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AQUATIC ACTIVITIES

EDUCATING IN WATER: THE THREE EXECUTIVE FUNCTIONS THAT STRENGTHEN LEARNING

Juan Antonio Moreno Murcia

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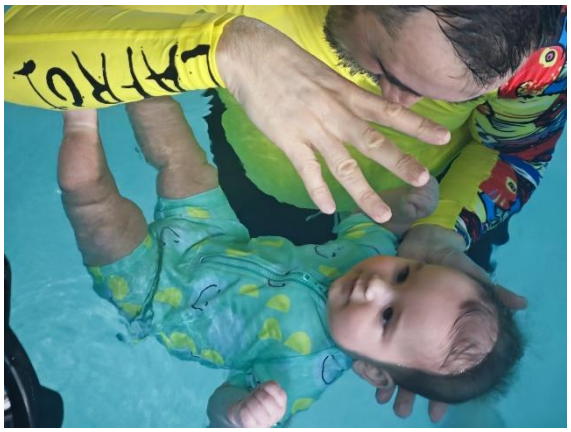
Executive functions are essential in the water because they enable children to control impulses, maintain attention, and follow instructions in a stimulating environment. They promote safety, facilitate technical learning, and help regulate emotions such as fear or excitement, making the aquatic experience more conscious and effective.

Introduction



In the context of child development, motor skills and executive functions form an essential combination for learning, self-control and social participation. Although their influence has traditionally been analysed in school or land-based sports environments, the aquatic environment represents a unique setting where these skills take on even greater relevance. In particular, motor inhibition, a key component of executive function, is a determining factor in children's safety, technical learning, and emotional self-regulation during aquatic activities (Chichinina et al., 2025).

From a neuroevolutionary perspective, behavioural inhibition is based on the progressive maturation of the prefrontal cortex, a region of the brain located behind the forehead that is responsible for impulse control, attention and planning. Between the ages of three and six, this area undergoes a period of particular plasticity, in which motor, emotional and social experiences contribute decisively to its functional development. The aquatic environment, due to its novel and multisensory nature, offers a unique opportunity to stimulate this maturation through experiences that require adjusting behaviour, waiting, stopping action, or responding in a controlled manner to changing stimuli.

Recent research suggests that aquatic programmes can have a positive impact on both inhibitory control and motor performance, not only in children without pathologies, but also in populations with developmental challenges, such as ADHD or cerebral palsy (Chang et al., 2014; Thorpe, Reilly, & Casebolt, 2005).

Therefore, the objective of this resource is to analyse the importance of executive functions in the context of aquatic education for children and to propose practical activities to stimulate this skill in this age group.

Why should aquatic educators care about executive functions?

Incorporating executive functions into lessons improves safety and accelerates learning because it trains children to wait, pay attention and curb impulses in a highly stimulating environment. In addition, understanding these functions helps educators interpret common behaviours (impulsivity, mental blocks, difficulty following instructions) and better adjust tasks, signals, and practice times.

Executive functions matter because they directly contribute to **water safety**: a child who knows how to wait, stop, or pay attention to a clear signal significantly reduces risks. They also **facilitate technical learning**, as working memory and sustained attention allow instructions to be retained, sequenced and executed more effectively. In addition, when children train their inhibitory control, **impulsive behaviours** such as jumping without permission, moving abruptly or losing concentration in response to any stimulus **are reduced**. All of this results in more fluid classes, with fewer interruptions and more consistent progress for the whole group.

Executive functions also play a role in **emotional management**, especially in an environment that can generate both excitement and insecurity. A child who can regulate their breathing, wait their turn or control their impulses will also be able to cope with fear, frustration or euphoria with greater balance. As a result of all this, among other things, classes become more stable, organised and effective. Understanding and applying these principles not only improves the quality of teaching, but also enhances children's autonomy, safety and enjoyment in the water.

Executive functions: working memory, cognitive flexibility, and inhibitory control

Executive functions are higher-order cognitive processes involved in the self-regulation of behaviour, thought, and movement, especially in new or non-automated situations (Diamond, 2013; Geuze & Boonstra, 2012). According to the classic model by Miyake et al. (2000), three main functions are recognised: working memory, cognitive flexibility and inhibition.

Working memory. Working memory is essential for **retaining and applying instructions** in movement sequences, such as coordinating breathing with leg movement. In aquatic teaching, this memory allows the participant to **integrate sensory and motor information in real time**, facilitating task comprehension and continuous improvement. Without adequate working memory, the learner may quickly forget the steps or fail to understand the logic of

the movement, hindering their progress.

