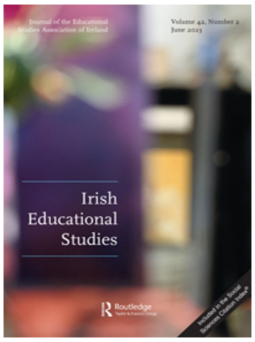

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H_2O Heroes: adding value to an environmental education outreach programme through intergenerational learning

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H_2O Heroes is an environmental education programme, which was piloted with primary school students aged 7–10 years in a rural community in Co. Cavan, Ireland. Environmental education is frequently aimed at children not just as an educational initiative but as a means of changing attitudes and behaviour. H_2O Heroes brings children on a fun interactive 3 h classroom-based tour of a water catchment, focusing on the link between human activity and water quality. The goal of H_2O Heroes is to inspire, inform and engage so that children become environmental ambassadors for water (H_2O) protection and conservation. This study is centred on adding long-term value to a short-duration science outreach programme by looking at how its reach and 'message' can be transmitted to a wider audience through the ripple effect of intergenerational learning. This small-scale study employed a mixed-methods approach taking advantage of both quantitative and qualitative research tools. Targeted feedback from children, parents and caregivers demonstrated the effectiveness of the programme in promoting both environmental awareness and intergenerational learning. Findings indicate that participation in the H_2O Heroes programme empowered children as agents of environmental change and successfully improved environmental awareness and effected behavioural change within their families.

Keywords: environmental education; intergenerational learning; water conservation; behaviour change

Introduction

As part of the United Nations (UN) Sustainable Development Goals (SDGs), the UN has committed to focus on water for a decade 2018–2028. SDG 6 aims to 'Ensure availability and sustainable management of water and sanitation for all', recognising that water and sanitation are at the very core of sustainable development, critical to the survival of people and the planet (United Nations 2018). In response, