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Application of ecological dynamics principles to drowning prevention

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ABSTRACT

Drowning has been identified as the cause of over 2.5 million preventable deaths globally in the past decade. Lower- and middle-income countries in Asia have recorded the highest numbers of drowning worldwide and children seem particularly vulnerable. Drowning is a complex phenomenon informed by multiple interacting factors, and the majority of deaths occur in natural environments such as ponds, ditches, rivers and oceans. Any potential drowning prevention strategy should acknowledge the important relationships that are created between individuals and their environment in water safety education. In this article, we share how the ecological dynamics theoretical perspective can help inform our understanding of drowning prevention. First, we review recent drowning prevention recommendations provided by the World Health Organization (WHO). Next, we discuss how well WHO's recommendations align with the principles of ecological dynamics. It is acknowledged that in many Asian countries, there are considerable challenges to delivering WHO's drowning prevention interventions. Teaching children basic swimming, water safety and self-rescue skills remains the most practical means to prevent drowning. The relevant scale of analysis for understanding behaviour is the individual-environment relationship. Specifically, the relative fit between these components may dictate how well water safety skills are learnt. Considerations such as installing barriers and adequate supervision around water can be scaffolded alongside an understanding of affordances in the context of water safety. We conclude that water safety education informed by an ecological dynamics approach is an effective partnership to help tackle the drowning pandemic.

1. Drowning: a global pandemic rampant in Asia

Whilst the Covid-19 pandemic has dominated the world's attention in recent times, another under-recognised, yet deadly pandemic continues to be a significant global problem: drowning. It has been identified as the cause of over 2.5 million preventable deaths in the past decade worldwide. Accordingly drowning prevention was recognized as one of the key challenges in the United Nation's commitment to achieve global economic, social and environmentally sustainable development (United Nations General Assembly, 2021). Every hour, over 40 people lose their lives to drowning and over 91% of deaths occur in low-and middle-income countries (World Health Organisation, 2014). According to the World Health Organisation's (WHO) global report on drowning (World Health Organisation, 2014), Asia is the continent that reports the highest numbers of drowning deaths (United Nations General Assembly, 2021). For example, in the Western Pacific (WP) region, 74,075 people drowned in 2019, which is the highest number of deaths in all regions of the globe (World Health Organisation, 2021). This toll is closely followed by the number of drowning deaths in the South-East Asia (SEA) region (70,034 deaths in 2019) (World Health Organisation, 2021).

Although floods and natural disasters have increasingly affected millions of people around the world due to the growing impacts of climate change (United Nations General Assembly, 2021), such events are not one of the main causes for drowning in Asia (Linnan et al., 2022). In low- and middle-income countries (LMICs) drowning occurs predominantly in natural waterways such as ponds, lakes, rivers, canals and oceans (Franklin et al., 2020). Compared to western countries, younger people are at a higher risk of drowning in Asia (World Health Organisation, 2021). Notably, almost two thirds of the world's children live in LMICs in Asia (Linnan et al., 2022). The majority of drowning deaths amongst children happen during daily activities, when they are often unsupervised in rural areas close to their homes (Linnan et al., 2022). Given the abundance of natural waterways in many Asian countries it is estimated that close to a quarter of the world's population are exposed to the risk of drowning on a regular basis.

Drowning is a complex phenomenon and rates vary considerably between countries in Asia. For example, the drowning rate per 100,000 inhabitants ranges from as low as 0.4 in Singapore up to 7.5 in Laos. While drowning rates in high-income countries as classified by WHO (e.g., Japan, Korea, Singapore) are typically low (14% average in WP, 45% in SEA), they are often high in low-income countries such as Cambodia,

Abbreviation: LMIC, Lower- and Middle Income Countries; SEA, South East Asia; WHO, World Health Organisation; WP, Western Pacific.

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Fig. 1. Photos contrasting swimming education in high- (left) vs low-income (right) countries. Images reproduced with permission from World Health Organisation (2014) (p.24).

Fig. 1. Continued

Mongolia, Vietnam (53% average in WP, 55% in SEA) (World Health Organisation, 2021). In fact, these differences are likely even greater in reality, as drownings are notoriously under-reported in lower-income countries (e.g., due to difficulties with measuring mortality outside health facilities (World Health Organisation, 2021). The relative wealth of a country is also likely to influence swimming participation and how water skills are learnt (Fig. 1). A range of factors such as the quality of education and availability of swimming pools influence the likelihood of children receiving formal swimming education (Hastings et al., 2006; Leavy et al., 2016). Poverty also influences other protective factors such as access to child supervision and quality health care. Therefore, it comes as little surprise that income statistics strongly influence the drowning rates in different countries.

Unlike a virus, there is no simple vaccine that can tackle the pandemic of drowning. The United Nations General Assembly recognized drowning as a leading cause of child mortality that “requires preventive measures, including awareness-raising” (United Nations General Assembly, 2021) (p.2). When considering childhood drowning and the development of water safety skills, it appears that a deep understanding of environmental, personal and social constraints acting upon those at risk is necessary. In this article, we share how an ecological dynamics (ED) theoretical perspective can help inform an understanding of drowning prevention. We will first present an overview of ten drowning prevention recommendations from recent WHO reports (World Health Organisation, 2014, 2017) and then go on to discuss their alignment with ED principles. We then summarize recent research adopting an ED lens on water safety. We focus our attention on two research case studies that investigated: (1) How infants and young children behave when located close to deep water, and (2) How children learn water safety skills taught in open water environments. Clearly drowning risks and prevention measures differ considerably by age. For clarity, and in line with WHO, in this article we define children of different ages as: infants (under 1 year old); young children (0–4 years old); children (0–14 years old), and young people (10–24 years old). We conclude that the WHO’s recommendations on how to reduce drowning can be implemented by practitioners alongside an ED approach to water safety policies and education.

