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September 15, 2025

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The integration of music, especially the voice as a teaching tool, into the Comprehensive Aquatic Method can enhance motor, cognitive and emotional learning in an inclusive, respectful manner based on neuroscientific evidence.

Introduction



The [Comprehensive Aquatic Method \(MAC\)](#) conceives learning in water as a process of guided motor problem solving, structured, in summary, into four successive phases (exploration, understanding, solution and consolidation) organised into a continuous cycle of question, search and answer. This methodology promotes autonomy and reasoning by transforming each physical experience into an opportunity to reflect on

the why and how of the action. Its effectiveness has been demonstrated through quasi-experimental studies with primary school children, which show significant improvements in aquatic knowledge, skills and attitudes after twenty sessions with the CAM, compared to traditional directive approaches (De Paula Borges & Moreno-Murcia, 2018).

The incorporation of music as a rhythmic-melodic stimulus enhances these educational benefits. The spoken and sung voice, used by the aquatic educator as a musical instrument, is integrated into each teaching proposal. Musical neuroscience has shown that external pulses synchronise sensorimotor networks and strengthen synaptic plasticity, facilitating the acquisition and stabilisation of new movement patterns. The “auditory-motor entrainment” model maintains that musical tempo functions as an internal clock that regulates motor execution, reduces gestural variability, and improves efficiency (Braun Janzen et al., 2022). In the aquatic environment, where resistance, buoyancy, and orientation differ from terrestrial locomotion, this external synchronisation promotes both respiratory coordination and postural regulation, which are key elements for performance and safety.

Likewise, the integration of sound resources into MAC expands its inclusive potential. Rhythm and prosody provide auditory cues that complement visual and tactile supports, making them especially valuable for people with sensory diversity or attention difficulties. This approach responds to the principles of Universal Design for Learning (UDL), which promotes multiple forms of access, participation and expression, ensuring

a meaningful experience for every child (Perry, 2016). Thus, music not only accompanies the action: it structures and motivates it, allowing the group to move forward together despite their differences.

In this framework, the MAMI proposal (Music Applied in the Comprehensive Aquatic Method in Inclusion) organises objectives in the four areas of the MAC (comprehension, decision-making, motor execution and socio-affective transfer) and offers musicalised teaching strategies that reinforce them. Thus, MAMI is presented as a comprehensive resource: solid in its didactic approach, enriched by the conscious use of music and genuinely inclusive.

Musical neuroscience and motor rhythm in the aquatic environment



Musical neuroscience has shown that music, and rhythm in particular, has a profound impact on the organisation and regulation of brain and motor activity. This effect is especially relevant in contexts such as the aquatic environment, where coordination and movement efficiency are essential. Research in musical neurology shows that rhythmic stimuli regulate cortical timing and facilitate the encoding of new motor patterns. The “auditory-motor entrainment” model explains how musical pulse stabilises movement frequency and reduces variability, generating more efficient patterns (Braun et al., 2022). This synchronisation between external rhythm and internal motor activity results in more precise and coordinated movements, even in people with no prior musical training.

The maternal voice has been the subject of multiple studies and is considered highly relevant due to its impact on the brain plasticity of the developing baby. Hearing is deemed fully functional between weeks 24 and 28 of gestation (Eggermont et al., 2012). Babies prefer their mother's voice, and in the early stages of their development, they have achieved a process of auditory discrimination where their sensory integration

with their environment allows them to be stimulated by the tonal frequencies, rhythms, melodies and sounds of their surroundings, feeling more confident when accompanied by their mother.



Brain plasticity, due to musical training, not only presents differences in structure but also in functioning as a result of musical training, both in the short and long term (Justel & Díaz, 2012). Thus, functional changes in the brain have been demonstrated not only after prolonged musical training but also after only one week of auditory discrimination training (Gaab et al., 2006).

Electroencephalography (EEG) studies have shown that neural oscillations can synchronise with the beat and rhythm of music, facilitating the anticipation and execution of rhythmic movements. In addition, musical practice induces rapid changes in the motor cortex and other brain areas related to movement control, such as the basal ganglia and cerebellum (Rubia-Vila, 2018).

In the aquatic context, music and rhythm have specific and measurable effects.

- **Synchronisation and motor efficiency.** Musical rhythm helps stabilise the frequency of movements in water, where resistance and buoyancy alter motor perception and execution. Music acts as an external metronome, facilitating muscle group coordination and the repetitive execution of efficient motor patterns.
- **Physiological regulation.** The heart tends to indirectly synchronise with the musical rhythm. Songs with a low beats per minute (bpm) can induce a reduction in heart rate, while faster music can increase it, helping to modulate the intensity of physical effort in the water.
- **Motivation and perception of effort.** Music in the aquatic environment reduces the perception of fatigue and monotony, promoting a more enjoyable and motivating experience. This is associated with the release of endorphins and greater adherence to physical activity.
- **Learning and motor memory.** The repetition of movements synchronised with music facilitates the consolidation of motor patterns, which is especially useful in teaching aquatic skills or in rehabilitation.

