Does a combined swimming pool and open water education programme for children develop adaptable water safety competencies?

Button, C.[1]*, van Duijn, T[1,2], Cocker, K. [1], Trotter-Dunn, G. [1], and Seifert, L.[3,4].

*Corresponding author: chris.button@otago.ac.nz
Phone: +64 21 224 7072

1. *School of Physical Education, Sport and Exercise Sciences, University of Otago, Dunedin. NZ.*
2. *School of Sport, Exercise and Rehabilitation, University of Technology Sydney, Australia.*
3. *CETAPS UR3832, Faculty of Sport Sciences, University of Rouen Normandy, Rouen, France*
4. *Institut Universitaire de France (IUF), Paris, France*

Abstract

Most learn-to-swim programmes are undertaken in one location (often a swimming pool), which is potentially less effective than learning across a range of aquatic places and contexts. Water safety education delivered in multiple environments may improve skill development and transfer. We investigated whether a combined pool and open water programme improves children's knowledge and skills. 66 children (7-11 years old, 34 males, 32 females) participated, of which 40 undertook a 5-day education intervention (two days in a pool, one day each in a harbour, beach, river) and 26 were controls. The skills taught and assessed were: continuous 5-minute swimming, floating and treading water, underwater swimming, and a water safety quiz. Skill competency was assessed in a harbour before, immediately after, and approximately one month after the education program. The number of children in the education group demonstrating high competency increased after the intervention (i.e., swim = +22%, floating/treading water = +37%, underwater swim = +29%, quiz = +20%). Furthermore, performance of the skills was generally improved when combined and adapted in a self-rescue transfer activity. The control group also improved in 3 out of 4 of the tasks, however their knowledge (quiz) performance decreased. Our findings indicate that teaching children water safety in several aquatic environments improved skill competency and transfer. Water safety education should be undertaken in a range of representative environments to promote skill transfer and thereby reduce the risk of drowning in open water. Education providers should consider opportunities to extend pool-based programmes to include exposure to open water environments.

Keywords
Drowning
Environment
Skill
Transfer

Introduction

Aotearoa, New Zealand is home to a plethora of different aquatic environments, many of which offer attractive recreational opportunities. However, it is important that people are properly educated to access and utilise these resources safely. Historically, it has been assumed that learn-to-swim education conducted within swimming pools is sufficient to develop aquatic competencies that prevent drowning (Brenner et al., 2006; Guignard et al., 2020; Stallman et al., 2017). However, despite this widely-held belief, a large number of drownings continue to occur in open water environments (World Health Organisation, 2015). It is possible that just learning foundational swimming strokes in a pool is insufficient to safeguard people from drowning (Hindmarsh & Melbye, 2011; Carey, 1993). Perhaps surprisingly, the influence of practice environment on the learning of water safety knowledge and skills has received very little attention to date (van Duijn et al., 2021). We need to understand how best to expose learners to different aquatic environments as they navigate this journey to water safety competency (Button, 2016).

In most developed nations, the education of swimming and water safety skills is typically undertaken in swimming pools (Chan et al., 2020; Di Paola, 2019; Stevens, 2016). Swimming pools provide a seemingly 'ideal' setting for education and competency assessments as the environmental conditions are relatively comfortable, stable and reproducible (i.e., water temperature, currents, waves, depth, etc.). However, Brenner et al (2006) argue that traditional measures of pool swimming ability are not the same as evaluating the skills needed to prevent drowning. In practical terms, a child may believe that if they can swim 25 metres in a pool then they can swim that distance to a pontoon at a lake. Or, perhaps because they can dive into a pool safely, then they can also dive safely from a jetty into the ocean. Unfortunately, such comparisons are made invalid and potentially dangerous by numerous environmental factors that can make tasks in open water much more challenging.

Motor learning is not just about reproduction and retention of certain movement patterns. Instead learning requires skills to be transferable which demands sensitivity to one's own action boundaries – the limits of our movement capabilities – as well as knowledge *of* the environment (Button et al, 2021; Seifert et al., 2018). Knowledge *of* the environment refers to a learner's ability to identify specifying and non-specifying information (Seifert & Smeeton, 2020). Specifying information (e.g., propulsive or resistive force, etc.) is directly related to the task goal and can help the learner to calibrate their movements well. Whereas non-specifying information (e.g., temperature, depth, etc.) is still important but does not directly inform how the learner should move. Affordances are opportunities for action offered by the environment that are relative to the individual's abilities. Exposure to such affordances during practice empowers learners to exploit them optimally (Oppici & Panchuk, 2022). Skill transfer is the capacity of motor behaviours to be adapted to another task or novel situation (Button et al., 2021). Transfer is multifactorial and nested within different continua (i.e., near/far; horizontal/vertical and specific/general transfer). The specific-general transfer continuum was neatly illustrated by Oppici and Panchuk (2022) within a pertinent example. They suggested that *specific* transfer from a pool to open water may be observed as an experienced pool-swimmer typically adopts a streamlined position in open water to minimise drag and propel themselves forcefully in a desired direction. As the swimmer practices in open water, they may also learn to utilise non-specifying information (like waves) invoking a more *general* form of transfer (or 'attunement to surrounding affordances'). Hence specific and general forms of skill transfer interact which helps us to understand why water safety skills (like floating or swimming) in open water can be challenging for pool-trained learners.

Hence, robust assessments of water safety competency should account not only for skill improvements and retention, but also for skill transfer (van Duijn et al., 2022). Knowing that a child can swim in a pool has limited relevance if they cannot adapt this skill to be performed in open water. This is because introducing more variability in the water conditions (such as waves) of a swimming pool demands transferable swimming skills. Indeed, Kjendlie et al. (2013) showed that when open water-like conditions (i.e., waves) are simulated in a pool, the levels of skill competency are markedly lower. In their study, 66 children (11-years old) performed identical tests in two different environments: a calm swimming pool and a simulated wavy environment. The tests performed in the waves clearly showed a performance decrement (between 9 and 14% longer time to complete the swimming test and 21%, 16% and 24% lower scores for rolling entry, diving and floating tests, respectively). The authors cautioned that "[children] should not be expected to reproduce swimming skills they have performed in calm water with the same proficiency in unsteady conditions during an emergency" (p.303). To our knowledge there is currently no data published about children's competencies when tested in open water nor how different practice environments can facilitate skill transfer.

