinking (cognitive

Table I: Summary of common simulated learning environment (SLE) types

Type	Description
Standardised Patients	A professional or semi-professional human actor who acts as a patient during simulation clinical exercises. Case history taking, basic examinations can be done through standardised patients.
Part-task trainers	Commonly designed to partially replicate the real case. Usually used for training basic procedures and techniques that include basic psychomotor skills. An example of part-task trainer is a low fidelity (LF) mannequin or a physical ear model with various diseases.
Computer-based simulations (CBS)	Simulated tasks or cases are given via a computer interface. This system mainly focuses on knowledge acquisition and decision-making skills. It is usually designed to be an interactive system that incorporates feedback to the users
Multimedia package	Cases or tutorial notes are kept on a DVD for students to learn and practice. Mostly covers the cognitive domain rather than psychomotor skills
Virtual reality	Cases are simulated close to the real experience via 3D computer-based technology
Haptic system	A system designed to produce real physical contact experiences. This system incorporates touch feedback, such as resistance and vibration, when the user is in contact with the simulated model. This system will focus mainly on training the psychomotor skill. It is usually incorporated into other types of simulators such as virtual reality, and part-task trainers.
Integrated simulator	The combination of two or more types of simulators to provide a close-to-real-case scenario. This system also aims, where possible, to cover all related learning domains, such as cognitive, psychomotor skills and critical thinking. Examples of this type are the virtual reality with the haptic system and the computerised manikin with a haptic system.

Source: Adapted from Cant and Cooper (2010)[23] and Maran and Glavin (2003).[9]

domain) to achieve the learning goal and avenues to carry out the practical skills. In addition, the majority of the audiology SLE literature includes only cognitive and psychomotor aspects in their training, with only four studies cover the social and affective learning domains, as shown in Table II. The learning domain from Table II for the respective SLE audiology literature and level of fidelity was reviewed and mapped by three evaluators (AAAD, SR, MB). This was based on an agreed definition between the evaluators towards the SLE training modules provided by the respective papers, because none of the papers specifically mentioned the learning domain as being involved in their studies.

Incorporated feedback to the SLE modules

Feedback is one of the sub-components that could enhance the cognitive abilities among students.[54] In any training methodology, feedback is important for ensuring that students can determine whether or not they are fulfilling the requirements of the respective learning task for the required course. Positive or negative feedbacks are both equally important because positive feedback indicates that the students are within the right direction, and this will motivate them to move forward. On the other hand, negative feedback is important for ensuring the students understand that they have done things incorrectly and know that steps must be taken to overcome their weaknesses. In a typical learning environment, feedback is delivered by the instructor.

For SLE training in general, feedback can be delivered by either an instructor (as part of the SLE module) or from the SLE devices themselves. As in HF SLE, feedback should consist of at least a formative feedback where the SLE provides an indicator that the student is carrying out a correct or incorrect method throughout the procedure or clinical application. For example, a study by Heitz[43] highlights their virtual audiometry software in which the system will tell the student through a light indicator in the interface if that student does not perform an otoscopic examination before performing the pure-tone audiometry. It is possible, although difficult, to design a simulation with objective "virtual tutor" abilities specifically for summative feedbacks, because the amount of mistakes made by students varies considerably and many 'triggers' are needed for that purpose.

Validity and reliability of assessment for SLE

To assess the performance of the student after undergoing SLE training (integrated modules with traditional teaching approaches), the instructor must select valid assessment methods and a valid and reliable marking scheme.[60] A valid assessment method is characterised by the ability of the assessment to reflect what it is supposed to measure. A valid assessment type is characterised by the link between the learning goals and the rubric. The alignment between the course learning goal/outcomes and the rubric is important for ensuring the SLE training (either alone or combined with other teaching methods) has the ability to transfer the skills in practice.[53] As an example, if, in the learning outcome stated by the end-of-course, the student should be able to perform pure-tone audiometry (including the SLE as part of the teaching and learning activities), the assessment should focus more on the "practical" methods of assessment to align with the learning goal instead of using multiple-choice question (MCQ) or essay types of questions. This is similar to the instructor including a "teamwork" component in their course where the students are expected to be able to enhance their "teamwork" skills. An instructor must use an appropriate method to assess that learning outcome (for instance, by judging the ability of each student to work with their pairs during paediatric cases).