2. Ten recommendations to prevent drowning

In 2014, the WHO published the first global report on drowning. The report listed some key risk factors for drowning, including poor awareness of water dangers, the lack of physical barriers to water bodies, inadequate child supervision, and poor swimming skills, amongst others. Such risk factors formed the basis of 10 recommendations for countries around the world to consider in helping to prevent drowning (see Fig. 2). This report was also significant as for the first time, WHO promoted that a multisectoral scaling-up of global efforts is needed to reduce the drowning burden.

The 2014 report was followed in 2017 with a call to action: the Implementation Guide for Drowning Prevention (World Health Organisation, 2017). The implementation guide re-categorised the 10 recommendations from 2014 into two sub-groups, consisting of four strategies (Fig. 2: Actions 1–4) and six interventions (Fig. 2: Actions 5 –10). Consistent with the 2014 global report, a ‘systems approach’ was apparent in the implementation guide as strategies and interventions were targeted from the individual, community and societal level through multiagency collaboration, policies and legislation.

Since the 2017 implementation guide, several regional reports have been published as status updates on drowning in the world regions as classified by World Health Organisation (2022). Despite the WHO recommendations, eight of the 11 regions did not report a significant reduction of drowning between 2014 and 2018 (World Health Organisation, 2021). As previously stated, the SEA region is one of the worst performing regions in terms of numbers of drowning (coming a close second to the WP region). There are numerous drowning risks listed in the SEA regional report including living near water, working or travelling by boat, recreation around water, bathing, collecting water and flooding disasters. Over half the drownings reported in this region were people aged 24 years old and below (World Health Organisation, 2017). The SEA status report (World Health Organisation, 2021) concluded that more work was required in terms of implementing effective drowning prevention in the region: “When developing a drowning prevention strategy, it is crucial to have a plan in place to ensure strategy endorsement. National drowning prevention strategies within the Region have stalled between development and endorsement, with their implementation blocked” (Pg. 48). Specific to the SEA region only one country (Indonesia) reported that swimming and water safety lessons had been legislated to appear in school curricula (Table 1). Seven countries (70%) from the SEA region reported that basic water safety and rescue skills were taught to school children, however details surrounding the programmes and the specific teaching approaches were not provided.

To summarise thus far, over the last decade the WHO have highlighted the global burden of drowning and provided 10 recommendations that countries should consider in their drowning prevention efforts. Emerging data from the SEA region suggests that many countries are struggling to implement the WHO recommendations effectively (World Health Organisation, 2021). We suggest that an important step is to consider how such recommendations align with contemporary motor learning principles. Next we explain why the ED framework can provide a robust scaffold to help different practitioners (e.g., politicians, plan-

Fig. 2. Recommended interventions and strategies from the WHO Implementation Guide for Drowning Prevention (World Health Organisation, 2017).

Table 1
List of SEA countries requiring swimming lessons in school curricula (10 out of 11 member states participated in WHO SEA regional status report (World Health Organisation, 2021).

Country	Legislation (Yes / No) and regulation rating on a scale of 1 (limited) – 10 (maximum)	Water safety and rescue available at school?
Bangladesh	Not specified	Yes
Bhutan	Not specified	No
Democratic People's Republic of Korea	Did not participate in status report	No response
India	No	No
Indonesia	Yes: 6 out of 10	Yes
Maldives	No	Yes
Myanmar	No	Yes
Nepal	No	Yes
Sri Lanka	No	Yes
Thailand	No	Yes
Timor Leste	Not specified	No

ners, teachers, lifeguards, caregivers, etc.) build their understanding of how to implement the WHO's recommendations within their specific contexts.

3. Do the WHO's actions for drowning prevention align with ecological dynamics principles?

We propose that the ED theoretical framework is appropriate to understand and implement drowning prevention measures. To explain why we advocate for ED, we first describe some key principles. The ED framework was formed within the field of motor learning through the fusion of complexity sciences, dynamical systems theory, and ecological psychology (Button et al., 2020b). A core concept is that human movement is an emergent phenomenon resulting from the interaction of constraints (variables in the environment, individual or task) in any given situation. The individual-environment relationship is fundamental and is continually adapted over time as a learner explores and discovers more effective and energy-efficient ways to move. Consider briefly how we learn to swim. A novice swimmer's movements at first may seem ungainly and lacking in coordination as they prioritise keeping their head above water to breathe. Inexperienced learners can find moving through the water very challenging and even quite stressful if their actions do not generate buoyancy. However, as people learn to swim, they may discover through exploration that a more streamlined position in the water helps them to move with less effort (by reducing drag). The so-called 'doggy-paddle' swimming technique that early learners often adopt is later replaced by purpose-fitted movement patterns such as freestyle or backstroke that allow learners to swim faster and for longer. As a learner becomes yet more skilled their actions are attuned to the energy flows around them and adapt seamlessly to subtle changes in the environment (e.g., turbulence and currents in the water). In colloquial terms, this process is often referred to as developing a better 'feel for the water'; in ED terms it is functionally varying their actions to fit their environment (Button et al., 2020b).