New Zealand's 'Water Skills for Life' (WSFL) initiative was launched following a nationwide review which exposed large variation in water safety education programmes across the country (Stevens, 2016). WSFL lists a range of 15 water competencies that children are expected to have learnt by year 8 of high school (see Figure 1). For example, 13-years-old children should be able to float and tread water independently for up to 5 minutes, to swim underwater for up to 5 seconds, and to be able to swim for up to 100 m (up 5 minutes) using whichever stroke/s they prefer. Importantly, WSFL also emphasises the need for children to develop knowledge and skills associated with open water environments and local hazards (Figure 1).

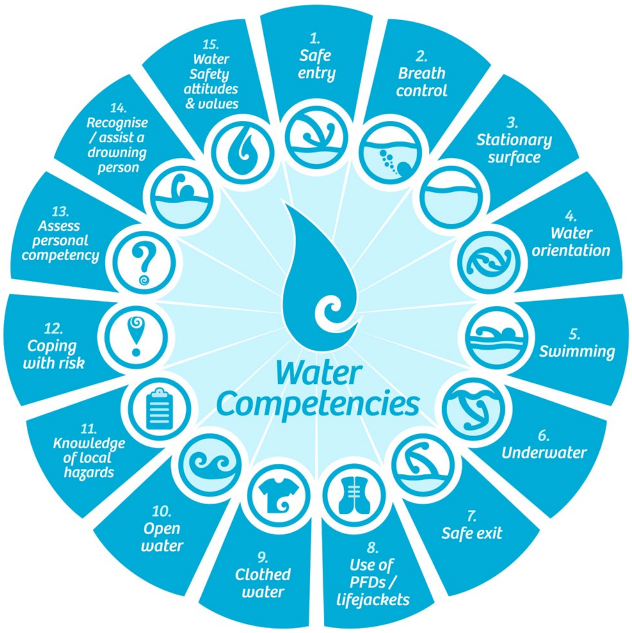

Figure 1. Fifteen water safety competencies that form the foundation of the Water Skills for Life Programme. To be reproduced with permission of Drowning Prevention Auckland.

Recent studies by Button and colleagues (2017; 2020) have provided initial data about some of the WSFL competencies of NZ children. Button et al. (2017) tested 48 children (7-11 years old) in swimming pools. The percentage of children achieving a high competency rating at pre-test was typically low. The children's knowledge about risk in different environments was particularly poor with only 15% performing well at a pre-test quiz. Furthermore, 62% of children could not swim 100 m (or up to 5 minutes) continuously in a pool. In Button et al.'s (2020) follow-up study the water safety competencies of 98 children (7-11 years old) were tested in a swimming pool before, immediately after, and three months after receiving a three-day intensive education program (delivered in a river, at a beach and in the harbour). At pre-test, once more a typically low competence level was found with less than 50% of children achieving a high level of water safety competence. However, after the 3-day intensive program, competency in each of the six tasks assessed had increased with up to 80% of participants completing the tasks unassisted. The three-month retention of these skills was also generally high (i.e., competency levels were either maintained or improved). Whilst these studies are informative it is important to acknowledge that the children were assessed in swimming pools, it needs to be established how robust these skills are when performed in an open water environment.

In summary, a swimming pool is a relatively safe aquatic environment to begin educating children about water safety. Skill transfer is sensitive to surrounding conditions at the time of transfer and is highly dependent on activities undertaken during training. However, there is a lack of evidence to show how best to develop transferable competencies into open water environments. Theoretically, practicing in a range of aquatic environments exposes learners to a rich 'aquascape of affordances' promoting specific and general skill transfer. Hence, we examined whether education undertaken in various environments improves water safety competency and the capacity to adapt such skills in a simulated survival scenario. We expected a combined pool and open water education programme to improve children's water safety competencies, as well as to develop transferable skills that might be adapted to an emergency scenario.

Methodology

Participants

The target sample size was 96 participants, based upon a conservative population estimate of approx. 500,000 (NZ children aged 7-11 years), confidence level of 95%, and confidence interval of 0.1. Exclusion criteria included any recognised learning difficulties, or existing health conditions (e.g., injuries, severe asthma) that may put the participant at risk during testing. A two-week period of advertising (i.e., website, social media, posters) resulted in 116 registrations of interest. All registered children were invited to the competency screening test (see Procedure) at a public swimming pool. The screening test was necessary to exclude potential participants who would require one-on-one supervision (i.e., non-swimmers or very anxious children) and any participants that were unable to complete all scheduled tests (n = 36). 80 children successfully passed the screening test and were eligible to participate. These children and at least one parent or guardian provided written informed consent to participate in the study.

The 80 registered participants were allocated into two groups that were scheduled to receive the same water safety education programme. Group 1 consisted of 40 children (20 males, 20 females). Group 2 initially had 40 children, however, due to increased restrictions imposed by an unanticipated change in Covid-19 alert levels, Group 2 were unable to complete the education programme and this group took no further part in the study. However, 26 children from Group 2 did complete two baseline assessments to contrast with Group 1. Hence, data from 66 children (Education Group: N = 40, Control Group: N = 26) was collected and presented in the results (Table 1).

Group	Gender	N	Age / yr (SD)	Height / cm (SD)	Weight / kg (SD)
1. Education	Female	20	9.17 (1.3)	140 (11.7)	39.6 (15.2)
	Male	20	9.87 (1.3)	141 (8.5)	35.4 (8.8)
2. Control	Female	12	9.48 (1.5)	143 (18.1)	40.2 (16.7)
	Male	14	9.89 (1.1)	143 (8.5)	39.6 (10.3)

Table 1. Descriptive statistics by group

Procedure

Ethical approval was obtained from the host institution's Human Ethics Committee prior to the study commencing (Ref: 21/138). A competency screening test was included for safety and logistical reasons. The screening test required participants to complete a basic physical activity questionnaire for children and a basic water-skills assessment conducted in an indoor swimming pool. The water skills included: entry into deep water from side of pool, float on back for 30 seconds, submerge 1 m to retrieve an object, swim back to poolside and safely exit the pool. Each child's performance in the screening test was visually assessed by a qualified aquatic educator who was in the water within arms-reach of participants. The children were permitted to wear a lifejacket at any time in the screening test if they wished to.

Participants were required to visit the testing location (a public beach beside a harbour channel) for competency assessments on three separate occasions, each 5-7 days apart. During each visit of approximately 60 minutes duration, participants were asked to perform a water safety skills test battery (see Table 2). The tasks required the participants to perform several physical tests of water safety skills unaided[1] as well as assessments of risk perception and knowledge in the form of a quiz. Tasks 1-4 were undertaken separately in the first and second testing session. For the third session, all four tasks were undertaken in series as part of a mock self-rescue scenario. All sessions were video recorded from the shore (distance of between 5-20m away depending upon the task) to enable retrospective cross-checking of the assessor's ratings.

Thorough risk assessments for all activities were undertaken in advance, and the health and safety of researchers, volunteers and participants was prioritised at all times. The weather and water conditions were monitored closely and strict criteria were applied in order for outdoor sessions to proceed (i.e., ambient temperature no less than 10°C, within 2 hours of high tide, wind strength no greater than 50k/hr). Close supervision was provided at all times during testing by experienced staff with valid life-saving and first aid qualifications. No fewer than six supervisory staff (four in the water, two at water-edge) closely monitored the participants' behaviours. Also, no more than eight participants were allowed in the water at the same time (i.e., supervisor to participant ratio of 1:1.3). Participants were required to wear a wetsuit at all testing sessions for their own comfort.

In the week between the first two competency assessments, the education programme was conducted (see details in Table 3). The first two pool-based education days were run by swimming school educators at a private pool. Days 3-5 were run in different open water locations by outdoor education providers who were experienced at delivering such programmes for children. An important feature of the education programme that was developed for this research project was the focus on transferable skills and how to adapt them to different aquatic environments (Guignard et al., 2020). For example, a key emphasis for the swimming pool education sessions was on contrasting differences between the pool and open water. Children also practiced skills in the pool that would be helpful for immersion in different environments such as safe entry and exit, floating, treading water and self-rescue techniques. When the children progressed to the open water sessions, they were reminded of the knowledge and practical skills they had acquired in the swimming pool.

[1] Although children undertook the 4 tasks 'unaided' they were supervised for all tasks by the researchers to ensure their safety and comprehension of the task goal.

At the completion of the competency testing, the education group participants were asked to complete a feedback questionnaire together with a parent or caregiver. The questionnaire contained 10 items with of a mix of short, open answer questions and closed, Likert-scale type responses.

Task	Task description	Assessment (grades 0-5)
1. Water safety quiz	A series of multi-part questions prompted by pictures of various aquatic environments (e.g., ocean, river, lake, harbour). The knowledge tested included: 1. Understands how various open water conditions influence risk 2. Knowledge, understanding and attitude towards water safety rules, hazards and risks 3. Recognise an emergency for yourself or others 4. Know how/who to call for help	0 = 0-2 correct 1 = 3-6 2 = 7-10 3 = 11-13 4 = 14-17 5 = 18-20 N.B: Participants could provide up to 20 correct answers
2. Buoyancy and treading water	The floating task took place in deep water where the children could not reach the ground to support themselves. Participants were required to enter the water safely and then to float on their back for one minute. If they accomplished this, they then had to tread water for four further minutes. Once five minutes was completed, the participants had to call for help with one hand in the air before exiting the water.	0: No attempt or enters water unsafely (i.e., jumps without checking) 1: Cannot complete back float (<30s), no treading water 2: Cannot complete back float (<60s) or treading water (<60s) 3: Completes back float, partial completion of treading water (<120s) 4: Completes back float, partial completion of treading water (>120s) or no help signal 5: Completes back float, treading water (240s), signals for help and exits safely
3. Submersion, underwater swim, retrieve an object	The submersion task took place in semi-deep water (about 1.5m deep) approximately 5m from shore. Participants were asked to hold their breath and to submerge completely and then swim through three large, submerged hoops to retrieve a bright diving ring situated 1, 2 and 5m away. The diving ring was held by a lifeguard under the water. Once participants had retrieved the ring they gave it back to the lifeguard and then got out of the water. The use of swimming goggles was optional for this task.	0: No attempt, or does not submerge face 1: Swims through 1m ring in +1 attempt 2: Swims through 1m ring in one attempt (without surfacing for breath) 3: Swims through 2m ring in +1 attempt 4: Swims through 2m ring in one attempt (without resurfacing) 5: Swims through 5m ring in one attempt (without resurfacing)
4. Swim	Several floating buoys were attached by a 12.5 m long rope in water of approximately 2m depth (about 15 m from the beach). 10kg anchors were attached to the rope at each end to secure its position in the water. The rope and buoys created a temporary swimming 'channel' in the water. The children were transported by kayak to one of the buoys. They then got in the water unsupported and were asked to swim continuously beside the rope on their right for whichever came first of up to 5 minutes or for 8 lengths (100 m). They were instructed not to touch the rope or ground if possible and that they could use whichever stroke they preferred. The use of swimming goggles was optional. When the child wanted to finish the task or completed it successfully, they swam to a nearby kayak.	0: No attempt 1: 0-25m aided 2: 0-25m unaided 3: 25-50m unaided 4: 50-75m unaided or up to 5 mins 5: Able to swim continuously for 100 m without assistance (< 5 mins)

5.	Transfer / self-rescue	Simulated survival scenario in which a combination of task elements described above were performed in sequence (i.e., floating/treading, underwater swim, swim, quiz). First participants had to choose the furthest distance they felt that they could swim from 5 brightly-coloured buoys positioned 15m, 30m, 50, 100m, 150m from the jetty. The researcher then paddled the participant to the chosen buoy in a two-person kayak. A hypothetical scenario was described to participants that their kayak was about to be overturned by a wave and they had to act to rescue themselves. A lifeguard also remained at arms-reach of participants during the scenario with a buoyancy aid if required. Upon their return to the jetty, participants then completed the knowledge quiz with questions about the activity they had just undertaken. During this scenario participants wore a wetsuit under some light clothing (i.e., old jumper, trackpants and trainers).	For the transfer activity each of the 4 tasks described above (Buoyancy, Submersion, Swim, Quiz) was embedded within the simulated survival scenario. The same criteria used above was applied to rate the participants performance at each task (out of 5).

Table 2: Series of tasks presented independently to participants before and after the education programme, and in combination as part of a Transfer test. Note that a comprehensive risk management and analysis of the feasibility of undertaking these assessments in open water was undertaken in advance (van Duijn et al., 2022).

Day	Duration (hrs)	Activities	Staff-participant ratio	Equipment	Notes
1. Pool	3	Safe entries/exits Floating Submersion Swim - calm water	1:6	Wetsuits, lifejackets, pool noodles, dive rings, fake seaweed	Actual size of group in pool 18-20 with 3 educators
		WSFL theory: different aquatic environments, identifying risks	1:20	Overhead projector, quizzes, paper, pens	Lesson provided by qualified WSFL educator
2.Pool	3	Treading water Lifejackets, boat capsize and rope rescues Swim - turbulent water	1:6	Wetsuits, lifejackets, ropes (5 m), pool boards, inflatable rescue boat	Actual size of group in pool 18-20 with 3 educators
		WSFL theory: what to do in emergencies, who to ask for help	1:20	Overhead projector, quizzes, A0 paper, pens	Lesson provided by qualified WSFL
3.River	4	Survival swim position / floating River crossings Rope rescues Navigating strainers Understanding current and other dangers	1:6	Wetsuits, lifejackets, ropes (10 m), inflatable tube, pool boards, first aid kit, emergency blankets	Groups of 6, overall group size of 40. 5 rotating stations set up for each activity
4. Beach	3	Identifying risks at the beach Signalling for help Flags Rips, sand sculptures Navigating waves Floating, treading water Submersion	1:10 (theory) 1:6 (practical)	Wetsuits, radio, dummy flare, rescue tubes, whiteboard, paper and marker pens	60 min theory session followed by 120 min practical. Groups of 20 children supervised by 3 lifeguards and a parent/caregiver
5. Harbour	3	Boats Weather, equipment and tell someone Fitting lifejackets Safe jump entry Capsize from boat Floating, treading water	1:20 (theory) 1:6 (practical)	Wetsuits, rescue boat, personal locator beacon, flare, rescue tubes, whiteboard, paper and marker pens	90 min theory session followed by 90 min practical. Groups of 20 children supervised by 3 lifeguards and a parent/caregiver

Table 3. Summary details of combined pool and open water environment safety lessons

Data Analysis

Each participant was allocated a unique identifying code for the purposes of organising data and protecting anonymity. For the pre-test, post-test, and transfer tests each participant's water safety competencies were visually assessed and recorded manually by one of four researchers. The competency demonstrated for each skill was rated on a 6-point Likert type scale, based on a previously validated toolset (Button et al., 2020). The assessors observed participants in small groups of up to four at a time. The researchers marked competency scores (i.e., grades 0-5 as described in Table 2) on an assessment sheet following the completion of each task. Cross-checking of ratings occurred regularly between assessors. Furthermore, one assessor viewed video footage of all trials to ensure consistency and accuracy of observations. The inter-rater (Light's Kappa = 0.81) and intra-rater (ICC = 0.83) reliability of 10% of the assessments was confirmed to be 'good' and 'almost perfect agreement' respectively (Hallgren, 2012). Changes in skill competency were based on comparisons between the pre-test and post-test, whereas skill transfer was assessed in terms of whether participants were able to maintain their post-test performance in the transfer task. The post-study questionnaire data was collected in a spreadsheet and descriptive statistics such as means, standard deviations, percentages and ranges were used to summarise data trends. As the data were ordinal, non-parametric comparisons were run to detect changes over test session (i.e., Kendall's coefficient of concordance) or between groups (i.e., Mann-Whitney U). All statistical analyses were undertaken with SPSS for Windows (IBM, SPSS Statistics v. 27.0).

Results

The main competency data from the education group for each task they were assessed on is summarized in Figure 2. From baseline to post-test, the number of children in the education group demonstrating high competency (rating of ≥4) in each task increased (quiz = +20%, floating/treading water = +37%, underwater swim = +29%, swim = +22%) Furthermore, performance in the floating and swimming elements of the transfer task were generally improved from baseline (Figure 2). The statistical comparisons broken down by task are provided in the following sub-sections.