Cognitive flexibility. The aquatic environment is dynamic and ever-changing. Cognitive flexibility allows learners to **adapt to new sensations, changes in depth, temperature or speed**, and to **modify movement strategies** according to environmental conditions or the instructor's instructions. In addition, this function encourages **motor creativity and problem-solving**, essential qualities in aquatic activities.

Inhibitory control. In an aquatic environment, inhibitory control allows learners to **regulate their impulses and maintain their attention** on the teacher's instructions, avoiding distractions or automatic reactions to the fear or euphoria that water can generate. For example, a child learning to float needs to inhibit the impulse to move constantly and trust the instructor's directions. Developing this ability promotes **emotional and motor self-control**, key aspects for safety and progression in the acquisition of aquatic competence. Within the latter, three types can be distinguished:

- **Perceptual inhibition:** avoids distraction by irrelevant stimuli. For example, a child is performing a task involving moving a board and must follow the line at the bottom of the pool while other children play and splash water around them. To achieve their goal, they must ignore irrelevant visual and auditory stimuli and keep their attention on the instructions given by the teacher.
- **Cognitive inhibition:** filters unnecessary information from working memory. For example, during a game of "Water Traffic Lights," the child learned that red meant stop, but in a new round, the educator changes the rules: now red means slow down. The child must suppress the previous rule in their working memory and adapt to the new instruction without getting confused.
- **Behavioural or motor inhibition:** stops impulsive, overbearing responses (Geuze & Boonstra, 2012). For example, in an activity involving jumping from the edge, the child must wait for the educator to call their name before jumping, even though they see other children doing so first. This involves controlling the impulse to act without authorisation and maintaining an active waiting posture.

The study by Chichinina et al. (2025) shows that motor inhibition is a robust predictor of overall motor competence, particularly in tasks involving fine control, such as manual dexterity. In the aquatic environment, this skill translates into the ability to regulate movement with precision, conserve energy, avoid unnecessary movements, and maintain body control in the face of fluctuating stimuli.

Table 1 below clearly and practically summarises what executive functions are and how they manifest themselves during aquatic teaching. It is a quick tool for educators to identify what to work on in each session.

Table 1. Executive functions in the water: a quick guide for aquatic educators.

Executive function	What does it mean?	What does it look like in the water?	How do we train it?
Working memory	Ability to remember and use short instructions while acting.	The child remembers the sequence: breathe → submerge → float → kick. They do not get lost halfway through the task.	Using brief instructions (max. 7 words), repeating short sequences and establishing rhythms ("kick-soft, kick-soft-kick hard").
Cognitive flexibility	Adapt to changes in rules, pace or instructions without becoming frustrated	Does not freeze up if the activity changes; accepts new rules in games such as "water traffic lights".	Gradually change rules, vary the pace, and introduce new challenges ("now blue means hide").
Motor inhibition	Controlling impulses: waiting, stopping, not acting prematurely.	The child waits their turn, does not jump without permission, and stays still while floating.	With clear signals (visual or tactile), active waiting games, and stopping with sensory cues ("when I touch your shoulder, you jump").
Perceptual inhibition	Ignore irrelevant stimuli from the environment.	Keep your eyes on the baseline, even if others splash or talk.	Use focal points ("look at the baseline"), reducing distractions at key moments.
Cognitive inhibition	Suppress old information to follow a new rule.	Accept that "red now means move," even though it used to mean something else.	Games with changing rules, instructions that require updating memory ("today green means float").

The learning process in the aquatic environment

Learning in the aquatic environment is not solely a motor skill issue; above all, it is a process of **cognitive and emotional regulation** in which **executive functions** play a central role. Each experience in the water activates a continuous cycle of perception, attention, memory, control and interpretation, through which the child transforms sensory experience into bodily knowledge and confidence.

It all begins with the **aquatic environment**, a space rich in visual, auditory, tactile and proprioceptive stimuli. Buoyancy, water resistance and the absence of stable references create a novel situation that requires an attentive and controlled response. In this context, **attention** acts as a filter: the child selects relevant stimuli (the educator's voice, visual cues or the sensation of balance) and suppresses distractions such as splashes or noises. Only through this initial focus is it possible to process information and give way to conscious action.

Once attention is activated, **working memory** comes into play, allowing short-term motor instructions to be retained and manipulated. This function enables the child to remember sequences of actions such as "inhale, submerge, float, propel, etc" and execute them in a coordinated manner. Without this active memory, the movements would lack coherence and understanding of the task would be disrupted.