Another important ED principle we shall refer to is representative learning design. Brunswick (1954) originally proposed the ecological principle of representative design in relation to the design of psychology research studies which are intended to simulate an aspect of human behaviour. The better the representative design, the closer the match of an experimental environment to the aspect of behaviour it is simulating from the real-world. The goal of representative learning design is to match the constraints on the learner in practice activities to the constraints that are present in the situations in which the learner would like to recreate those practice skills. In other words, practice activities could be viewed as simulations of real-world situations. Thus, the simulated performance environment in practice needs to be high in action fidelity to improve the generality/transfer of learning. According to Pinder et al. (2011) to attain representative learning design: "practitioners should design dynamic interventions that consider interacting constraints on movement behaviours, adequately sample informational variables from the specific performance environments, and ensure the functional coupling between perception and action processes." (p. 151).

Hence, emergence of behaviour through constraints, the individual-environment relationship, skill adaptability and representative learning design are some key principles within the ED framework. Our inspiration for using ED principles to scaffold drowning prevention measures comes partly from the pioneering work of Langendorfer & Bruya (1995) whose book "*Aquatic Readiness: Developing Water Competence in Young Children*" remains one of the most influential and enduring publications in the water safety literature (Langendorfer, 2015). The book recognises how the dynamic range of constraints that act upon a learner may be used by practitioners to help children develop a broad range of water competencies. Thereby preparing children adequately for safe aquatic activity.

Before discussing the 10 WHO actions in turn, it seems important to first acknowledge and commend the multisectoral systems approach that WHO have used to highlight the complexity of drowning as a global problem. Margaret Chen – Director-General of WHO in 2014 – suggested that "[Drowning] has important intersections with a range of major agendas, including climate change; mass migration, asylum seekers; and child and adolescent health. The multisectoral nature of drowning prevention demands improved coordination across various agendas and sectors" (World Health Organisation, 2014) (p. iii). This statement dovetails well with the complexity sciences' philosophy that underpins the ED framework. Complexity science demands that we examine system behaviour holistically because the behaviour of the whole is much richer that the sum of the contribution of individual parts (Button et al., 2020b). Without the combined effort of a range of different organisations, systems, structures and people, it will be very difficult for WHO's call to action to be realised.

The first action from the 2017 implementation guide is to "Install barriers controlling access to water" (World Health Organisation, 2017). Similar to WHO, we reveal below in Case Study 1 how young children are particularly vulnerable in the absence of physical barriers to prevent them from entering the water. This recommendation links to the principle of information-movement coupling and specifically to the notion of affordances - or opportunities for action – that can *invite* different forms of behaviours to emerge (Withagen et al., 2017). The ecological psychologist Gibson (1979) recognised that animals perceive the world not in physical terms but in relation to affordances for action and that they can exploit environmental features like natural waterways to satisfy their own individual needs (such as to drink, wash, to cool down, or for transport). Accordingly, the first recommendation acknowledges the powerful attraction to water that animals – including humans - innately possess. At the same time, this innate attraction may place unsupervised, young children at risk of drowning without the skills and experience to cope when immersed in water. It is quite likely that children might associate water with opportunities to play or – particularly in hot, humid environments - to cool down, drink or wash themselves. However, what these enticing affordances may disguise is the risk of entering a body of water with unseen dangers that the individual is not physically prepared for. Errors in judging the relation between one's physical abilities and the demands of the situation have been suggested as an important factor contributing to accident risk (Cordovil et al., 2015). Architects and designers of aquatics facilities could potentially use an understanding of affordances to either invite safe behaviours and/or discourage risky behaviours from occurring.

Case Study 1. Young children's fatal attraction to water: Why controlling access is necessary.

Drowning has long been identified as the leading cause of unintentional deaths amongst young children worldwide (Peden et al., 2009). In fact, the highest drowning rates worldwide are amongst children 1–4 years of age (Franklin et al., 2020). Before acquiring self-locomotor capability (under 1 year of age) infants can drown in bathtubs inside the home (Peden et al., 2018). After gaining independent mobility, drowning occurs mostly in bodies of water around the home such as private swimming pools (in higher income countries) and ponds, lakes and dams elsewhere (Rahman et al., 2012). The WHO has suggested that young children are overrepresented in drowning statistics because they become "mobile but [are] too young to recognize danger or to get out of water" (World Health Organisation, 2014) (p.9).

Only recently have researchers begun to investigate how motor development changes behaviour close to water. In this case study, the ED approach was applied to investigate the relationship between young children's perceptual-motor development and their behaviour in risky environments (Anderson, 2018). Inspired by the classic 'Visual Cliff' paradigm (Gibson & Walk, 1960), Burnay & Cordovil (2016) created the Real Cliff / Water Cliff apparatus, comprising a platform that on one side has no protection from falling - the Real Cliff - and on the opposite side is a tub filled with water - the Water Cliff (see Fig. 3A and B). The behaviour of young children was examined once on each side. On both types of cliff, crawling experience was linked to avoidance behaviour. In other words, infants and young children with less crawling experience tended to fall on both cliffs while those with more crawling experience avoided the fall (Burnay et al., 2021a, 2021b). Interestingly, prior crawling experience informed avoidance behaviour even after they had learnt to walk (Burnay et al., 2021a, 2021b). These results confirmed the influence of locomotor experience on young children's avoidance of drop-offs (Campos et al., 2000; Kretch and Adolph, 2013) and, for the first-time, linked locomotor experience to their behaviour around bodies of water.

In a follow up study, Burnay et al. (2021c) investigated whether a sloped surface would influence the baby's behaviour differently to a sudden drop-off into water. The procedure was similar to the one used on the water cliff (see Fig. 4). Contrary to the effects observed on the water cliff, no effect of locomotor experience on babies' avoidance of deep water was observed on the water slope. While 70% of the babies demonstrated adaptive behaviour by avoiding falling from the water cliff (Burnay et al., 2021a), only 38% avoided deep water when on the water slope (Burnay et al., 2021c). The results indicated that babies behave differently around different types of entrances into water. Therefore, sloped and gradual entrances to bodies of water – common accessways to ponds, rivers and oceans - may increase babies' risk of drowning (Burnay et al., 2021c).

There is some evidence that after 2 years of age, babies can learn some swimming skills, but there is no evidence to suggest that a baby younger than 2 years old would survive independently for a prolonged period in the water (Taylor et al., 2020). Therefore, this case study provides support for WHO's recommendation to install barriers to control access to water for babies (Action 1). It also provides evidence around the importance of adequate supervision of young children (Action 2). This fascinating research has the potential to contribute to the development of new strategies to prevent drowning of young children. Future research could consider investigating the effect of early learn-to-swim programs on young children's behaviour around natural water bodies.

The second WHO action is to "Provide safe places away from water with capable child-care". Like the first action, this recommendation links to the ED principle of information-movement coupling reflecting how young children might be placed at risk if left unsupervised around water. In many LMICs parental or community surveillance for young children can be compromised which may result in unsupervised children being around water (Sansiritaweesook et al., 2015). Inadequate supervision might result from a number of factors when living in impoverished conditions such as parents needing to work for extended periods, large family sizes, and increased exposure to public waterways (i.e., for hygiene and essential daily living) (Hyder et al., 2008). Leavy et al. (2016) conducted a review of all drowning prevention interventions for children and young people with a focus on differences between the income of countries. They found that one of the most effective injury prevention strategies was child supervision. Furthermore, it was a low-cost, socially acceptable method to prevent drowning across all cultures. At a young age, children are still discovering their action boundaries or extent of their movement capacity, which will inevitably change as they mature (Guignard et al., 2020). Consequently, caregivers have an important role to play in designing and creating safe but stimulating environments that will occupy young children, help develop their movement competence

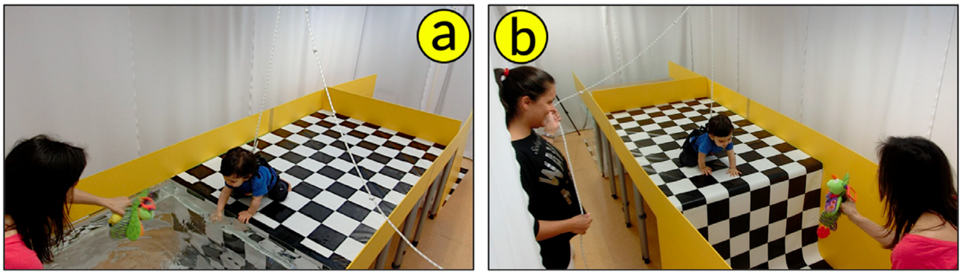

Fig. 3. Real cliff (a) and water cliff (b) experimental set-ups. Photos reproduced with the permission of the child's mother.

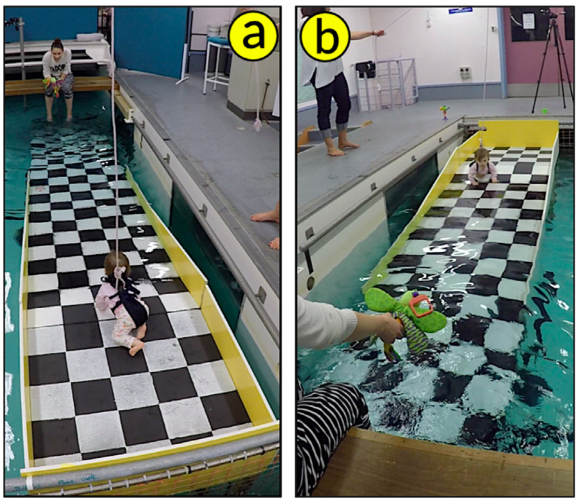

Fig. 4. Water slope experimental set-up front view (a) and back view (b). Photo reproduced with the permission of the childs mother.

which contributes to overall physical literacy, yet not expose them to unnecessary danger (Rudd et al., 2021). Therefore, this second WHO recommendation also invokes the principle of emergence of behaviour under the confluence of constraints. In the developed world, playcentres and nurseries may provide 'enriched' play environments (Rudd et al., 2020) for children but such facilities are not accessible or affordable for many people in low- and middle-income countries. In under-developed countries caregivers may need to consider innovative ways to create safe play environments within the natural environment. For example, by utilising shallow bodies of water like streams and ponds under supervision, caregivers can modify constraints to engineer an important balance between presenting affordances to play and teaching basic water safety skills with a relatively low level of risk.