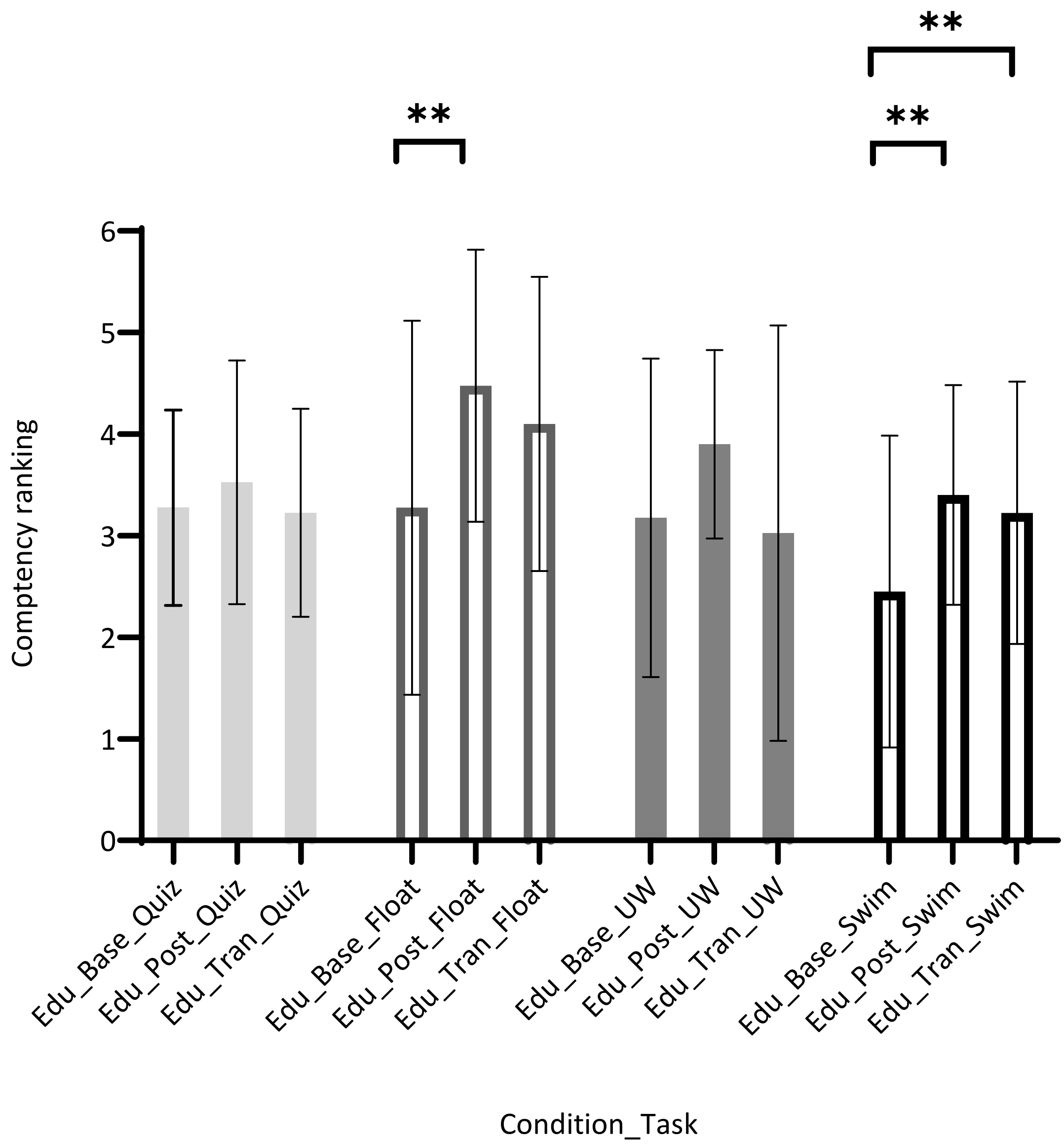

*Figure 2. Column chart (means and error bars) of Education group competencies for each task. Note ** denotes significant difference (P < .01) between conditions. Edu – Education group; UW – Underwater task; Base – Baseline assessment; Post – Post education assessment; Tran – Transfer assessment.*

Quiz

Quiz ratings for the education group were not significantly different over test sessions (Q(2) = 4.84, p = 0.089). The post-test ratings (mean = 3.53) did trend higher than either the baseline (mean = 3.27) and the transfer test (mean = 3.23), but these comparisons were not significant (P >.05) (Figure 2).

In terms of the group comparisons, there was no difference between the groups at the first baseline test (wave 1 = 3.28, wave 2 = 3.42: Z =-.63, p >.05) (Figure 3). The education group performed significantly better than the control group in the post (second baseline) test (Z = -3.45, P <.001). It was noted that whilst the education group improved their quiz ratings from baseline by 8% (mean 3.53), the control group decreased by 25% (mean = 2.58).

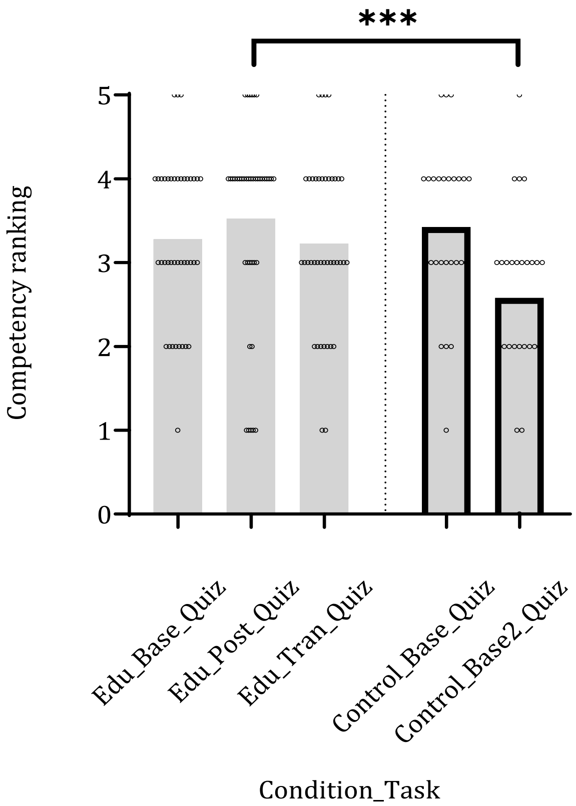

*Figure 3. Column (means) and scatter dot plot of Quiz competency for education group (left side – unbordered columns) and the control group (right side – bordered columns). Note *** denotes significant difference (P < .001) between groups. Individual datapoints are denoted by ° symbol. Base2 – 2nd baseline test (in essence the 'post-test' for the control group)*

Floating

Floating competency assessments were significantly different over time for the education group (Q(2) = 15.50, p <.001). As shown in Figure 2 the post-test ratings (mean = 4.47) were higher than baseline (mean = 3.28). The transfer test (mean = 4.10) also trended higher than baseline, but this comparison was not significant (p > .05).