In the aquatic environment, it is essential to take advantage of its physical properties and the benefits it offers, especially for neurodivergent individuals, people with disabilities, young children (0 to 24 months) and elderly people. The combination of respectful aquatic education, the Comprehensive Aquatic Method (CAM) approach and practices aimed at functional diversity provides sensory and proprioceptive stimuli that promote body movement through safe exploration, reducing weight load, facilitating

mobility, strengthening and functional training (Morris, 2004). In these groups, motor and meaningful learning processes tend to develop at a different pace than in the neurotypical population, so the MAMI proposal adapts to these times by integrating with the CAM pedagogical algorithm (Moreno-Murcia, 2023), thus enhancing the work of the aquatic educator and real inclusion in the aquatic environment.

Musicalised pedagogical principles

In this section, we will discuss how musicalised pedagogical principles, based on the neuroscience of rhythm and motor learning, can enhance teaching in the aquatic environment. Through strategies such as rhythmic problem solving, musicalised feedback, variability in practice, and the promotion of autonomy, active, adaptive, and motivating learning is promoted, which favours both the motor and cognitive development of students.

Curiosity and continuous training, an essential element that aquatic educators must cultivate (Fonseca-Pinto et al., 2025), involve the need to learn and understand auditory discrimination so that it can be used and practised daily. In this way, the voice becomes a musical teaching tool that is always with the educator and allows them to be in tune with their students. As Brown (1893) points out in Fernández et al. (2016), “the human voice is so superior to all instruments made by human hands that any attempt to define its nature will necessarily be incomplete.” Just as it is necessary for an aquatic educator to know how to teach swimming without necessarily being a high-performance athlete, it is not necessary to become a professional singer, but it is necessary to know how to use one's voice.

In a MAMI class, voice qualities such as tone and intensity will be available to the aquatic educator, who will identify them in their students. It will be an emotional musical connection where their voices (spoken or sung) will guide them in the musical proposal they will emit with their voice, with or without the support of instruments, identifying the frequencies/tones in aquatic education sessions that are



respectful of babies and their families in the voice of Mum and/or Dad, or, failing that, the carer as the primary attachment figure, that of a child or group of children, that of a neurodivergent child or a child with a disability, or that of any of their students of other ages. The aquatic educator may emit their voice at the same frequency/tone or at frequencies/tones of harmonic voices that may be in a minor or major octave, considering the abilities and good health of their vocal organ. To this end, they may find free digital tools such as [EarMaster](#), among others, to engage in their vocal knowledge.



Principle 1. Rhythmic problem → motor search → cooperative solution

Presenting a rhythmic problem (e.g., two short beats and one long beat) and asking children to respond with an appropriate motor gesture (such as diving-turning-emerging) is a strategy that integrates problem solving, motor creativity, and cooperation. According to musical neuroscience, rhythmic patterns act as temporal scaffolds that structure motor action. In addition, problem-guided motor learning encourages exploration and decision-making, key skills for transfer and adaptation. This dynamic promotes the active construction of motor knowledge, encourages social interaction and enhances intrinsic motivation, as children participate in the search for solutions and do not just imitate models.

Principle 2. Sung interrogative feedback

The use of sung instructions, such as “What would you do if the wave speeds up?” in 6/8 time, introduces elements of musical prosody into pedagogical feedback. This musicalised language not only captures the learner's attention more effectively but also promotes understanding of complex instructions and their encoding in memory. Unlike direct instruction, feedback in the form of a sung question promotes reflection, critical thinking, and autonomous decision-making. By becoming a multisensory stimulus, this technique helps to maintain sustained attention and strengthen active participation.

In neurodivergent and/or disabled populations, the rhythm, tone, intensity and melody of the voice take on special relevance. Sung interrogative feedback can be interpreted through emotional or motor responses, whether verbal or non-verbal, such as gestures, sounds, expressions or movements. Therefore, the aquatic educator must anticipate each proposal with rhymes or slogans at the appropriate frequency, generating a

sensitive and effective connection with the student. In this context, their role is not limited to directing, but also to observing, interpreting and offering positive feedback, accompanying the learner's process of discovery, as proposed by the CAM approach (Moreno-Murcia, 2023).

Principle 3. Variability of practice



Once this basis for sound and emotional interaction has been established, constant variation in tone, tempo and metre becomes a key tool for avoiding premature automation and stimulating motor adaptation. Introducing changes not only maintains interest and motivation but also

exposes learners to new conditions, promoting flexible and creative responses. In the aquatic environment, where each situation requires different adjustments, this variability strengthens neural plasticity and tactical versatility.

In addition, it allows the aquatic educator to identify, through observation of responses, which rhythms or frequencies generate the greatest connection with their learners, facilitating a more personalised and meaningful practice. Thus, a dynamic and enriching learning experience is fostered, in tune with the needs and potential of each participant.

Principle 4. Increasing autonomy and accessibility

The incorporation of floating buttons that emit musical loops (repetitive sound patterns) colour-coded according to their level of difficulty, promotes the development of autonomy and self-regulation in the aquatic environment. According to the literature on self-directed learning and motivation, offering choices and allowing students to make decisions increases their engagement, reinforces their sense of competence, and encourages more active participation.

In addition, the accessibility of these musical resources allows the complexity and workload to be adjusted to the individual and collective characteristics of the group. This approach not only promotes inclusion by giving each child the opportunity to choose challenges according to their abilities, but also encourages shared responsibility in the learning process, enhancing cooperation, self-reflection and the construction of a meaningful experience for all.

Example of a MAMI class

Proposal for a MAMI class for a group of children aged between 5 and 7, lasting between 45 and 50 minutes. The main aim is to promote auditory discrimination, stimulation and sensory regulation.

Narrative warming-up (10 min). Initial greeting song with body percussion in a circle (Hello water) with 3 tone changes and 3 different rhythms, from a low frequency (C), intermediate (E), and higher (G), or in major scale intervals integrated into a natural vocal range for male or female voices, considering the auditory discrimination perception of the educator. All songs and musical activities in the class can maintain the changes in tone and rhythm.

Movements with jumps in shallow water (Rabbit round) where they will stand, changing direction and forming various figures. Each learner defines their number of jumps between 1 and 10. Once their turn is over, the bubbles (according to their ability and perception) determine the change of direction or figure suggested by the song. Guiding question: How do your bubbles sound when the rabbit stops? Is it easy for you to change direction?

Phase I: Understanding (15 min). A children's water orchestra is formed, where each child chooses a musical instrument that they imagine playing and imitates the sound with their voice. One at a time or in pairs, they will walk and play their instrument without stopping on a floating mat from the edge of the pool and jump off at the end to play their song in the water, which they perform on their platform. The learner will identify the exit point from the pool, which is at a distance estimated by the aquatic educator based on their abilities, and this will be the ladder to climb back onto the stage (starting point at the edge of the pool) to move towards it by jumping or kicking.

Phase II: Solution (15 min). A tactical karaoke is proposed, which consists of completing a sound pattern by inventing the manoeuvre in changes of floating mats (The Sailor Dances) where each child chooses the name of a part of the body that will be part of the song, sings, dances, and at the end indicates the change of floating island, which will be separated from each other by 1 or 2 metres in a closed figure (circle, square, triangle), as well as the direction in which they will jump and move.




Phase III: Consolidation (5 min). Each child chooses a partner. Floating mats are arranged in a line parallel to the edge of the pool where the learners will be, at a safe distance according to their competence and abilities. Each pair defines 4 or 8 gesture-music bars to teach the group so that their classmates can imitate them. Using the proposed gesture-music, they must reach the floating island where they will be rescued




and interviewed by the centre's news programme to find out how they managed to save themselves. The activity will be repeated in the opposite direction with a floating island (mat) at the edge of the pool, with a new partner in cooperative practice.


Closing (5 min). Safety mantra-song and reflection on when they will apply what they have learnt outside the pool ("I'm going into the water with Mom, I'm going into the water with Dad, I can't be alone, I must always swim safely"). Farewell song (Bye-bye water) where each learner says goodbye to their partner by name and with a gesture of their choice, or the educator suggests a hand touch, fist bump, double hand, foot, double foot, laugh, whatever the creativity and imagination of the learners and the educator come up with.

Task proposals

Hereunder, we share a set of example tasks that include an illustrative image, a description of their development and an explanation of their pedagogical relevance.

Task	Development	Importance
Exploration of the learner's auditory discrimination. 	Musical instruments or elements (such as bells, sound tubes, water xylophones, or other objects that generate different tones) are available to allow the learner to freely experiment with sounds organised in a musical scale. The aquatic educator will carefully observe the spontaneous emotional or motor responses produced by each auditory stimulus, identifying those to which the child responds most assertively or receptively. Based on this observation, a pedagogical proposal will be designed that may include motor songs, rhymes, or mantras adapted to the frequency/tone that generated the sensory connection. This adaptation allows for effective non-verbal communication through music, emotionally integrating the learner into the aquatic environment.	This task is key to establishing meaningful sensory communication with the learner, especially in neurodivergent or functionally diverse populations, where responses to sound stimuli can be highly individualised. Auditory discrimination not only promotes sensory integration but also lays the foundation for more effective and empathetic interventions in the aquatic environment. The conscious use of tone facilitates emotional access to learning, strengthens the bond with the educator, and improves receptivity to the motor and musical activities that are developed later in the session.
Musical stimulation with the voice in immersion for neurodivergent people or those with different abilities.	The aquatic educator uses their own voice as an instrument to produce simple musical stimuli (motor songs, sung stories, vocal improvisations, onomatopoeia, nasal resonances, etc.) outside the water and then inside it, in immersion. The key is to identify the tone or frequency to which the learner responds positively. Based on this	The human voice is one of the most significant auditory stimuli from early stages of development, and it takes on special relevance when working with neurodivergent or functionally diverse individuals. In the aquatic environment, where the sensory surroundings amplify