The impoverished living conditions common to LMICs mean that the WHO actions 1 and 2 are unlikely to be universally implemented in the near future (Hyder et al., 2008). Hence, additional emphasis is placed upon the viability of the remaining recommendations in LMICs. The WHO recommended action with arguably the closest alignment to the ecological dynamics approach is: "Teach school-age children swimming and water safety skills". Indeed, this recommendation resonates strongly with several key ED principles such as information-movement coupling, skill adaptability, and representative learning design. Water safety education should develop foundational aquatic skills that individuals might need when finding themselves in a possible drowning scenario (Button, 2016; Stallman et al., 2017). Different aquatic skills such as floating, swimming and safe methods of entry/exit are potentially life-preserving, and they also help to promote engagement in different water environments. Careful consideration may be given to how learners can acquire the foundational aquatic skills that maybe transferable to different outdoor environments (Kjendlie et al., 2013). Teaching learners how to become competent swimmers in a variety of swimming strokes should not be considered as the sole primary focus for drowning prevention, but rather as complementary to situations designed to help learners to feel comfortable and adaptable in varied aquatic environments (Stallman et al., 2017).

The concept of representative learning design (Pinder et al., 2011) would support a shift towards teaching children in a range of aquatic environments to promote better transferable skills and knowledge (this issue resurfaces below in Case Study 2). Hence, it is important for educators to expose learners to the affordances typically present in an environment so that they can better appreciate such factors and how to adapt their movement patterns accordingly (Cordovil et al., 2015). For example, learning how to tread water as a water safety technique is ideal in natural open environments such as rivers, lakes and beaches. However, if access to these natural environments is limited and only stable environments such as swimming pools are accessible, practitioners could increase representativeness of the learning activity by creating some water surface turbulence with kickboards (Guignard et al., 2020).

Case Study 2. Water safety education – does the learning environment matter?

In high-income countries learners are typically taught to swim in comfortable, clear and calm aquatic environments (i.e., swimming pools) mainly for safety and logistical reasons (Button et al., 2020a). However, it is possible that learning to swim within the sheltered confines of a swimming pool creates a misplaced confidence in aquatic ability that does not transfer well to other aquatic environments (Guignard et al., 2020). For example, a child may believe that swimming 25 m in a pool equates to an ability to swim the same distance in an open-water environment such as the ocean. However, such comparisons are made invalid and potentially dangerous by numerous environmental factors that can change unpredictably (e.g., tide, current, water temperature). Open-water environments offer complex affordance niches (rich in behavioural opportunities) with currents that can move a swimmer away from or towards land, waves differing in height that can be avoided by diving or rising above them, multiple ambient temperatures, light or dark water, variable depths, and unseen submerged obstacles. In contrast, swimming pools typically offer a stable landscape of affordances with different opportunities for interaction (e.g., a clear volume of water with a regulated temperature and a calm, predictable surface). The implication is that swimming pools are sanitized, highly structured environments in which a learner is trained to utilise affordances in restricted ways and in a reproductive manner, which are primarily designed for early learners.

Recent research by Button et al. (2020a) had 98 children (7–11 years old) undergo a water safety education programme that included supervised practice sessions at harbour, river and beach environments (Fig. 5). Despite the brief duration of the education programme (3 days) the results demonstrated that most children significantly improved their aquatic competencies (i.e., both physical skills and safety knowledge) and retained them for up to 3 months later. Button et al. (2020a) contrasted their data with children of the same ages who were taught a similar programme in swimming pools. Results indicated that whilst similar levels of skill improvement were obtained, the retention of skills was superior amongst children taught in open water environments. Indeed, it appears that context matters and that education of aquatic skills to prevent drowning should consider exposing learners, especially the young

Fig. 5. Children participate in a beach education session in New Zealand (Button et al., 2020a). Photo reproduced with permission of all participants.

Table 2
List of swimming and water survival skills taught in the SwimSafe programme (Rahman et al., 2012).

Categories	Skills/Competencies
Breathing skills	• put face in water • submerge and blow bubbles • hold breath and exhale in submerged position
Swimming skills	• walk in the water • walk with arm pulling • float in the water with support • float in the water without support • kick by holding support • push and glide without support • push and glide with kick • kick and pull with instructor or kickboard support • kick, arm pull and breathing • push, glide, kick and arm pull
Survival competencies	• swim 25 m using any recognizable stroke • float for 30 s
Elementary rescue techniques	• be rescued with a pole • rescue others using pole and rope from edge of pond • rescue others by throwing floating objects

to open water environments where the majority of child drownings occur (approximately 80% (MacKay et al., 2016)). From this logic, pedagogical practice, learning and training are in need of radical change to help learners acquire “physical, cognitive, and affective competencies which together makes for water competent individuals who may be less susceptible to the risk of drowning” (Stallman et al., 2017) (p. 2).

The importance of the physical environment in teaching children swimming and water safety skill has been discussed by van Duijn et al. (2021). With environmental conditions being different across the globe, the aquatic skills and proficiencies of children are likely specific to different WHO regions and countries. One education programme that is recommended by WHO for countries to consider adopting is ‘SwimSafe’ which has been found to be effective in impacting water safety skills (Talab et al., 2016). The SwimSafe programme was originally developed in Bangladesh (Rahman et al., 2012) and subsequently implemented in a range of other Asian countries such as Thailand and Vietnam (World Health Organisation, 2017). The SwimSafe programmes includes 18–22 basic swimming and water survival skills (see Table 2) distributed across up to 20 lessons. The recommended ratio of instructor to students is 1:5.