There were no significant differences between groups for floating at the first baseline test (Z = -.965), nor at the second baseline test (Z = -1.389). Figure 4 shows that both groups showed better floating competency by their second test (wave 1 increased by 36%, wave 2 increased by 14%).

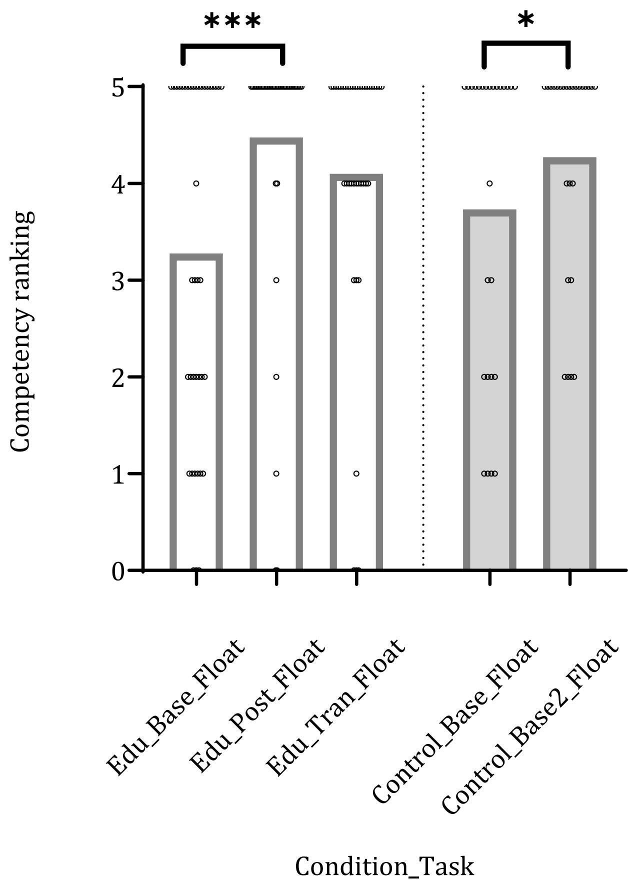

*Figure 4. Column (means) and scatter dot plot of Floating competency for education group (left side – bordered columns) and the control group (right side – shaded columns). Note *** denotes significant difference (P < .001) between conditions, * denotes significant difference (P < .05) between groups. Individual datapoints are denoted by ° symbol.*

Underwater swim

The underwater swim ratings were not significantly different over time for the education group (Q(2) = 5.13, p = 0.075). The post-test ratings (mean = 3.90) did trend a little higher than either the pre-test (mean = 3.18) and the transfer test (mean = 3.03) but these comparisons were not significant (p's > .05).

There were no significant differences between groups at the first baseline (Z = -1.601) nor at the second baseline (Z = -0.197) for the underwater swimming task.

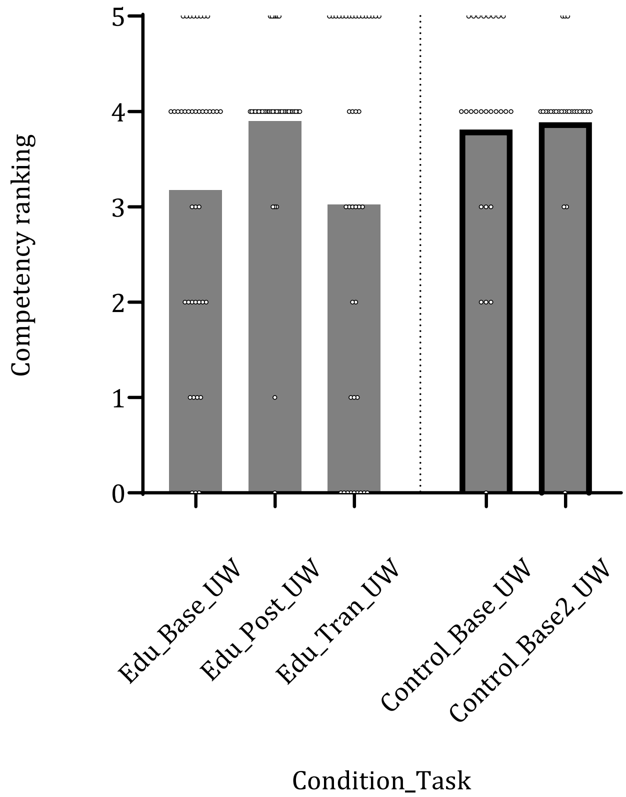

Figure 5. Column (means) and scatter dot plot of Underwater competency for education group (left side – unbordered columns) and the control group (right side – bordered columns). Note: Individual datapoints are denoted by ° symbol.

Swim

Swim ratings were significantly improved over test sessions for the education group (Q(2) = 20.01, p <.001). The post-test score (mean = 3.40) and transfer test (mean = 3.23) were both higher than the pre-test (mean = 2.45) as shown in Figure 2. There were no significant differences between groups at the first baseline (Z = -1.121) nor at the second baseline (Z = -0.197) for the swim task (Figure 6).

