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EDITED BY

Gavin T. L. Brown,
The University of Auckland, New Zealand

REVIEWED BY

Walter Capa,
National University Federico Villareal, Peru
Jessica Surdey,
University College Dublin, Ireland

*CORRESPONDENCE

Kiri Mealings
✉ kiri.mealings@mq.edu.au

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An interdisciplinary approach to enhance children's listening, learning, and wellbeing in the classroom: The Listen to Learn for Life (L³) Assessment Framework

Kiri Mealings^{1,2*}, Kelly Miles^{1,2}, Rauno Parrila³, Rebecca Holt^{2,4}, Felicity Cox^{2,5}, Harvey Dillon^{2,5}, Mridula Sharma^{2,5}, Katherine Demuth^{2,4}, Greg Leigh^{6,7}, Catherine McMahon^{2,5}, Genevieve McArthur³ and Joerg M. Buchholz^{1,2}

¹ECHO Laboratory, Department of Linguistics, Macquarie University, Sydney, NSW, Australia, ²Macquarie University Hearing, Sydney, NSW, Australia, ³Australian Centre for the Advancement of Literacy, Faculty of Education and Arts, Australian Catholic University, Sydney, NSW, Australia, ⁴Child Language Laboratory, Department of Linguistics, Macquarie University, Sydney, NSW, Australia, ⁵Department of Linguistics, Macquarie University, Sydney, NSW, Australia, ⁶NextSense Institute, Sydney, NSW, Australia, ⁷School of Education, Macquarie University, Sydney, NSW, Australia

Introduction: Listening is the gateway to children learning in the mainstream classroom. However, modern classrooms are noisy and dynamic environments making listening challenging. It is therefore critical for researchers from speech and hearing, education, and health sciences to co-design and collaborate to realistically assess how children *listen to learn* in the classroom and to understand how listening can be improved to enhance children's learning and wellbeing – an understanding which is currently lacking. Such highly interdisciplinary thinking demands a holistic classroom listening framework that can integrate a range of varied assessments and outcomes.

Methods: An extensive review of literature into classroom listening was conducted but failed to identify a suitable framework. In this hypothesis and theory article we present a new framework that we have developed – the Listen to Learn for Life (L³) Assessment Framework.

Results: The L³ Assessment Framework holistically incorporates frameworks from health, speech and hearing sciences, and education sectors. The framework accommodates a broad range of different factors that may affect listening, allowing for researchers to choose specific factors dependent on the context of use.

Discussion: Selected examples of applying the framework are provided demonstrating how to assess children's performance during different classroom activities as well as the effectiveness of a chosen intervention. For example, the framework can be used to assess the effectiveness of a wireless remote microphone intervention during group work activities for a child with autism.

Conclusion: The L³ Assessment Framework provides a theoretical basis for the future development of research and practice as applied to listening in a classroom setting.

KEYWORDS

listening, learning, wellbeing, framework, classroom, education, school

1. Introduction

Children spend a great deal of their formative years listening and learning in noisy classrooms. Around 70% of classroom time is spent either listening to their teacher in lecture-style teaching or communicating with their peers during group work (Mealings et al., 2015a). Even though their auditory pathways are still developing, primary school (i.e., schooling for children aged 5–12 years) is where children forge social connections, navigate play, and absorb learning instruction through speaking and listening. Here in this hypothesis and theory paper, we focus on developing a framework based on what it means to listen to learn for life in a classroom and provide practical examples of how to use the framework to assess and improve children's listening, learning, and wellbeing. We draw on Kiessling et al. (2003) definition of listening as the process of taking in information through the sense of hearing with intention and attention. That is, listening is more than just a passive process – it requires intent to extract meaning from the signal. For children, listening in the classroom is essential for intellectual development (Atkin et al., 1977), learning to read (Snow et al., 1998), mathematical understanding (Hintz and Tyson, 2015), science understanding (Phibbs, 1991), and for building social skills.

Beyond learning outcomes, problems with listening may affect children's life more broadly, however, there is limited research on this. For example, hearing loss in children has been shown to reduce their quality of life both at school and socially (Roland et al., 2016). However, quality of life can be significantly improved when applying an intervention such as a hearing device (Roland et al., 2016). Noisy classroom environments have additionally been linked to higher levels of fatigue and stress in children both with and without hearing loss, related to the increased effort required for listening (Bess and Hornsby, 2014; Brännström et al., 2021; Gustafson et al., 2021). Children with poorer language skills, again including children with and without hearing loss, furthermore, display increased rates of behavioural, emotional, and social problems (e.g., hyperactivity, anxiety, aggression/bullying, isolation from peers) relative to their peers with better language abilities (Stevenson et al., 2010; Hogan et al., 2011). These negative psychosocial effects of language difficulty may be exacerbated in challenging listening situations. Additionally, poor classroom acoustic environments may lead to poor learning outcomes and diminished skill level which could impact work salary (James et al., 2012). Therefore, it is important to develop a framework that realistically assesses how listening affects not only early learning, but also consequences for life outcomes.

Children need to develop listening, learning, and life skillsets in fast-paced, dynamic learning environments where listening conditions are often sub-optimal (Mealings, 2016). Classroom noise levels and reverberation times often well exceed recommended guidelines [cf. Mealings (2016) for review]. Noise and long reverberation times can adversely affect speech intelligibility (Finitzo-Hieber and Tillman, 1978; Crandell and Smaldino, 2000; Jamieson et al., 2004; Mealings et al., 2015b), disrupt auditory processing, and increase cognitive effort (Gheller et al., 2020). Listening in noisy environments is especially challenging for children with special educational needs, such as children with hearing loss (MacKenzie and Airey, 1999; Crandell and Smaldino, 2000), central auditory processing disorders (Keith, 1999), and English as a second language (Nelson and Soli, 2000; Nelson et al., 2005). Background noise can also enhance sensory sensitivities and distract and/or distress children with attention deficit

hyperactivity disorder (Adams et al., 2009) and autism (Kanakri et al., 2017). Therefore, the classroom environment provides a challenge for most children – they must work hard to not just locate the right signal in classroom noise but also hear the information and ignore the irrelevant signals or risk missing valuable instruction and social interactions. While this research shows that poor classroom acoustics affect listening, and there is some research showing that poor classroom acoustic conditions can negatively impact on children's literacy, numeracy, cognition, behaviour, physical health, and mental wellbeing (Klatte et al., 2013; Lamotte et al., 2021; Minelli et al., 2022; Mealings, 2022a,b,c,d,e,f), the link between listening, learning, and wellbeing and what external and internal factors influence these links is yet to be established.

Evaluating a child's ability to listen in a classroom setting is rife with challenges. Assessments in real-world classrooms have high ecological validity; however, with little control over the test environment, there is low test sensitivity, and replicability is highly problematic. In contrast, testing in the laboratory permits high control and test sensitivity, but low ecological validity, which to-date has predominantly been driven by unrealistic assessment materials such as contrived speech and background noise recordings and lack of visual cues. There is clearly a crucial need to bridge the gap between real-world classroom listening and laboratory assessments to better understand and assess how children listen to learn for life in the classroom. This will then allow us to assess how interventions can improve children's listening, learning, and wellbeing. A highly interdisciplinary approach is needed to provide the crucial nexus between understanding real-world classroom listening and laboratory experimentation. This need has fuelled the development of the Listen to Learn for Life (L³) Assessment Framework – a holistic classroom listening assessment framework integrating existing frameworks across disciplines. The aims of the L³ assessment framework are to help researchers from speech and hearing, education, and health sciences to co-design and collaborate to better understand learning activities and perceptual settings of educational environment (Characterisation of Activity), assess classroom listening more realistically (Functioning Assessment), and assess how differences in listening translate into real-world learning and wellbeing outcomes (Impact), considering how different factors may affect this (Internal and External Influences). The framework can also be used to assess the efficacy of an intervention. The overarching goal in using the framework is to improve listening so that children's learning and wellbeing is enhanced.

This hypothesis and theory paper describes the development of the L³ Assessment Framework through the stages of a scoping review of existing classroom listening frameworks (see [Supplementary material](#)), a broader review of health, speech and hearing, and education frameworks (see Appendix), and the synthesis of these frameworks into one uniting structure. The results of future studies that use the L³ Assessment Framework have the potential to inform clinicians, educators, and policy makers on best practice to improve classroom listening and hence learning and life outcomes.

2. Overview of the L³ Assessment Framework

Initially, a scoping review of classroom listening frameworks was conducted via a search of the Education Resources Information

Centre (ERIC) Institute of Education Sciences database <https://eric.ed.gov> in August 2021. The search term was *classroom listening framework* with the elementary education filter applied. This returned 18 peer-reviewed papers. The primary education filter was also applied separately which returned four results, but all of these were covered by the elementary education filter. Each of the 18 papers were reviewed in terms of the frameworks discussed and the relevance to a classroom listening framework. The results are summarized in the [Supplementary material](#). As a classroom listening framework was not found from this search, the search was expanded to include the secondary education filter. This returned an additional 12 papers, but no additional frameworks were found.

Although some helpful concepts were observed in the scoping review, no classroom listening frameworks were found. A broader search of potentially relevant frameworks was therefore conducted online by searching health, speech and hearing, and education frameworks. Fifteen additional relevant frameworks (or concepts) were found, ranging from health ($n=3$) to speech and hearing sciences ($n=2$) to education ($n=10$), providing both an international and Australian perspective (see Appendix). These frameworks provided multiple additional perspectives that were then unified into the proposed L³ Assessment Framework.

An overview of the L³ Assessment Framework is illustrated in [Figure 1](#). The L³ Assessment Framework has three main components: Characterisation of Activity (yellow), Functioning Assessment (green), and Impact (blue). These are affected by External and Internal Influences (purple). The L³ Assessment Framework requires a staged approach where each component feeds into the next. First, it is important to provide a Characterisation of Activity. To do this, a researcher needs to understand the classroom activities that take place in the real classroom. For the purpose of the L³ Assessment Framework, these are divided into lecture, group work, and independent work activities ([Mealings et al., 2015a](#)). It is also important to characterise the perceptual setting that these activities elicit which affects speech intelligibility. Functioning Assessments of hearing, listening, communicating, and comprehending are then conducted.

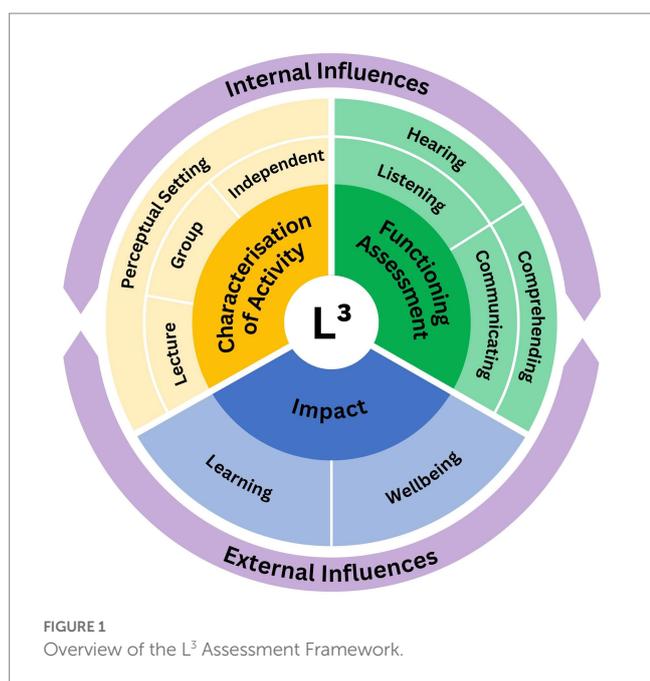


FIGURE 1
Overview of the L³ Assessment Framework.

comprehending, or communicating can then be developed and implemented with children, either directly in the classroom or in the laboratory, using methods that authentically represent/reflect the given learning activities and acoustic environments. Finally, the Impact of the child's listening abilities during the characterised activity can be assessed in terms of their learning and wellbeing. Each of these three components can be affected by the External and Internal Influences surrounding the periphery of the wheel, which should be profiled and taken into consideration when interpreting the results. The L³ Assessment Framework can be used in between-subjects study designs to identify the impact of different influencing factors, perceptual settings, or activities on listening to learn for life, and in within-subjects study designs to identify barriers and facilitators to listening and learning for life.

3. The L³ Assessment Framework components

3.1. Characterisation of Activity

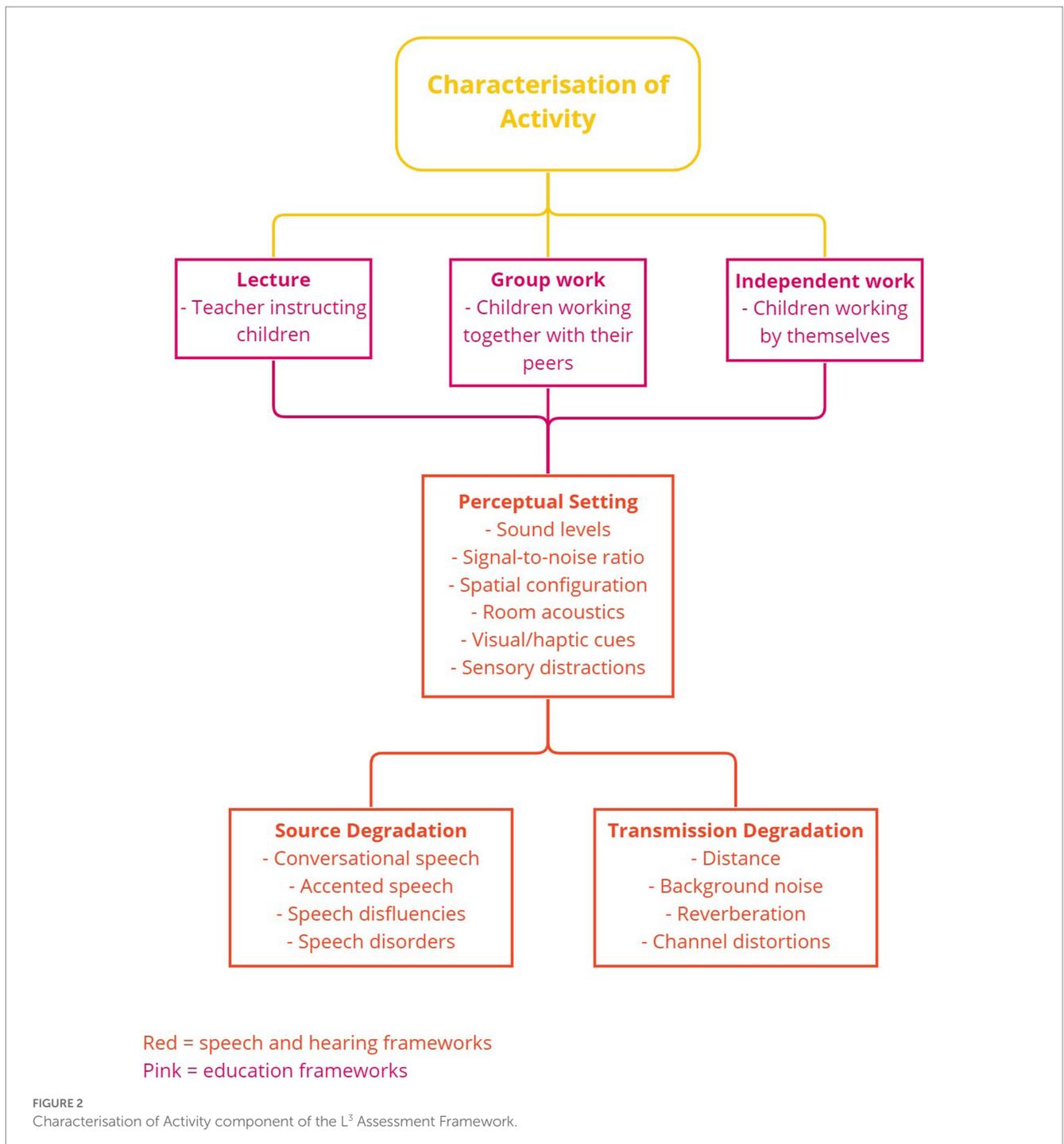
The first component of the L³ wheel is Characterisation of Activity, which includes the classroom activity and the perceptual environment.