The fourth WHO action also aligns with the concept of representative learning design: “Train bystanders in safe rescue and resuscitation”. This is an important action that, if realised, would see an increase in the number of competent people that can identify drowning incidents and act to prevent them from occurring. However, potential rescuers can place themselves and casualties in further danger if they do not recognise the risks, and if they have insufficient knowledge and skills to respond appropriately (Avramidis et al., 2009). Critically, educating learners to recognise key information sources can enable them to act quickly and safely (recall once more the ED principle of information-movement coupling). By way of a simple example, at the beach inexperienced swimmers tend to look to enter the ocean in calm, less wavy patches of water but these locations are often where strong rip currents are to be found that can drag people away from the shore. If more people were aware of the information sources that accompany dangers in open water environments it would help them to recognise an emergency unfolding and seek help. Practicing simulations of rescues are particularly valuable teaching activities as they can help protect both the rescuer and potential victim/s from drowning. When teaching learners to perform a rope throw to someone in the water from the side of a swimming pool, the ‘rescuer’ should be taught to get low to the ground before towing in the ‘victim’ to prevent getting pulled into the water themselves. An innovative programme implemented in Indonesia in 2018 called “Search and Rescue goes to school” aimed to educate and raise awareness on drowning prevention and early search and rescue activity through schools (World Health Organisation, 2017). At the end of the training, participants were able to respond in the event of a sudden disaster – either to rescue themselves or offer help to rescue others. Critically, it was noted that the teaching of water safety and rescue was conducted in natural settings such as at beaches and rivers, which from an ED perspective enhances representativeness (authenticity) in the learning context.

Each of the six strategies listed by the WHO (Fig. 2: Actions 5–10) require alignment and co-operation of numerous organisations including national and local politicians, schools, hospitals, rescue and support services (amongst others). These six strategies are less closely associated with the ED framework than the four actions discussed thus far. Nonetheless, they are each good examples of the nested layers of constraints (micro, meso and macro-levels) that are depicted within the ecological model of human development proposed by Bronfenbrenner (1977). Bronfenbrenner recognised that the development of any one individual person is influenced by a range of psychological, physical, cultural and societal factors and that a holistic perspective is essential for understanding the mechanisms underlying behavioural change. For example, action 5, "Strengthen public awareness and highlight the vulnerability of children", is suggestive of a sophisticated educational campaign targeting individuals, families, schools, communities and the nationwide population. While education of aquatic skills and water safety are critical areas that have been recommended as interventions to tackle drowning, the implementation guide (World Health Organisation, 2022a) does not yet provide details on pedagogical approaches that could be adopted to teach the various skills and competencies that are transferable from stable learning environments to open, dynamic natural environments where most drowning or near-drowning episodes are recorded. Indeed, there is a surprising lack of research in some of the most fundamental elements of water safety education such as the role of buoyancy aids and different practice environments (van Duijn et al., 2021). This void of knowledge is reflected well in the tenth WHO action: "Address priority research questions with well-designed studies" and has led Stallman et al. (2008) to lament that the field of aquatic skill learning desperately needs more evidence-based instruction tools and methods. Perhaps, Bronfenbrenner's ecological model (Bronfenbrenner, 1977) that is represented in the ED approach can provide a useful framework to help researchers and practitioners to address this important action (e.g., (Shen et al., 2016)). In summary, whilst the ED approach has perhaps less direct connection to strategies 5–10 than it does with actions 1–4, these are extremely important in enabling behaviour change and helping countries to implement the WHO recommendations.

4. Concluding thoughts

Drowning is a global problem although it seems particularly acute in LMICs, especially across the SEA and WP regions (United Nations General Assembly, 2021; World Health Organisation, 2014, 2021). It remains one of the most common causes of accidental death or injury. Compounded with the variable reporting of incidents and fatalities, drowning statistics are likely to be underestimated (Hyder et al., 2008). In this article, we focused our analysis upon the region of SEA where drowning is prevalent amongst children and often occurring in natural environments. Challenges in accessing quality swimming education, inadequate supervision, poor living conditions, and also an increasing frequency of extreme weather events due to climate change, render children particularly vulnerable. The WHO has confirmed that drowning is a 'multisectoral issue' and that a wide range of approaches are necessary to prevent drowning from occurring (World Health Organisation, 2014). Such actions include: restrictions over access to water; supervision and safe places for young children to play; better education of risks/dangers; increasing access to rescue equipment; teaching of foundational aquatic skills as well as training safe rescue and resuscitation techniques.

We have discussed WHO's recommendations in relation to theoretical principles of ED. The ED approach suggests that the relevant scale of analysis for understanding learning is the individual-environment relationship and their connection will dictate how well water safety skills are learnt. Considerations such as installing barriers and adequate supervision around water can be scaffolded alongside an understanding of affordances which may invite interactions even when it may be unsafe to do so. Across the world, the general approach in water safety education is still fairly traditional and perhaps understandably fairly 'swim-centric'. In other words, educators prioritise and seek to teach 'textbook techniques' that are well suited to an enclosed swimming pool (i.e., in warm, sterile and stable water environments without currents, waves, etc.). However, the WHO's call to action (World Health Organisation 2022a) suggests that developing water safety skills is becoming increasingly necessary, and that swimming education must go beyond the assessment of swimming competency alone (Langendorfer, 2015). Practitioners must also be aware that there are a range of physical, cognitive and affective competencies to be developed and be guarded from focussing too heavily on physical competencies alone. These skills include evaluating risks against one's own competency before getting in the water, the ability to enter and exit the water safely, navigate obstacles, stay afloat, clothed swimming, and making good decisions (Button, 2016; van Duijn et al., 2021). Water safety teachers might purposely choose equipment and environment to create task and environmental constraints, in order to support exploration, increased sensitivity to action-boundaries, increased detection of affordances and to stimulate the development as well as adaptation of effective movement solutions (Guignard et al., 2020; van Duijn et al., 2021).