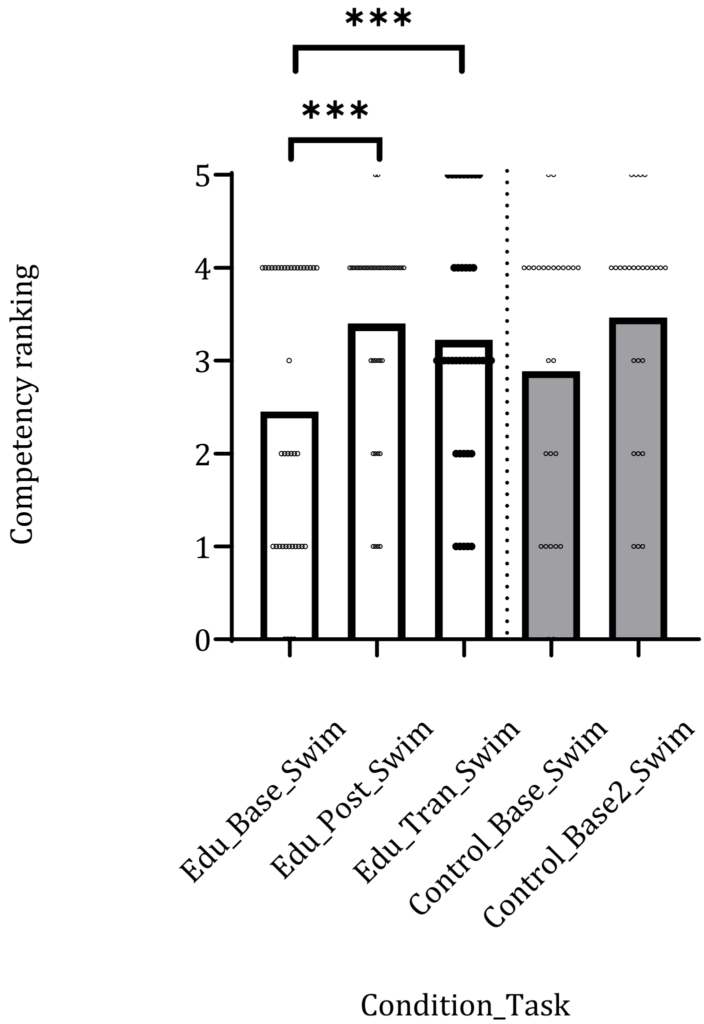

Figure 6. Column (means) and scatter dot plot of Swim competency for education group (left side – bordered columns) and the control group (right side – shaded columns).
*Note *** denotes significant difference (P < .001) between conditions. Individual datapoints are denoted by ° symbol.*

Participant and Caregivers Questionnaire

Twenty responses to the questionnaire were received overall. For 11 of the returned questionnaires there were multiple children in the family taking part in the study, hence the responses actually represented 35 of 40 children from the Education group (87.5%). Summary data are presented in Table 5 for the quantitative statements that required closed-scale responses. There was uniformly strong agreement for each positive statement that described various aspects of the water safety program.

Statement	Mean (1 strongly agree – 5 strongly disagree)	SD	Range
1. Overall, I am pleased with my experiences in the study	1.1	0.31	1 - 2
2. I am likely to recommend a program like this to others	1.1	0.65	1 - 4
3a. I am more aware of dangers around natural water environments	1.1	0.36	1 - 2
3b. I know how to respond should an emergency occur	1.4	0.60	1 - 3
3c. I have developed important water safety skills	1.4	0.36	1 - 2
3d. I have more adaptable water safety skills	1.2	0.44	1 – 2
3e. I have improved my open water swimming ability	1.3	0.66	1 – 3

Table 5. Descriptive statistics for closed-item responses from post-study questionnaire

In terms of qualitative data (i.e., free-text responses) the feedback generally supported the quantitative data presented in Table 5. Several of the free-text responses also provided some valuable suggestions to consider. Example quotes are provided below:

"My child learned many things from the water safety [study] that are not being taught at school."

"The increase in confidence and ability to gauge the safety of her swim environment has been significant."

"My daughter felt challenged, yet supported. She was reassured by the accessible and thorough explanations."

"Thankyou, it has made P….. more confident in trying new experiences."

"Real life simulations ensure kids appropriately judge their abilities in non-pool scenarios."

"This should be an essential part of what we teach our children – alongside swimming lessons."

"I do wonder if a Te Reo Māori approach could be layered/added to each context and have a Māori perspective too here in Aotearoa?"

Discussion

The aim was to better understand how education can improve the water safety competency of children. Specifically, we investigated whether education undertaken in various environments improves water safety competency and the capacity to adapt such skills in a simulated survival scenario. Before discussing the key results, it is important to acknowledge that the study faced several logistical challenges due to an unanticipated change in Covid-19 restriction levels that occurred in the middle of testing. Due to the increase in restrictions concerning social distancing, mask-wearing, and gathering of groups, it was not possible to provide the planned education program for group 2 (that became the Control group). Hence the data reported here represents just under half the sample size that we aimed to recruit. Whilst the small sample size is an acknowledged limitation, we still believe the data that was collected provides valuable information that contributes to the general aim of the study.

To answer whether the combined swimming pool and open water education program improved children's water safety competency it is necessary to compare baseline performance to the post-test data. We found significant improvements for two of the tasks (i.e., Buoyancy and Swim) and small, but non-significant, improvements for the other two tasks (i.e., Quiz and Underwater swim). It is possible that the small size of the education group (N=40) meant that the improvements in the Quiz and Underwater swim did not reach statistical significance. Future research with a larger number of participants will be required to determine if that interpretation is correct. It may also be the case that the Quiz and Underwater swim tasks received insufficient focus in the education program to prompt similar improvements to those seen in the Buoyancy and Swim tasks. For the Quiz task, perhaps providing supplemental learning resources may enable learners to improve their knowledge within the short timeframe that the program was offered (Tipton et al., 2021). In terms of the Underwater swimming task many children were able/willing to submerse their head (i.e., swim through at least one hoop 1m away which was sufficient to achieve grade 3) but they then struggled to hold their breath and to navigate their swim underwater for up to 5 m (i.e., necessary to achieve grade 5). It seems that greater emphasis on breath-holding and underwater navigation during the education program may be required. Our previous water safety studies have shown improvements in knowledge and underwater swimming with a similar education study (e.g., Button et al., 2020) but the scale of measurement used in this study was adapted from a 4-point to a 6-point scale of competency. On the basis that there were significant improvements shown in two of the four skills tested, we conclude that the education program was at least partially successful in improving children's water safety competency.