3.1.1. Characterisation of the classroom activity

For the L³ Assessment Framework, classroom activities are divided into lecture, group work, and independent work activities (see [Figure 2](#)). The need for these three types of teaching scenarios is evident throughout the education documents reviewed (see Appendix). The [NSW Government Education Centre for Education Statistics and Evaluation \(2020\)](#) emphasizes the importance of explicit teaching (lecture-style) when learning new or complex concepts and skills. The second type of teaching scenario – guided learning in groups – encompasses collaboration, the importance of which is discussed by the [Centre for Education Statistics and Evaluation Advisory Council \(2013\)](#) and [Australian Government Department of Education and Training \(2011\)](#). Our scoping review (see [Supplementary material](#)) clearly identified the value of peer-led discussion groups to support reading comprehension ([Berne and Clark, 2008](#)). Finally, the [NSW Government Education Centre for Education Statistics and Evaluation \(2020\)](#) recommends that once teachers have explicitly taught (lecture-style) and guided their students (guided group learning), then students benefit from independently practising the new concepts and skills (i.e., engaging in independent work activities) to reinforce and consolidate their learning.

3.1.2. Characterisation of the perceptual setting

The characterisation of the perceptual setting includes factors that affect speech intelligibility, which is vital for listening in the classroom, using the work of [Mattys et al. \(2012\)](#) and [Lemke and Besser \(2016\)](#). [Mattys et al. \(2012\)](#) provides a classification of adverse listening conditions according to their *origin* and *effect*. With respect to the *origin* of adverse listening conditions, degradation of the speech signal can occur at the source (the speaker), during transmission (through the environment from the source to the receiver), or at the receiver (the listener) due to perceptual or cognitive limitations such as hearing loss, poor language skills, or cognitive load. Degradation at the source and during transmission are discussed here, whereas degradation at



the receiver is covered under Internal Influences. Source signal degradation can occur via several means. For example, conversational speech can include syllable deletion, segment elision, and segment reduction, as well as disfluencies such as repairs, restarts, and fillers. Additional degradation can result from speech disorders. [Mattys et al. \(2012\)](#) also suggest that accented speech is a source degradation, however, it could be argued that this is a receiver limitation in their ability to interpret the source as all speech is accented but varies in the familiarity of the accent. Environmental or transmission degradation can also occur in several ways. Background noise can interfere with speech transmission and reverberation can distort the speech signal;

and both are exacerbated when communicating over distance. Additionally, channel distortions such as those experienced in online, or hybrid learning can distort the speech signal.

With respect to the *effect* of adverse listening conditions on the listener, failure of recognition can occur when the listener misses information due to not recognising the words the speaker is saying ([Mattys et al., 2012](#)). Perceptual interference occurs when competing signals such as background noise affects the listener's interpretation of, or attention to, the target speech signal ([Mattys et al., 2012](#)). When there is a distractor present there is an attentional cost of trying to selectively attend to the target speech while disregarding the distractor

(Mattys et al., 2012). Multi-tasking also reduces attentional capacity due to divided attention (Kahneman, 1973). Additionally, listening in adverse listening conditions places higher demands on memory resulting in reduced memory capacity (Mattys et al., 2012). However, there can also be a positive effect of listening in adverse conditions, that is, perceptual learning. The sensory system can improve in its response to adverse listening conditions via learning through experience (Mattys et al., 2012).

Lemke and Besser (2016) provide a conceptual description of how situational influences (listener-external factors) affect listening and listening-related effort. The listener-external factors include the following physical characteristics: sound levels, number of target sources (i.e., people the listener is trying to understand), number of interfering sources (i.e., number of people making up the background noise), frequency spectrum and temporal structure of the target and interfering sound sources, the acoustic properties of the room (e.g., reverberation), the spatial configuration of the target sources and interfering sources, the presence of visual or haptic cues, the presence of sensory distractions, and the language and/or accents of both the target and interfering speech. Each of these factors can influence how much processing effort is needed for speech recognition.

3.2. Functioning Assessment

The second component of the L³ wheel is Functioning Assessment, which consists of assessments that can be categorised along the spectrum of hearing, listening, comprehending, and communicating as defined by Kiessling et al. (2003). Each factor builds on the previous factor (see Figure 3).

3.2.1. Hearing

According to Kiessling et al. (2003), hearing is a passive function that involves “sensing the presence of sounds and discriminating the location, pitch, loudness and quality of sounds” (pg. 93).

3.2.2. Listening

According to Kiessling et al. (2003), “listening is the process of hearing with intention and attention” (pg. 93). It is purposeful and requires effort. This includes evaluative listening as defined by Davis (1996) which is where the listener is listening for something in particular, for example a correct answer to a question. It is surface-level listening that does not require searching for deeper, underlying meanings (Burlison, 2011).

3.2.3. Comprehending

According to Kiessling et al. (2003), “comprehending is the reception of information, meaning or intent” (pg. 93). It goes beyond hearing and listening. This includes interpretive listening and hermeneutic listening as defined by Davis (1996). Interpretive listening seeks information and responds to it. It involves deliberate, active interpretation. Hermeneutic listening involves exploring, making sense of, and building on the ideas discussed in multiple perspectives, so requires receptive language skills.

3.2.4. Communicating

According to Kiessling et al. (2003), “communicating requires the bi-directional transfer of information, meaning or intent between two

or more people” (pg. 93). The specific communication skills in Figure 3 have been selected from the World Health Organisation International Classification of Functioning, Disability and Health: Children and Youth version (WHO ICF-CY; World Health Organisation, Switzerland, 2007).