In summary, there remains much to be done to address the drowning pandemic but at least a robust and comprehensive set of recommendations now exists to facilitate this effort (World Health Organisation, 2017). To help address logistical challenges in the implementation of WHO's actions to prevent drowning (Hyder et al., 2008), we invite practitioners to consider how the ED framework can help them to better understand how the individual-environment relationship impacts transferability of water safety skills to real-world environments. The required efforts to coordinate drowning prevention approaches across multiple, nested systems are considerable, but achievable. Indeed, the lives of many children and young people may well depend on such efforts.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Anderson, D. I. (2018). Motor development: Far more than just the development of motor skills. *Kinesiology Review, 7*(2), 99–114.

Avramidis, S., Butterly, R., & Llewellyn, D. (2009). Drowning incident rescuer characteristics: Encoding the first component of the 4W model. *The International Journal of Aquatic Research and Education, 3*(1), 66–82.

Bronfenbrenner, U. (1977). Toward an experimental ecology of human development. *American Psychologist, 32*(7), 513–531.

Brunswick, D. (1954). A revision of the classification of instincts or drives. *The International Journal of Psycho-Analysis, 35*, 224–228.

Burnay, C., Button, C., Cordovil, R., Anderson, D. I., & Croft, J. L. (2021c). Do infants avoid a traversable slope leading into deep water? *Developmental Psychobiology, 63*(6), e22169.

Burnay, C., & Cordovil, R. (2016). Crawling experience predicts avoidance of real cliffs and water cliffs: Insights from a new paradigm. *Infancy : The Official Journal of the International Society on Infant Studies, 21*(5), 677–684.

Burnay, C., Cordovil, R., Button, C., Croft, J. L., & Anderson, D. I. (2021b). Experienced crawlers avoid real and water drop-offs, even when they are walking. *Infancy : The official journal of the International Society on Infant Studies, 26*(5), 770–779.

Burnay, C., Cordovil, R., Button, C., Croft, J. L., Schofield, M., Pereira, J., et al. (2021a). The effect of specific locomotor experiences on infants' avoidance behaviour on real and water cliffs. *Developmental Science, 24*(3), e13047. doi:10.1111/desc.13047.

Button, C. (2016). Aquatic locomotion: Forgotten fundamental movement skills? *New Zealand Physical Educator, 49*(1), 8–10.

Button, C., Button, A. J., Jackson, A. M., Cotter, J. D., & Maraj, B. (2020a). Teaching foundational aquatic skills to children in open water environments. *The International Journal of Aquatic Research and Education, 13*(1), 1–24.

Button, C., Seifert, L., Chow, J. Y., Araújo, D., & Davids, K. (2020b). *Dynamics of skill acquisition: An ecological dynamics approach.* Champaign, Illinois: Human Kinetics Publishers.

Campos, J. J., Anderson, D. I., Barbu-Roth, M. A., Hubbard, E. M., Hertenstein, M. J., & Witherington, D. C. (2000). Travel broadens the mind. *Infancy : The Official Journal of the International Society on Infant Studies, 1*(2), 149–219.

Cordovil, R., Araújo, D., Pepping, G. J., & Barreiros, J. (2015). An ecological stance on risk and safe behaviors in children: The role of affordances and emergent behaviors. *New Ideas in Psychology, 36*, 50–59.

Franklin, R. C., Peden, A. E., Hamilton, E. B., Bisignano, C., Castle, C. D., Dingels, Z. V., et al. (2020). The burden of unintentional drowning: Global, regional and national estimates of mortality from the global burden of disease 2017 study. *Injury Prevention, 26*(1), i83–i95.

Gibson, E. J., & Walk, R. D. (1960). The "visual cliff. *Scientific American, 202*(4), 64–71.

Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.

Guignard, B., Button, C., Davids, K., & Seifert, L. (2020). Education and transfer of water competencies: An ecological dynamics approach. *European Physical Education Review, 26*, 938–953.

Hastings, D. W., Zahran, S., & Cable, S. (2006). Drowning in inequalities: Swimming and social justice. *Journal of Black Studies, 36*(6), 894–917.

Hyder, A. A., Borse, N. N., Blum, L., Khan, R., El Arifeen, S., & Baqui, A. H. (2008). Childhood drowning in low-and middle-income countries: Urgent need for intervention trials. *Journal of Paediatrics and Child Health, 44*(4), 221–227.

Kjendlie, P. L., Pedersen, T., Thoresen, T., Setlo, T., Moran, K., & Stallman, R. K. (2013). Can you swim in waves? Children's swimming, floating, and entry skills in calm and simulated unsteady water conditions. *The International Journal of Aquatic Research and Education, 7*(4), 4. doi:10.25035/ijare.07.04.04.

Kretch, K. S., & Adolph, K. E. (2013). Cliff or step? Posture-specific learning at the edge of a drop-off. *Child Development, 84*(1), 226–240.

Langendorfer, S. J. (2015). Changing learn-to-swim and drowning prevention using aquatic readiness and water competence. *The International Journal of Aquatic Research and Education, 9*(1), 4–11.

Langendorfer, S. S., & Bruya, L. (1995). *Aquatic readiness. Developing water competence in young children*. Champaign, Illinois: Human Kinetics.