Another interpretation of the competency improvements we found between baseline and post-test (for the Buoyancy and Swim tasks) is that the children simply benefitted from performing the task a second time (i.e., an order effect). Admittedly, there was some support for this interpretation in that the control group also generally performed better in their second baseline test. However, it was noted that the control group's performance in the Quiz dropped markedly (by about 25%) in the second baseline test. Different questions were asked each time the Quiz was administered so it is possible that the second baseline quiz was more difficult than the first, whereas for the other three tasks the same activities were repeated by the children. As such we should not rule out the possibility that the improvements in competency shown following the program were not simply due to repeating the same task rather than the education that was delivered. Future research could remedy this issue by having participants complete multiple baseline tests before competency assessments take place.

The other part of the research question concerned whether the education program would allow children to adapt (transfer) their skills successfully into a simulated survival scenario. To identify whether the combined pool and open water program developed transferable skills it is necessary to compare the post-test to the transfer test data. Only for the swimming task children did maintain their improved post-test ratings (mean rating = 3.4, 38% increase from baseline) in the transfer test (mean = 3.2, 31% increase from baseline). For the other three tasks the transfer performance was not significantly different from baseline. Although, transfer performance in each element of the simulated survival task was not markedly different from baseline it was notable that all 40 children completed the scenario successfully and independently. They were able to judge appropriately how far they could swim from a capsized boat in deep water and then able to demonstrate that they could actually swim that distance. They were also typically able to perform other required elements of the scenario such as Buoyancy (N=37, 93%) and Underwater swimming (N=27, 67%) as demanded within the scenario they were presented with. Indeed, none of the 40 participants required rescuing or asked to stop the transfer test prematurely. Our interpretation of these apparently conflicting results is that generally the participants DID develop transferable skills to stay safe. By allowing participants to choose the level of challenge in each element of the transfer test (i.e., how far to swim, how to float, whether to swim underwater, etc.) they set themselves achievable and sensible targets that they knew they could satisfy. Arguably these results demonstrate strong practical relevance in that the children were able to judge their abilities and the conditions well, thereby showing improved knowledge *of* the environment (Seifert & Smeeton, 2020). However, by allowing participants to self-regulate the level of challenge in the Transfer test the competency data arguably do not provide a clear/comparable indication of *specific* skill transfer from the education programme. Instead, our interpretation is that there is evidence of reasoned decision-making and hence *general* learning transfer has resulted from the programme. Careful design of transfer tasks in future work is needed to account for the interaction of different types of skill transfer that have emerged (Oppici & Panchuk, 2022).

As well as providing quantitative information about water safety competencies, the post-study questionnaire was a valuable source of information about how the study was perceived by participants, parents and caregivers. The data (e.g., Table 5) indicate that the children generally felt more confident in their knowledge and abilities after the study had concluded. For example, most children agreed with statements that they had improved their open water swimming and knowledge thereby showing better awareness of affordances and when it was safe to use them (Seifert & Smeeton, 2020). Unfortunately, the questionnaire did not require participants to report on specific elements of the study, so it is not clear if it was either the assessments and/or the education program that boosted their confidence. In future research we intend to explore more thoroughly how the children's emotional engagement (i.e., confidence, anxiety, motivation, etc.) was influenced by the programme. Importantly, participants reported that they enjoyed the study and the various challenges and environments it exposed them to. Free text comments offered by several of the parents/caregivers aligned well with their children's perceptions in that they too valued the opportunity for their children to be educated in this way. Several comments indicated that this program offered much more than just learning to swim in a pool and that they would like to see such a program freely available to all New Zealand children.

Limitations

As well as the limited sample size there are several other limitations that were encountered with this study. We did not collect comparison data from a pool-trained control group which would have allowed us to quantify the influence of educating water safety in different environments. It is also possible that an order effect explains some of the competency improvements found amongst the children in the post-test and transfer task. Additionally, the ratings that assessors made were at least partly subjective and therefore potentially biased towards the education program. We are investigating means to address such limitations in planned research in the future.

Conclusion and Practical Implications

The statistical power of the study was affected by an unanticipated change in Covid restriction levels that meant we were unable to achieve the target sample size. Despite this limitation, 40 children aged 7-11 years old received a 5-day water safety education delivered in a pool and several open water locations. The children's water safety competency increased after the programme particularly for the Floating and Swimming tasks. The Quiz and Underwater swimming tasks demonstrated smaller but non-significant improvements. In terms of adaptable skills, all children were able to independently complete a self-rescue task that combined the 4 assessed tasks. The feedback received from participants and parents/caregivers about the program was very positive. Whilst further investigation is required into the different skills that were assessed in the program this was a valuable step demonstrating that a combined pool and open water education model is feasible and successful in developing competency. An intensive education programme conducted in a swimming pool and multiple open water locations can effectively develop adaptable water safety competency. Water safety education should be undertaken in representative environments to optimise skill transfer (van Duijn et al., 2022) and thereby reduce the risk of water related injury or drowning.

The following practical implications are recommended for consideration:

- Water safety competency amongst NZ children is quite variable. Some children are very competent, but others show worryingly low competency levels
- Developing collective responsibility across multiple sectors (i.e., water safety organisations, schools, outdoor education providers, parents/caregivers, etc.) is

required to improve the water safety competency of Aotearoa's children/tamariki

- Parents and caregivers highly valued the opportunity to have their children educated in open water environments
- Summer holiday programmes and school camps present important opportunities in which children can develop water safety competency in short, intense learning blocks
- Distributed learning over longer periods would also add value to the education as weather patterns and water conditions can change over the Seasons – which are not captured well be short programmes.
- Education providers that operate solely within swimming pools should consider opportunities to extend pool-based programs to include exposure to open water environments. However, open water education should only be undertaken by trained and knowledgeable education providers: Local knowledge of the environment is crucial, as are appropriate supervision and risk management strategies

Acknowledgements

We wish to acknowledge the support of Water Safety New Zealand to help fund this research study. The host tertiary institution also generously provided financial support.

We would like to thank the following organisations and people for their invaluable contributions to the education programme undertaken within this research:

- Water Safety New Zealand
- Just Swim Dunedin
- Wild Earth Adventures Inc.
- Surf Lifesaving NZ
- Parents and participants

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