3.3. Impact

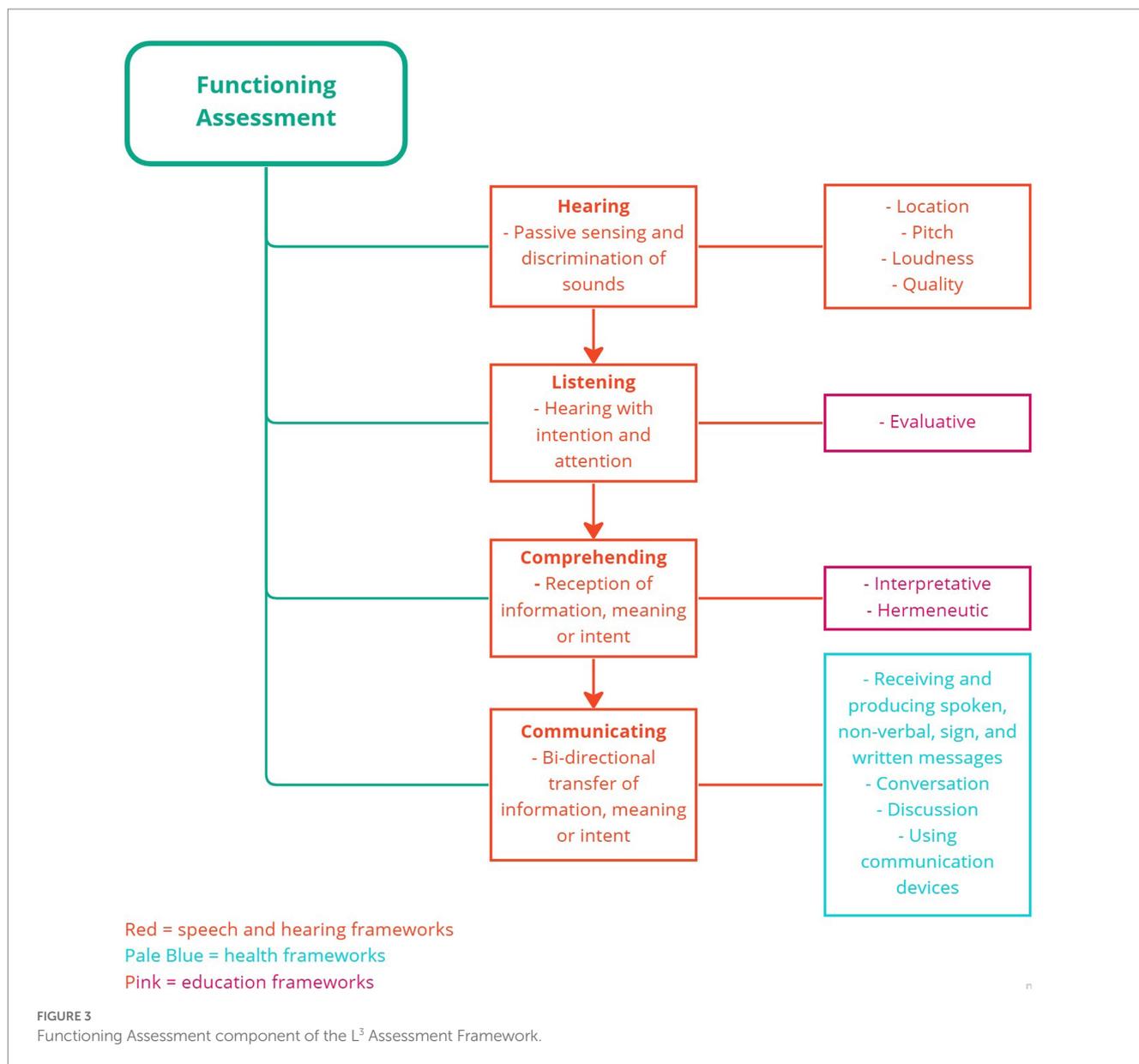
The third component of the L³ wheel is Impact, which comprises learning and wellbeing using the education and health frameworks (see Appendix). A full list of the elements in the Impact component can be seen in Figure 4.

3.3.1. Learning

For learning assessments, we have incorporated elements from the WHO ICF-CY conceptual framework (World Health Organisation, Switzerland, 2007) and the education frameworks (see Appendix). Assessments associated with the WHO ICF-CY classifications are basic learning and applying knowledge. We augment this set by adding assessments of the skills from Anderson and Krathwohl (2001) revised version of Bloom’s taxonomy known as the Taxonomy for Teaching, Learning, and Assessment. These skills are: remember (recognising and recalling), understand (interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining), apply (executing and implementing), analyse (differentiating, organising, and attributing), evaluate (checking and critiquing), and create (generating, planning, and producing) (pg. 67–68). These skills are further expanded on by adding research skills, critical thinking, creativity, collaboration, information, media, and technology skills, and reflection. These have been drawn from the Partnership for 21st Century Learning (2019), the NSW Government Great Teaching, Inspired Learning: A Blueprint for Action (Centre for Education Statistics and Evaluation Advisory Council, 2013), and My Time, Our Place – Framework for School Age Care in Australia (Australian Government Department of Education and Training, 2011) as described below.

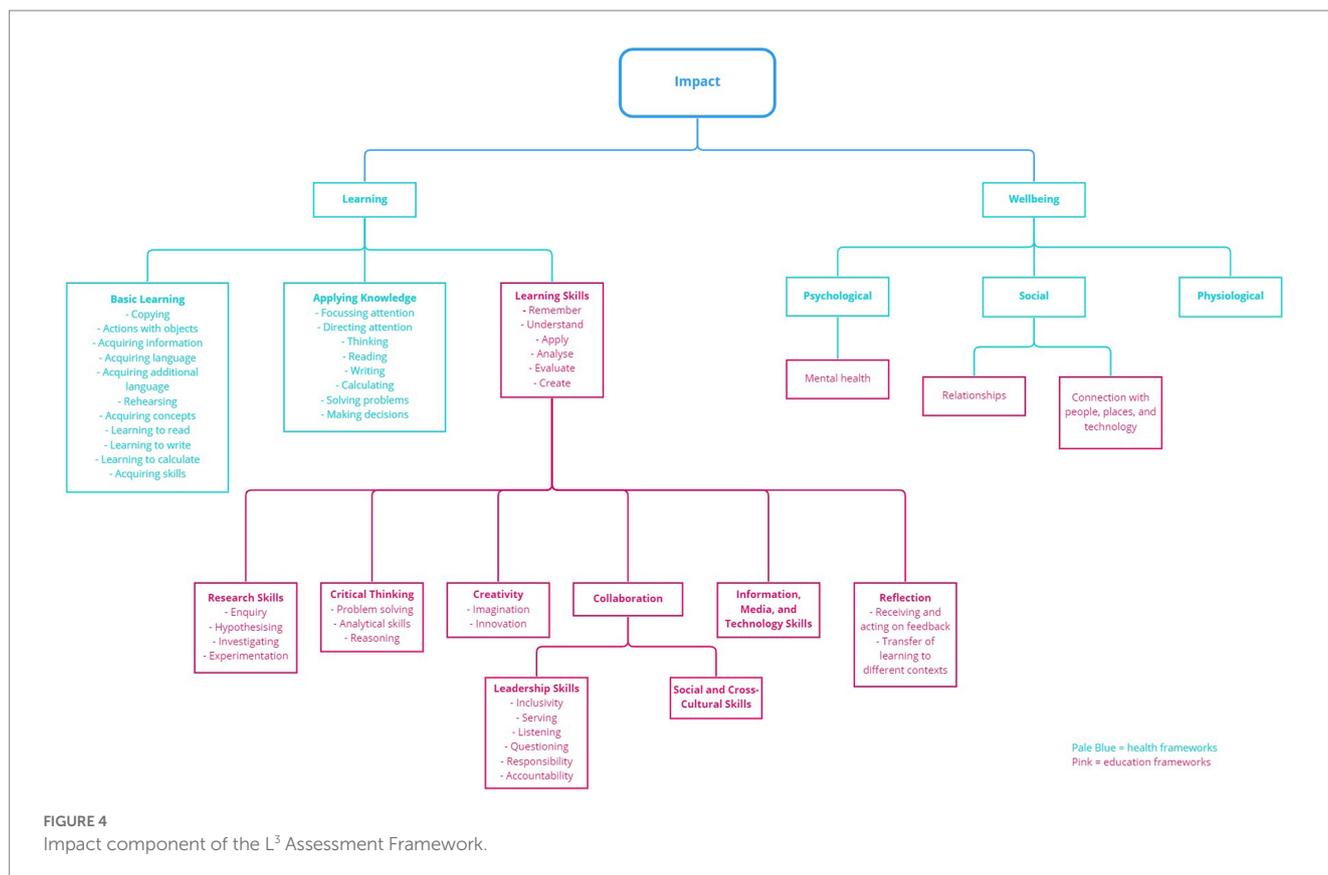
The Partnership for 21st Century Learning (2019) Framework for 21st Century Learning outlines the skills, knowledge, and expertise needed for success in work and life. These include creativity and innovation (thinking creatively, working creatively with others, implementing innovation), critical thinking and problem solving (reasoning effectively and solving problems), information, media, and technology skills (accessing and evaluating information, using and managing information, analysing media, creating media products, applying technology effectively). The Centre for Education Statistics and Evaluation Advisory Council (2013) discusses the importance of students being able to solve problems, think creatively, innovate, and connect through technology for success at school, work, and in life. They also need to be creative and innovative in solving challenges and making the most of opportunities. The Australian Government Department of Education and Training (2011) states that children need to demonstrate skills in problem solving, enquiry, experimentation, hypothesising, researching, and investigating.