In general, a valid rubric must undergo content validation by both the academics and professionals involved and, in this case, the audiology clinical preceptors.[61] According to Allen and Knight,[61] there are several steps be taken by the academic faculty to obtain a valid assessment rubric. First, they need to evaluate the rubrics, whether they can differentiate between weak and excellent student performances. Second, a sample of the rubric must be evaluated by more than two instructors or a jury panel. Modifications need to be made to the rubrics, based on the consensus among the jury, to check for the

Table II: Summary of SLE audiology modules from the literature with the descriptions on areas of applications, types of SLE training, availability of feedback and source of feedback (human instructor/ simulator), learning domains and skills covered, types of assessments and level of fidelity

Study	Applications	Type of SLE training [a]	Availability of feedback (source of feedback)	Learning domains & skills coveredb	Types of assessments	Level of Fidelityc
Durham et al. (1994)[42]	Visual reinforcement audiometry	CBS	Yes (simulation)	Psychomotor and cognitive	Practical examinations using real clinical cases	Medium
Sistrunk (2002)[45]	Interpreting and integrating full diagnostics audiology assessments	Multimedia package	Yes (simulation)	Cognitive	Survey and focus group discussions	Low
Lieberth & Martin (2005)[44]	Web-based audiometry (pure-tone audiometry)	CBS	Yes (simulation)	Psychomotor and cognitive	Post-training practical examinations	Low
Wilson et al. (2010)[2]	Diagnostic audiology assessments (pure-tone audiometry, tympanometry, acoustic reflex & speech audiometry)	CBS and standardised patients	Yes (human)	Psychomotor, cognitive, social	Post-training self-perceived surveys	Medium
Heitz (2013)[43]	Diagnostic audiology assessments (pure-tone audiometry, case history and Speech Audiometry	CBS	Yes (simulation)	Psychomotor, cognitive	Practical/role play, self-perceived Learning questionnaire, Paper-based examinations, Interview scale for case history	Medium
Kaf et al. (2013)[47]	Otoscopic examination	Part task trainer	Yes (human)	Psychomotor and cognitive	Practical examinations using manikin, Paper-based examinations, Self-perceived skills evaluations	Medium
Dzulkarnain et. al. (2014)[48]	Auditory Brainstem Response	CBS	Nil	Psychomotor and cognitive	Paper-based examinations	Medium
Naeve-Velguth et al. (2013)[49],	Audiology counselling	Standardised patients	Nil	Cognitive, Social, Affective,	Questionnaire survey about student feedback and learning experience with standardised patient	High
English et al. (2007)[50]	Audiology counselling	Standardised patients	Nil**	Cognitive, Social, Affective,	Questionnaire survey about student learning experience with standardised patient	High
Kompis et al. (2012)[51]	Multi-lingual audiometer	CBS	Not clearly stated	Cognitive, partial psychomotor skills of pure-tone audiometry	Nil	Medium
Slosberg & Levitt (1978)[46]	Pure-tone audiometry computerised system	CBS	Nil	Cognitive, partial psychomotor skills of pure-tone audiometry	Nil	Medium
Yens (1969)[52]	Pure-tone audiometry computerized system	CBS	Nil	Cognitive, partial psychomotor skills of pure-tone audiometry	Nil	Medium
Hughes et al. (2016)[22]	Case history and feedback	Simulated Patient	Nil	Cognitive, social, psychomotor and Affective	Practical examination with simulated patient	High

[a.] Type of SLE training based on description in Table I

[b] and [c] The learning domain and level of fidelity were reviewed and mapped by the first, second and fourth authors

** No feedback included for the objective stated in the study although the actual SLE module consists of instructional feedback)

Table III: Learning goals for most of the audiology common diagnostic evaluation test batteries