	<p>identification, a personalised musical experience is built, which may include progressive changes in rhythm, starting with slow tempos and ending with a return to calm, integrated with water games. This methodology allows complete sensory stimulation that is emotionally safe, especially if the learner begins to enjoy reproducing or anticipating the songs.</p>	<p>perception, the intentional use of the voice while submerged can help establish emotional connection, promote self-regulation, and encourage movement integration. In addition, adapting musicality to the tone that generates a positive response allows the educator to modulate the learning experience according to the learner's sensory needs, creating a more accessible, respectful, and effective environment.</p>
<p>Percussive rhythms alternation.</p> 	<p>Create musical patterns with rhythm changes using parts of the body that the learners can suggest (hands, feet, elbows, hips, forearms, knees) using any material that generates sound as if it were a percussion instrument, accompanied by a song that the group performs in different rhythms suggested by the educator to stimulate or calm the session.</p>	<p>Rhythm is incorporated into the baby's neurodevelopmental process from the stage of gestation, through the mother's heartbeat, changes in her voice in daily communication, and her breathing, among other factors, and therefore influences the natural emotions of the baby.</p>
<p>Song while floating on the back.</p> 	<p>The song is chosen according to the frequency/tone at which the aquatic educator "connects" with the child, in a floating position on the back with or without floating support (tubular float, adapted floating mat, board), performing rocking movements and gentle stretching. The child must adapt to the environment, tolerating water in their ears, head or face, always under constant supervision of their response. The reflection of the child and the CAM aquatic educator aim to achieve greater joint range, reduction of hypertonia, non-verbal or verbal communication, language stimulation, socialisation and emotional well-being, among other things. Example of a song (modified Baby Shark), "So let's float! Du, du, du, du, du, du... faster! Du, du...", the name of each child can be incorporated, and the educator's creativity is the limit.</p>	<p>The aquatic educator takes advantage of the benefits of dorsal flotation in accordance with proven hydrotherapy exercises in this position, which have been shown to improve muscle tone, coordination, and overall relaxation (Fragala-Pinkman et al., 2008), as well as breathing patterns and muscle asymmetries, among other things (Kelly & Darah, 2005). In neurotypical populations, this same task is fundamental in achieving this skill autonomously, competently, and socially, performing it in a group with the same song sung by the aquatic educator and the learners, modifying the lyrics of the song to incorporate dorsal propulsion.</p>
<p>Session with babies aged 0-36 months, identification of</p>	<p>Together with the accompanying adult, the aquatic educator will</p>	<p>In a group class, it is important for the aquatic</p>

<p>Mum's or dad's tone/frequency</p> 	<p>identify the tone/frequency of Mum, Dad or the accompanying adult (auditory discrimination) from the moment they are welcomed. This takes place before entering the water, without asking questions beforehand or requesting that they speak or sing to identify them. It is something that should be done naturally, just as when everyone hears their favourite song on the radio, they get excited and show it. It is this analogy that the aquatic educator, especially the CAM, will apply to start their session with their voice or with the support of musical instruments</p>	<p>educator to understand the frequencies within the lines of the pentagram (E, F, approx. 250 Hz to 4,000 Hz), which are the ones that babies can distinguish from the prenatal stages (Olsho, 1984). Therefore, they can adjust their songs during the session within that range with changes in rhythm and voice intensity.</p>
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Conclusion



The MAMI proposal reaffirms the value of integrating music, particularly the voice as a pedagogical tool, into aquatic teaching from a respectful, inclusive and learner-centred approach. Its incorporation into CAM can not only enrich motor, cognitive and socio-emotional processes, but also allow the educational experience to be adapted to the diversity of abilities, rhythms and needs present in the aquatic environment.

The conscious use of rhythm, prosody and vocal expression contributes to a greater connection between educator and learner, facilitates sensory and emotional regulation, and makes each session a meaningful experience. By promoting autonomy, creativity, cooperation and active participation, MAMI establishes itself as a pedagogical tool that structures, accompanies and enhances learning through sound art in the water.

In short, MAMI is not only an innovative proposal, but also an invitation to transform aquatic teaching into a lively, sensitive and accessible experience for all children and realities, where movement, music and respect intertwine in harmony.

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