Leavy, J. E., Crawford, G., Leaversuch, F., Nimmo, L., McCausland, K., & Jancey, J. (2016). A review of drowning prevention interventions for children and young people in high, low and middle income countries. *Journal of Community Health, 41*(2), 424–441.

Linnan, M., Rahman, A., Scarr, J., Reinten-Reynolds, T., Linnan, & Rui-Wei, H. (2022). Evidence for a newly recognized cause of child mortality in low- and middle-income countries in Asia. *Child drowning.* UN, New York: Innocenti Working Papers No. 2012/072012 (accessed 28 Marc. doi:10.18356/6f5e0df6-en.

MacKay, J. M., Steel, A., & Dykstra, H. (2016). *Dangerous waters: Profiles of fatal child drowning in the U.S. 2005-2014*. Washington, DC: Safe Kids Worldwide https://www.safekids.org/research-report/dangerous-waters-research-report (accessed 28 March 2022.

Peden, A. E., Franklin, R. C., & Pearn, J. H. (2018). Unintentional fatal child drowning in the bath: A 12-year Australian review (2002–2014. *Journal of Paediatrics and Child Health, 54*(2), 153–159.

Peden, M., Oyegbite, K., Ozanne-Smith, J., Hyder, A. A., Branche, C., Rahman, A. K. M. F., et al. (2009). *World report on child injury prevention (Vol. 2008*. Geneva: World Health Organisation.

Pinder, R. A., Davids, K., Renshaw, I., & Araújo, D. (2011). Representative learning design and functionality of research and practice in sport. *Journal of Sport & Exercise Psychology, 33*(1), 146–155.

Rahman, F., Bose, S., Linnan, M., Rahman, A., Mashreky, S., Haaland, B., et al. (2012). Cost-effectiveness of an injury and drowning prevention program in Bangladesh. *Pediatrics, 130*(6), e1621–e1628.

Rudd, J. R., Pesce, C., Strafford, B. W., & Davids, K. (2020). Physical literacy - A journey of individual enrichment: An ecological dynamics rationale for enhancing performance and physical activity in all. *Frontiers Psychology*, 1904. doi:10.3389/fpsyg.2020.01904.

Rudd, J. R., Renshaw, I., Savelsbergh, G. J. P., Chow, J. Y., Roberts, W., Newcombe, D., et al. (2021). *Nonlinear pedagogy and the athletic skills model: The importance of play in supporting physical literacy*. London: Routledge.

Sansiritaweesook, G., Muangsom, N., Kanato, M., & Ratanasiri, A. (2015). Effectiveness of community participation in a surveillance system initiative to prevent drowning in Thailand. *Asia-Pacific Journal of Public Health / Asia-Pacific Academic Consortium for Public Health, 27*(2), NP2677–NP2689.

Shen, J., Pang, S., & Schwebel, D. C. (2016). Cognitive and behavioral risk factors for unintentional drowning among rural Chinese children. *International Journal of Behavioral Medicine, 23*(2), 243–250.

Stallman, R. K., Junge, M., & Blixt, T. (2008). The teaching of swimming based on a model derived from the causes of drowning. *The International Journal of Aquatic Research and Education, 2*(4), 372–382.

Stallman, R. K., Moran, K., Quan, L., & Langendorfer, S. (2017). From swimming skill to water competence: Towards a more inclusive drowning prevention future. *The International Journal of Aquatic Research and Education, 10*(2), 3.

Talab, A., Rahman, A., Rahman, F., Hossain, J., Scarr, J., & Linnan, M. (2016). 270 survival swimming - Effectiveness of SwimSafe in preventing drowning in mid and late childhood. *Injury Prevention*, 22. doi:10.1136/injuryprev-2016-042156.270.

Taylor, D. H., Franklin, R. C., & Peden, A. E. (2020). Aquatic competencies and drowning prevention in children 2–4 years: A systematic review. *Safety, 6*(2), 31. doi:10.3390/safety6020031.

United Nations General Assembly (2021). Global drowning prevention. In *Proceedings of the resolution adopted by the general assembly (A/75/L.76)*. United Nations https://digitallibrary.un.org/record/3925005?ln=en, 2021 (accessed 28 March.

van Duijn, T., Ng, J. L., Burnay, C., Anderson, N., Uehara, L., Cocker, K., et al. (2021). The influence of equipment and environment on children and young adults learning aquatic skills. *Frontiers in Psychology, 12*, 4417. doi:10.3389/fpsyg.2021.733489.

Withagen, R., Araújo, D., & de Poel, H. J. (2017). Inviting affordances and agency. *New Ideas in Psychology, 45*, 11–18.

World Health Organisation. (2017). Preventing Drowning: An Implementation Guide. Geneva: WHO Press. https://www.who.int/publications/i/item/preventing-drowning-an-implementation-guide (accessed 28 March, 2022).

World Health Organisation. (2014). Global report on drowning: preventing a leading killer. Geneva: WHO Press. https://www.who.int/publications/i/item/global-report-on-drowning-preventing-a-leading-killer (accessed 28 March 2022).

World Health Organization. (2021). Regional Status Report on Drowning in South-East Asia. New Delhi: Regional Office for South-East Asia. https://apps.who.int/iris/handle/10665/343085 (accessed 28 March, 2022).

World Health Organisation. (2022). World Health Organisation countries classification. https://www.who.int/countries (accessed 28 March 2022).