Collaboration is another important skill evident in the education frameworks. Bowman’s (2014) Framework for Leadership in Elementary Schools includes four distinctive leadership dispositions: the spirit to include, the passion to serve, the discipline to listen, and



the courage to question. These dispositions are important to consider for the L³ Assessment Framework, especially when thinking about child-directed classroom communicative and social interactions where a child must work with a group of children on a problem. *The spirit to include* is focused on the child including those who have been excluded by listening to the perspectives of others and transforming relationships. *The passion to serve* is about the child serving others with a moral purpose and thinking of themselves less often. *The discipline to listen* is focused on the child being less interested in themselves and more interested in and curious about others to create shared meaning and shared partnerships. *The courage to question* encourages the child to question themselves and know themselves. These leadership skills are expanded on by the [Partnership for 21st Century Learning \(2019\)](#) which includes the importance of productivity and accountability (managing projects and producing results), and leadership and responsibility (guiding and leading others and being responsible to others) for success. The [Partnership for 21st](#)

[Century Learning \(2019\)](#) also notes the importance of communication and collaboration (communicating clearly) and social and cross-cultural skills (interacting effectively with others and working effectively in diverse teams). The NSW Government Great Teaching, Inspired Learning: A Blueprint for Action ([Centre for Education Statistics and Evaluation Advisory Council, 2013](#)) states that students need to have the confidence to work by themselves and in a team, analyse what they see and hear, and be able to confidently use technology to enhance communication, learning, and quality of life. Students need to be clear communicators and expressors of ideas and have the interpersonal skills to relate with others. My Time, Our Place – Framework for School Age Care in Australia ([Australian Government Department of Education and Training, 2011](#)) also notes that children need to be able to interact verbally and non-verbally with others, collaborate with others and express ideas, and make use of a range of media and communication technologies to become effective communicators.



3.3.2. Wellbeing

For wellbeing, we take on the definition by Dodge et al. (2012): “Stable wellbeing is when individuals have the psychological, social and physical resources they need to meet a particular psychological, social and/or physical challenge. When individuals have more challenges than resources, the see-saw dips, along with their wellbeing, and *vice-versa*.” (pg. 230). As can be seen from this definition, wellbeing is balanced by the person’s resources compared to the challenges they face. Both the resources and challenges consist of psychological, social, and physical components. This sector of the Impact component of the wheel is expanded on by the education frameworks Centre for Education Statistics and Evaluation What works best: 2020 Update (NSW Government Education Centre for Education Statistics and Evaluation, 2020), the NSW Government Great Teaching, Inspired Learning: A Blueprint for Action (Centre for Education Statistics and Evaluation Advisory Council, 2013), and My Time, Our Place – Framework for School Age Care in Australia (Australian Government Department of Education and Training, 2011) as described below.

The NSW Government Education Centre for Education Statistics and Evaluation (2020) states that student wellbeing encompasses “cognitive, social, physical, emotional and spiritual wellbeing” (pg. 33) and, among other factors, is related to a student’s academic achievement (Bücker et al., 2018). Student belonging, valuing their voice, and promoting engagement in learning helps improve student wellbeing which results in improved academic achievement, mental health, and life choices.

The Australian Government Department of Education and Training (2011) emphasises that children need to have a strong sense

of social and emotional wellbeing by showing trust and confidence, enjoying working both collaboratively with others and independently, and demonstrating self-regulation of their emotions. Children need to take increased responsibility for their wellbeing by being connected to others, regulating their emotions, increasing their competence in using equipment, and increasing their awareness of healthy lifestyles. The Centre for Education Statistics and Evaluation Advisory Council (2013) also notes that children need to understand their social responsibility and look after their own wellbeing.

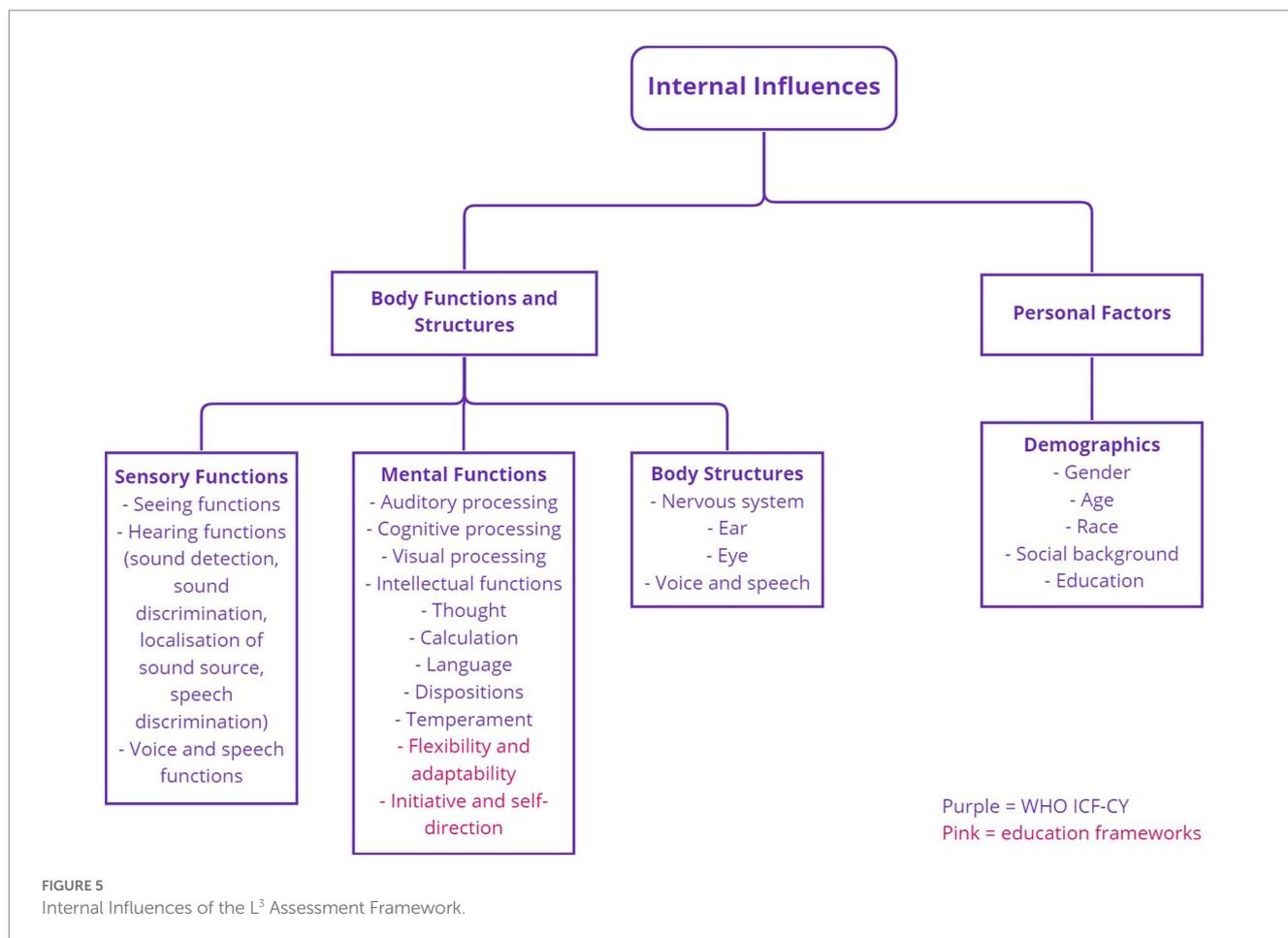
4. The L³ Assessment Framework influencing factors