Type of applications	Learning goal [a]	Teaching and learning domains	Cognitive levels [b]
Otoscopic examination	• Give clear instructions and appropriate use of language to the patient • Perform the otoscopy with correct technique • Identify normal and abnormal external auditory canal and tympanic membrane • Check for collapsing ear canal • Use the information from the inspection to integrate with subsequence diagnostic testings • Acquire complete audiological history while at the same time attending to patient's major concern/s • Able to extract correct information from patient • Deduce possible cause of auditory pathology or potential source of testing errors	Cognitive, psychomotor and social learning domains	Level VI
Pure-tone audiometry	• Give clear instructions and appropriate use of language to the patient • Choose suitable transducer and correct placement • Use correct technique to identify hearing threshold for air conduction and bone conduction • Identify auditory masking, central masking and awareness of masking dilemma • Perform air conduction and bone conduction masking using correct technique • Structure the stimulus presentations to avoid false positives and take appropriate actions when these occur • Awareness of inconsistent and unexpected responses including malingering and deal with these appropriately • Able to obtain and interpret audiogram accurately and correlate their findings with the test batteries • Identify potential cause of hearing loss through audiogram • Awareness of inconsistent and unexpected responses and deal with these appropriately • Re-explain test sequence in accurate detail	Cognitive, psychomotor, affective and social learning domains	Level VI
Speech Audiometry	• Clear instructions and appropriate use of language to the patient • Perform speech-audiometric threshold using correct technique • Identify the need for speech masking and perform masking accurately • Correct interpretation of the speech audiogram • Able to identify consistency between speech audiogram and pure tone audiogram	Cognitive, affective, psychomotor and social learning domains	Level VI
Acoustic Immitance	• Clear instructions and appropriate use of language to the patient • Correct probe selection and able to obtain good acoustic seal • Seek acoustic reflex threshold correctly • Able to interpret reflex pattern • Able to interpret tympanogram • Relate reflex findings to the pure-tone audiometry and tympanometry results	Cognitive, psychomotor and social learning domains	Level VI
Auditory Brainstem Response	• Give clear instructions and appropriate use of language to the patient • Able to do pre-test procedures including skin preparation and electrodes placement • Perform impedance checking • Seek auditory brainstem response threshold correctly • Determine the presence and absence of auditory brainstem response • Correct peak selection and interpretation of auditory brainstem response waveforms • Determine the quality of the recording by looking to the signal-to-noise ratio and electroencephalogram activity monitoring • Able to integrate with other test batteries	Cognitive, psychomotor, affective and social learning domains	Level VI

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Type of applications	Learning goal [a]	Teaching and learning domains	Cognitive levels [b]
Hearing aid	• Perform pre-session preparation (cable and data information) • Able to prescribe suitable hearing aids based on patient audiological results • Taking ear impressions using correct procedure • Able to program hearing aid and fit hearing aid to patient based on listening needs and with correct technique • Do Client-oriented Scale of Improvement correctly • Do hearing aid verification, and validation and outcome measures based on guidelines	Cognitive, affective, psychomotor and social learning domains	Level VI
Otoacoustic Emission	• Perform pre-session preparation • Can choose appropriate probe size • Perform otoacoustic emissions using correct procedure • Able to interpret otoacoustic emissions and relate with other test findings • Able to relate any ear pathologies with the otoacoustic emissions results	Cognitive, affective, psychomotor and social learning domains	Level VI

[a] Learning goal was based on International Islamic University Malaysia Audiology clinic protocol (International Islamic University Malaysia, 2016)[59]
[b] Cognitive levels were categorised based on Revised Bloom's Taxonomy (Anderson et al., 2001)[56]

consistency in the meaning and how it reflects by having a discussion session when marking the same examination paper. Third, the rubric must be tested and statistically analysed. A highly-reliable rubric typically reflects the ability of the scheme to be able to trigger a consistent marking provided by the different instructors (inter-rating) and the same instructors (intra-ratings). With this in mind, developing a valid and reliable rubric following SLE training or an integrated SLE curriculum is also crucial. This reflects the readiness of the student to go for clinical placement (if the aims of the SLE are for basic training) or prior to the advanced clinical training.[62] Most of the assessment methods in the literature for measuring the effectiveness of the SLE in audiology are lacking in aligning the learning goal with the assessment methods in accordance with the learning domains provided for the course. Most of the literature, as highlighted by Dzulkarnain et al.,[7] did not use (and/or did not report) the validity and reliability of their assessment rubrics, which raised questions on how effective was the SLE training (or integrated SLE module). This is especially important in view of developing HF SLE modules. Because HF SLE modules may take up many financial resources, this component (a valid and reliable marking scheme) is, therefore, crucial.

Assessment methods in SLE

There is no consensus on the best assessment methods for measuring SLE performance specifically in audiology and other related fields, such as medicine and nursing or allied health sciences. Therefore, it is still unclear whether a student should be examined practically, based on real clinical cases or should still be examined using an SLE examination module upon completion of the SLE training. The level of SLE training needs to be taken into consideration when choosing the appropriate assessment methods, that is, between "real" and "simulated cases". If the SLE training is aimed at basic entry training (prior to the student entering the clinic), an initial SLE examination may be more appropriate; whereas, for intermediate or advanced training, "a real" case assessment is more appropriate to reflect the effectiveness of the integrated clinical audiology curriculum (consisting of both the SLE training combined with the traditional training methods). On the other hand, Scalese et al.[63] highlighted the advantage of using an SLE simulator because of its high reliability that would provide a high-level of consistency in the clinical cases of the students who had undertaken the examination.