At the same time, **inhibitory control** plays a decisive role. This function allows children to regulate their impulses, remain calm in the face of unexpected stimuli, and stop automatic responses that could compromise their safety. For example, inhibiting the impulse to move

suddenly when feeling water on their face or waiting for the teacher's signal before jumping into the water. This control supports the emotional and physical stability necessary for working memory to function effectively.

From this basis of regulation, **cognitive flexibility** comes into play, allowing children to adapt their motor strategies to changing environmental conditions. Adjusting breathing if the water is colder, modifying the rhythm of kicks according to depth, or adapting to new rules during a water game are examples of this process of constant adaptation. This function promotes creativity, problem-solving, and understanding of the body in interaction with the environment.

The aquatic environment: a setting for self-regulation and safety

The aquatic environment is an exceptional setting for the development of emotional self-regulation, as the physical properties of water (buoyancy, resistance, hydrostatic pressure and loss of visual references, both in natural and artificial environments) force the practitioner to continuously adjust their behaviour, muscle tone and emotional balance. In this context, **executive functions**, and **motor inhibition** in particular, act as essential mechanisms for safety and learning.

Scientific evidence supports this relationship. Stein et al. (2017) showed that increased motor difficulty increases the demand for executive control, while Maurer and Roebers (2019) emphasised that complex motor tasks require precise planning and the suppression of automatic impulses. In the aquatic environment, these demands are amplified: maintaining buoyancy, pacing oneself, or controlling breathing involves inhibiting unnecessary movements and remaining calm in the face of changing stimuli, such as a current, a wave, or losing one's footing.

Thus, the aquatic environment can be considered a **natural laboratory for self-regulation**. Each motor action (waiting for one's turn, staying afloat, or diving) requires the child to modulate their energy, anticipate consequences, and maintain attention on the instructor's instructions. In this process, **motor inhibition** not only drives technical progress but also becomes a vital tool for aquatic safety. Children who lack adequate inhibitory control tend to act impulsively (jumping without waiting for the command or becoming agitated upon contact with the water), which not only hinders learning but also increases the risk of accidents.

In contrast, programmes that integrate strategies to deliberately train motor inhibition (such as active waiting games, postural control or selective attention) encourage learning that goes beyond the physical. Children learn to **self-regulate their behaviour before, during and after movement**, achieving harmony between emotion, body and thought. Studies such as that by Chang et al. (2014) show that aquatic programmes with coordination and control components significantly improve behavioural inhibition, even in children with ADHD, strengthening executive function and motor autonomy. In these cases, it is essential to use **highly visible and consistent rules**, offer **shorter and clearer sequences of action**, and use visual aids such as coloured cards, pictograms or gestural signals to facilitate understanding. It is also advisable to **reduce distractions** during key moments (such as dives, jumps or movements) to promote attention and inhibitory control.

In short, the **aquatic environment is not only a space for motor skills practice**, but also a privileged context for **training self-regulation, attention and self-control**. Through play, exploration and the educator's instructions, children learn to think before acting, to remain calm in the face of uncertainty and to integrate thought, emotion and action. This convergence of cognition, emotion and movement forms the basis for safe, **conscious and meaningful aquatic learning**.

Play is a natural and highly effective way to train behavioural inhibition and self-regulation in childhood. Playing involves exploring, repeating and adjusting actions within a framework of rules, allowing children to continually practise their ability to stop, wait or modify an impulsive response. During these playful experiences, the child's brain "practises" the function of

putting on the brakes, strengthening the prefrontal circuits responsible for self-control. For this reason, games in the aquatic environment represent a particularly powerful form of learning, as they combine sensory stimulation, emotional experience and motor regulation in a motivating and safe context. The activities presented below transfer this playful principle to the aquatic environment, using play as a pedagogical vehicle to train inhibitory control and sustained attention.

Methodological guidelines for implementing tasks in the aquatic environment

In order for tasks designed to train executive functions to be truly effective in the aquatic environment, it is necessary to consider certain methodological criteria that guide their application. Firstly, **each task** should be short and tailored to the children's attention span: between **3 and 6 minutes** is usually the ideal interval to maintain motivation and avoid cognitive fatigue. Tasks that are too long tend to lose executive intensity and lead to impulsive behaviour or disorganisation within the group.

Similarly, it is advisable to work with **3 to 5 repetitions per activity**, leaving small intervals between them to facilitate emotional and motor recovery. Repetition allows for the consolidation of inhibitory control and focused attention, but always within a dynamic play framework to maintain the child's engagement.