Each of the three components above (Characterisation of Activity, Functional Assessment, Impact) are influenced by Internal and External Influences (see Figures 5, 6).

4.1. Internal Influences

4.1.1. Body Functions and Structures

The Body Functions and Structures which may influence listening and learning include those that are relevant from the WHO ICF-CY (World Health Organisation, Switzerland, 2007). These Body Structures include the nervous system, ear, eye, and structures involved in voice and speech. Body Functions include sensory functions and mental (psychological) functions. Several of these classifications are supported by the education frameworks. Hattie’s



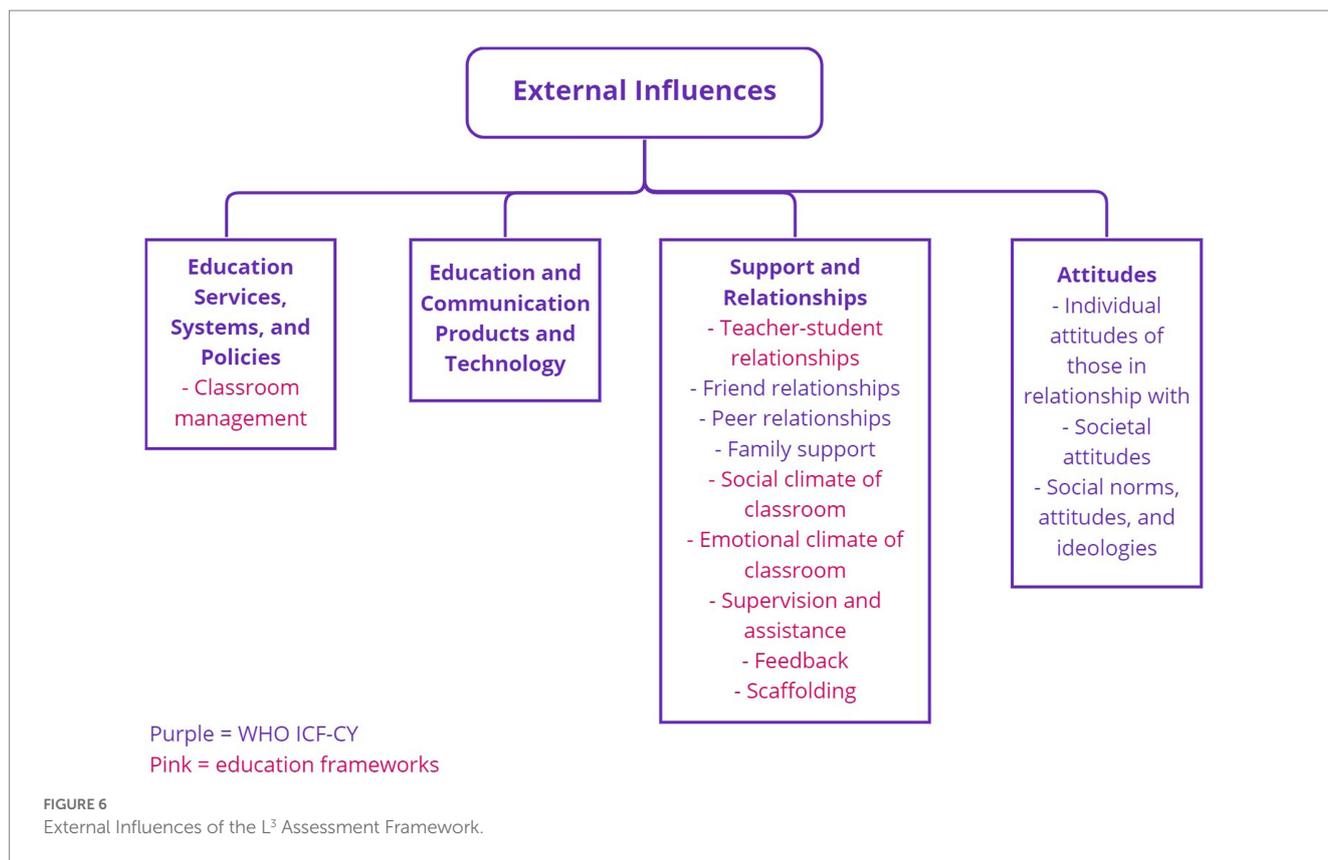
Visible Learning (Hattie, 2008) supports the contribution of the child's dispositions on achievement. We include these here as temperament and personality functions are considered body functions under the WHO ICF-CY, however, we also acknowledge that some of these may be learned. These functions include attitudes and dispositions such as personality, self-concept, motivation, concentration/persistence/engagement, anxiety, and attitude to maths/science. The Australian Government Department of Education and Training (2011) also states that children need to develop the skills of curiosity, cooperation, confidence, commitment, enthusiasm, persistence, imagination, and reflexivity. A couple of additions have been made to mental functions from the education frameworks: flexibility and adaptability, and initiative and self-direction. These come from the Partnership for 21st Century Learning (2019) which states the importance of adapting to change and being flexible, and managing goals and time and working independently.

The impact of these body functions and structures on listening are important to consider as outlined in the speech and hearing frameworks reviewed. Mattys et al. (2012) describe that degradation of the speech signal can occur at the receiver (listener). Receiver limitations can be caused by a peripheral deficiency (e.g., sensorineural hearing loss); an incomplete language model (e.g., children and non-native listeners); impaired access or use of the language model (e.g., neurological deficits); or due to cognitive load and limited processing resources. When there is a distractor present there is an

attentional cost of trying to selectively attend to the target speech while disregarding the distractor. Multi-tasking also reduces attentional capacity due to divided attention. Additionally, listening in adverse listening conditions places higher demands on working memory, resulting in reduced memory capacity available for other tasks such as comprehension (Osman and Sullivan, 2014; Sullivan et al., 2015). Lemke and Besser (2016) also describe that listener-internal factors such as auditory processing and cognitive processing can affect listening effort. Auditory processing includes audiometric thresholds, ability to process supra-threshold spectral and temporal cues, and binaural processing of interaural time and level differences. Cognitive processing includes language ability, semantic, episodic, and working memory, attention, executive functions, and speed of information processing. The *personal state* characteristics of the listener that affect listening effort include their physiological state (e.g., tiredness), motivation (e.g., engagement), emotional state (e.g., stress or grief), and social-psychological factors (e.g., self-advocacy).