As highlighted in Table II, the student-learning outcome after undergoing SLE audiology training was assessed via several assessment methods in the literature. In general, the assessment methods in the literature used practical examinations (through role-play or real cases or standardised patients), paper-based examinations or self-perceived levels of assessment. It is worth noting that a holistic assessment approach using more than one assessment method to cover all the learning domains (psychomotor, affective, cognitive and social) could be used to evaluate the students' performances. Specifically, a combination approach such as combining a practical examination, (based on real clinical cases or based on SLE examination module) or a paper-based and self-perceived level are more appropriate, because it would cover all the teaching and learning domains and thus would represent the overall achievement of the learning goal. The use of more than one assessment is supported in that it could provide a high level of evidence to the instructor that learning is occurring among their students and could provide a fair and better opportunity for the student to achieve the respective learning goal.[63,64]

What are the possible types of HF SLE that are suitable for audiology training?

This review has listed the learning goals for all possible types of SLE audiology training modules with the inference that the majority of the clinical teaching modules involve the

cognitive, affective, psychomotor and social learning domains. In addition, this review has also listed a few possible tools that must be included in HF SLE modules, such as the inclusion of summative and formative feedback, validated and reliable assessment methods and validated and reliable marking schemes. This is to ensure the learning goal of the integrated SLE training is accomplished and that student performance can be validly evaluated and graded.
With this in mind, all the common types of HF SLE readily available in medicine, dentistry and nursing are applicable for use in HF SLE clinical audiology training modules with at least two limitations. First, and to the authors' knowledge, none of the existing types of stand-alone HF SLE simulators in audiology or in other health sciences related fields completely cover the social learning domain, for example, none of the HF SLE incorporates the two-way verbal communications between student and patients (except for a certain training that only requires the use of standardised patients without a simulator). Second, to the authors' knowledge, none of the stand-alone HF SLE could provide the opportunities for students to enhance their soft skills (affective domain), for instance, none of the HF modules included the strategies to teach students in building a rapport with patients, especially when dealing with paediatric or other special populations, such as the elderly or disabled patients (except for a certain training that only requires the use of standardised patients without a simulator). Most of the current simulators employ a non-verbal two-way communication, (for example, a student is asked to key in a question using a keyboard with the system answering the question and displaying the answer on the computer screen), thus hindering both the social and affective learning domains taking place.

To resolve the above issues, it is therefore recommended that SLE clinical audiology training use combination of HF SLE taining modules or part-task trainers, rather than a stand-alone HF simulator - at least, until such types of HF simulators are available. HF SLE audiology training modules may comprise a combination of standardised patients[22] with integrated MF CBS mannequins or a stand-alone virtual-reality (for instance, the use of virtual-reality highlighted in Heitz)[43] or integrated virtual-reality with a haptic system (if available or developed in the future). The feedback component could be conducted by a HF virtual tutor or, as an alternative, a human tutor (for on-going and summative feedbacks for the whole simulation learning). A "haptic" system (if available) can also serve to provide feedback to the student, for instance, by providing a feeling sensation or a trigger when audiology students make an error during the audiological assessment. This HF SLE training model could be considered by many institutions that accept SLE as one of the training methodologies based on the availability of SLE training tools, trained instructors and financial resources to cover the costs of running the SLE training as a whole (such as paying a professional standardised patients).

Whilst this review emphasises developing HF SLE modules for a comprehensive clinical training, it is acknowledged that, for certain basic learning goals, the use of LF or MF SLE may be sufficient. As an example, to improve student abilities in interpreting and integrating audiological findings, the use of a LF multimedia DVD with many case studies including feedback should be sufficient to achieve the learning goal without the need of an HF SLE.

CONCLUSION

This review has highlighted a few important considerations in developing an HF SLE training module. This paper, therefore, has highlighted, (i) the importance of instructors understanding their respective learning goals prior to introducing SLE, (ii) the need for valid methods to assess students following the SLE training with valid rubrics and, (iii) that with the current scenario of limited resources of HF SLE in audiology, the importance of using combined methods of different levels of SLE fidelity to achieve an HF SLE training module for clinical audiology training.

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