Another key aspect is the **progression in difficulty**, which should be structured gradually. At an **initial level**, simple signals and stable rules are used, such as a single visual or auditory cue to stop or move forward. At an **intermediate level**, two signals or rules are incorporated that require updating working memory and adjusting the response. Then, at an **advanced level**, unexpected changes, variations in rhythm or quick decisions are introduced, thus promoting cognitive flexibility and the transfer of what has been learned to real-life aquatic situations.

Progress can be assessed through systematic observation of key behaviours linked to motor inhibition. Some useful indicators are **how quickly the child stops the action when given a signal**, the **number of uncontrolled impulses** (such as jumping ahead), their **ability to adapt to changing rules**, **actively waiting their turn without continuous supervision**, and **postural stability, for example, while floating**. This continuous observation acts as a small **"executive check-up"** that allows for the assessment of the evolution of self-control in the aquatic

environment.

Proposed tasks for developing motor inhibition in the aquatic environment

Below are some examples of tasks designed to stimulate motor inhibition in young children (Table 2). These activities can be motivating and also introduce a cognitive and executive structure that reinforces the ability to control movement, which is directly related to aquatic competence.

Conclusion

Current research reinforces the importance of considering the aquatic environment as a privileged space for the development of **executive functions**, especially motor inhibition, both in typical children and in populations with attentional or neuromotor difficulties. The study by Chichinina et al. (2025) confirms that motor inhibition predicts overall motor competence, while research such as that by Chang et al. (2014) shows that aquatic programmes can significantly improve inhibitory control in children with ADHD. Furthermore, the clinical literature (Geuze & Boonstra, 2012; Thorpe et al., 2005) supports the effectiveness of water as a therapeutic tool in complex motor and cognitive contexts.

It is important to remember that the development of motor inhibition is a gradual process that requires time, practice, and repeated experiences in emotionally positive environments. Just as children learn to slow down before acting in symbolic play or everyday activities, in the aquatic environment this skill is built through **repetition of instructions, active waiting, and the enjoyable experience of controlled movement**. The educator's patience and consistency in practice are essential to consolidating progress. The more children enjoy the activities, the more opportunities they will have to strengthen their self-regulation without perceiving it as an effort, integrating emotional and motor control in a natural and lasting way.

For the aquatic educator, these guidelines not only improve safety and learning but also allow for **more fluid, predictable, and emotionally balanced classes**. Integrating small executive routines into each activity transforms teaching in the aquatic environment into a space for self-regulation, confidence, and autonomy.

Table 2. Tasks designed to stimulate motor inhibition in early childhood.

Situation	Recommended wording	Variant for 3–4-year-olds	Variant for 5–6-year-olds	Executive function	Typical educator's mistake	Recommended correction
1. Wait before jumping	"Count with me: 1... 2... 3... and when I touch your shoulder, jump."	"When I raise my hand, jump. If it's down, freeze."	"Hand up = jump; hand to the side = crouch."	Motor inhibition. Sustained attention.	"Don't jump yet!" "Wait!"	Give a specific signal: "You jump only when I touch your shoulder."
2. Movement control during displacement	"Look at the bottom line and follow this rhythm: kick-soft, kick-soft... If you hear me clap, stop for a second."	"Sleeping feet... now wake up. (Clap = wake up)."	"Turtle rhythm/dolphin rhythm. Change when I say the animal."	Working memory. Selective inhibition.	"Don't get distracted!" "Don't look at the others!"	Focus signal: "Look at the bottom line and follow my rhythm."
3. Changing rules in water games	"Red = stop; green = return to the edge."	"Red = stop. Green = move."	"Red = move forward. Green = stop. Blue = hide underwater."	Cognitive flexibility. Updating rules.	Changing rules without warning; long instructions.	Introduce the change explicitly: "Now we're playing with new rules...
4. Wetting your face and blowing bubbles without pulling away	"Look at my hand. On the count of three, blow bubbles... and then breathe slowly."	"Bubbles to wake up the fish."	"Blow hard for 2 seconds, softly for 3 seconds. I'll set the pace."	Emotional inhibition. Breathing control.	"Don't be afraid!" "It's okay!"	Give specific instructions: "Blow bubbles with me... one, two, three."
5. Float without moving	"Big frozen star. If you hear me whistle, little star."	"You are a sleeping star. Don't wake up until I touch the water."	"Big/little star. Change with the whistle."	Postural inhibition. Selective attention.	"Stay still!" "Don't move so much!"	Clear signal: "Freeze like a star. I'll let you know when to change."

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