4.1.2. Personal Factors

Personal Factors include demographics as outlined in the WHO ICF-CY (World Health Organisation, Switzerland, 2007) which are also found in the education frameworks (Hattie, 2008). For example, student influences on achievement include aspects of their background such as their prior achievement, self-report grades (i.e., estimates of their own performance), and preschool influences. Regarding prior



achievement, children who do well at one point in time tend to do well in future points in time, though this is likely because the internal influences that caused the initial success are still there at future times, rather than prior achievement being the cause.

4.2. External Influences

External Influences include those in the WHO ICF-CY such as education services, systems, and policies; education and communication products and technology; support and relationships; and attitudes. We have made some additions to these from the education frameworks consulted. The Centre for Education Statistics and Evaluation What works best: 2020 Update (NSW Government Education Centre for Education Statistics and Evaluation, 2020) describe the importance of classroom management. Effective classroom management is important for maximising learning time, minimising disruptions, and improving students' performance. Effective classroom management has a positive effect on student behaviour, engagement, and achievement. Effective classroom management strategies include creating a positive social and emotional classroom climate and positive teacher-student relationships, communicating classroom expectations, rules, and routines, engaging students via active participation, supervising students to keep them on task and assisting when needed, and providing consistent and calm responses to help students re-engage when they become disengaged or disruptive.

The NSW Government Education Centre for Education Statistics and Evaluation (2020) also describes the importance of effective

feedback. Providing effective feedback is important so a student can improve in their learning. This includes reflecting and communicating about the task, providing detailed, specific feedback on how the student can grow, encouraging self-assessment, reflection, and monitoring, ensuring students act on the feedback received, providing feedback about a student's process or effort, and providing feedback that promotes self-regulation.

Hattie's Visible Learning (Hattie, 2008) also outlines how teaching-related factors influence academic achievement. The influences with the largest effect sizes were providing formative evaluation of programs (i.e., feedback to teachers about programs), reciprocal teaching (students taking turns at being the teacher), and feedback more generally. Hattie also suggests that variance due to teachers makes a difference to children's academic achievement. Hattie found that the influences with the largest effect sizes for teacher-related academic achievement were micro teaching (i.e., small group teaching), teacher-clarity, and teacher-student relationships.

The importance of relationships is also reflected in Vygotsky's Sociocultural Theory, which emphasises the collaborative nature of learning (Mahn, 1999). Children construct knowledge through social interactions. Guidance or collaboration from an adult or peer can help improve the learning potential of the child compared to solving a problem independently (Mahn, 1999). Complementing this is Krashen's Input Hypothesis which states that language acquisition occurs when the learner receives input slightly more advanced than their current knowledge (Gien and Nel, 2018). This hypothesis is important as it promotes scaffolding, i.e., the learner is assisted by a more knowledgeable learner/teacher when they lack the skills needed for further learning.

5. Discussion – the Framework in action

5.1. The L³ Assessment Framework process

The L³ Assessment Framework process is shown in Figure 7. The process starts by profiling the Internal and External Influences relevant to the population being studied. The Internal and External Influences typically form control, explanatory/predictor, or confounding variables. Many of these variables need to be measured, requiring additional assessments of, for instance, hearing ability, language skills, or cognitive skills, depending on the population being studied.

Then the Characterisation of Activity can be defined by determining the classroom activity (i.e., lecture, group work, or independent work activities) and the perceptual setting that may affect speech intelligibility. An accurate Characterisation of Activity is vital for creating a realistic Functioning Assessment.

Next, the Functioning Assessment can be completed by assessing the child's hearing, listening, comprehending, or communicating abilities. To assess children's functioning, it is important that the assessments are as realistic as possible. The Functioning Assessments may be either conducted directly inside the real classroom using the identified classroom activity and perceptual setting, or in the laboratory using experimental methods that well reflect the identified classroom activity and perceptual setting. There are pros and cons to both methods. The real-world assessment provides high ecological validity but lacks stimulus control and test sensitivity. In contrast, the laboratory assessment provides excellent stimulus control and test sensitivity but lacks ecological validity. Ideally, laboratory tests should provide equivalent outcomes to the real classroom assessments, which may be achieved by reproducing the real-world stimuli and tasks inside the laboratory. If that is possible, the resulting test has a high ecological validity and a test sensitivity that allows evaluation of (small) differences between individual children's abilities and the individual benefit provided by an intervention.

Finally, the Impact of different influencing factors, perceptual settings, activities, and listening abilities on particular learning and wellbeing outcomes selected specifically for the study are assessed. To show the Impact of these differences or benefits on the individual child's life, a relationship needs to be established between the outcomes of the Functioning Assessment and Impact assessments. The Impact assessments for learning can include objective tests, however, for wellbeing, the assessments typically involve questionnaires, which provide rather poor

test sensitivity and therefore require large test participant numbers to allow sufficient statistical power. Hence, if a strong correlation can be established between Functioning and Impact assessment outcomes using a significantly large participant group, the Functioning Assessment can then later be used as a sensitive proxy measure to assess individual differences or intervention benefits.

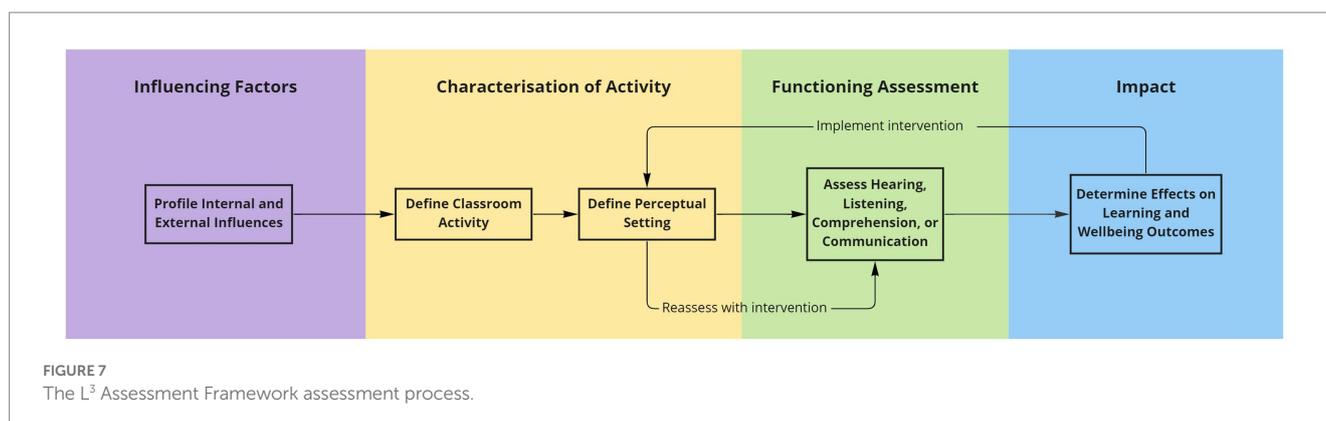
While many assessments already exist for profiling Internal Influences and Impact assessments of learning and wellbeing, Functioning Assessments that are realistic representations of the learning activity and perceptual setting are lacking. Utilising the L³ Assessment Framework will help with developing these more realistic assessments.

5.2. Between-subjects design: identifying the impact of different influencing factors on listening to learn for life

The L³ Assessment Framework can be used to assess the impact of different Internal or External Influences on listening and learning for life in studies with between-subjects designs. Different populations of children (i.e., with different Internal or External Influences) can be assessed to determine the impact of different abilities on children's listening and learning for life. For example, the performance of children with hearing loss might be compared to that of children with typical hearing (different Internal Influences) or children receiving different teaching approaches might be compared (different External Influences). Similarly, variability in performance within a population may also be examined and linked to variation in Internal or External Influences. For example, a researcher might examine the effect of working memory capacity (Internal) or parental support (External) on performance within a group of typically-developing students.

5.3. Within-subjects design: identifying barriers and facilitators to listening and learning for life

The L³ Assessment Framework can also be used to assess barriers and facilitators to listening and learning for life for studies with within-subjects designs. The following equations compare the child's capacity in a standardised environment versus their performance in an experimental environment based on the theory from the WHO ICF:



- Standardised Environment + Ability = Capacity
- Experimental Environment + Ability = Performance

If performance in the experimental environment is poorer than capacity in the standardised environment, then the experimental environment is a barrier to listening and learning. If performance in the experimental environment is better than capacity in the standardised environment, then the experimental environment is a facilitator to listening and learning.

With this understanding, the L³ Assessment Framework can be used to evaluate the effectiveness of an intervention. This process is also shown in [Figure 7](#). Once the Influencing Factors are defined and there has been a Characterisation of Activity, the Functioning Assessment and Impact can be assessed. This initial test can be called the standardised environment test. Interventions can then be implemented which manipulate the perceptual setting. The change in functioning, as well as the impact on learning and wellbeing, can then be reassessed to determine whether the intervention is a barrier or a facilitator to listening and learning for life.

5.4. Examples of the framework in action

The L³ Assessment Framework can be applied to a wide range of children (Internal Influences), a wide range of Functional Assessments can be conducted either in the laboratory or the classroom, and a wide range of Impacts can be determined. As such, the framework provides a comprehensive list of factors that impact upon, or are impacted by, listening in the classroom. It is not intended that all of these factors be measured or controlled in any one evaluation related to listening in the classroom. Rather, we suggest that whenever some aspect related to listening in the classroom is investigated, that the framework be reviewed to determine which factors are most relevant to measure or control. The following hypothetical cases provide some examples of this approach. Below are four examples that highlight the breadth of the framework's utility in a range of contexts. Additionally, each example by itself can specifically assess any of the range of factors that are outlined in [Figures 2–6](#) whether explicitly defined or implicitly addressed.

5.4.1. Example 1

Take for example, that a researcher wants to assess listening comprehension during lecture-style teaching in rooms with different reverberation times in children differing in language abilities (i.e., a between-subjects design). They also want to determine the impact that these factors have on the children's learning and wellbeing. The researcher decides to create a realistic listening comprehension test in the laboratory. In applying the L³ Assessment Framework, they would first profile the children's language abilities on a language assessment. They would then define the classroom activity (in this case, a lecture) and the perceptual settings that are going to be manipulated (in this case, the classroom reverberation times). This would then be incorporated into a realistic laboratory assessment of listening comprehension. Learning and wellbeing assessments can then be conducted depending on the specific outcomes that they wish to assess. The results can be analysed to determine the effect of different language abilities and different classroom reverberation times (predictor variables) on children's listening comprehension (outcome

variable). Then children's listening comprehension can be used as a predictor variable to determine the impact on learning and wellbeing (outcome variables).

5.4.2. Example 2

Another example would be a researcher wanting to assess communication during different group work activities which produce different noise levels in children of different ages (i.e., a between-subjects design). They also want to determine the impact that these factors have on the children's learning and wellbeing. The researcher decides to assess the children's communication in the real classroom. In applying the L³ Assessment Framework, they would first profile the children's ages. They would then define the classroom activity (in this case, group work) and the perceptual settings that will differ (in this case, the classroom noise levels). This would then be incorporated into a communication assessment conducted in the classroom. Learning and wellbeing assessments can then be conducted depending on the specific outcomes that they wish to assess. The results can be analysed to determine the effect of different ages and different noise levels (predictor variables) on children's communication (outcome variable). Then children's communication can be used as a predictor variable to determine the impact on learning and wellbeing (outcome variables).

5.4.3. Example 3

Now take for example, that a researcher wants to assess the performance of a young child with autism during group work with their peers and the effect of different interventions (i.e., a within-subjects design). The researcher decides to assess hearing in the classroom. In applying the L³ Assessment Framework, they would first test the standardised environment, which in this case could be a quiet classroom complying with the classroom acoustic conditions recommended in the [Australia/New Zealand Standard \(2016\)](#) where the child is not using an assistive device. This would measure the child's capacity. Then they would test the child without any assistive device in the classroom during a group work activity and compare the two. Suppose that the outcome is that the noise during group work in the classroom affects the child's ability to hear, resulting in performance less than capacity. The Impact on learning and wellbeing can then be measured. If learning and/or wellbeing is worse, the conclusion could then be drawn that the classroom noise during group work is a barrier to listening and learning for life.

Now suppose that the researcher wants to assess if a wireless remote microphone assistive device placed on the desk to pick up the children's voices can help overcome some of the barriers in the group work scenario and see if it is a facilitator for the environment. To do this we make the performance of the child during group work their capacity for this scenario, and then add in the wireless remote microphone. Suppose that this results in improved hearing (i.e., performance in the experimental environment is better than capacity in the standardised environment without the wireless remote microphone). This Impact on learning and wellbeing can then be measured. If learning and/or wellbeing improves with the intervention, then it can be concluded that a wireless remote microphone is a facilitator to listening and learning for life.

Furthermore, classroom management techniques can be employed to further reduce the background noise. If this results in an additional boost to performance, then classroom management techniques are

facilitators to learning as well, and it can be recommended that both a wireless remote microphone and classroom management are used to improve listening and learning for life for this child during this activity.

5.4.4. Example 4

The L³ Assessment Framework can also be applied to online learning assessed via a laboratory study with a within-subjects design. Take for example that a child with hearing loss is listening to an online lecture, but there are channel distortions of the speech signal. Suppose that the child's capacity to listen and learn for life is low. A researcher can assess the effectiveness of an intervention – in this case, live captioning. Suppose the child's performance with live captioning is better than their capacity without it. We can then conclude that live captioning is a facilitator to listening and learning for life. Additionally, another intervention can be implemented and assessed – for example, using a sign language interpreter. Suppose again that the child's performance with a sign language interpreter is better than their capacity without an intervention. We can then conclude that sign language interpreting is a facilitator to listening and learning for life. Furthermore, the most effective intervention can be assessed by comparing the child's performance when using live captioning compared to a sign language interpreter. Whichever has the best performance is the most effective intervention.

6. Summary and conclusions

We conducted a scoping review of classroom listening frameworks and found that none currently exist. Therefore, a new Listen to Learn for Life (L³) Assessment Framework was developed unifying existing frameworks from health, speech and hearing sciences, and education. It was then demonstrated how this framework could be used to assess how a child performs in regard to their listening and learning for life in an educational environment. Our proposed framework focuses on listening to learn for life in primary school aged children as listening is essential to learning before (and after) the child can read fluently. However, the framework can be adapted to higher schooling and educational stages as well. The framework is primarily intended for speech and hearing researchers in co-design with education and health sciences researchers to use to provide scientific evidence to education institutions of ways to improve listening to learn for life. We hope that the framework we have developed can be used in the future to assess children's listening in a wide range of different classrooms and how the perceptual environment can be changed to enhance listening and learning for life. As children will go from one classroom to the other, it is recommended that a whole school approach is used to help all children, not just those with severe challenges. We also hope that the framework will be used when conducting systematic reviews and meta-analyses on classroom listening. The impact of using this framework to improve listening in the classroom could

include improved health, wellbeing, and quality of life for the child, and later, a higher quality workforce with increased productivity.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Author contributions

KMe: primary conceptualisation and first draft. KM_i, RP, RH, FC, HD, MS, KD, GL, CM, and GM: conceptualisation and revised article critically for important intellectual content. JB: conceptualisation, supervision, and revised article critically for important intellectual content. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2023.1185167/full#supplementary-material>

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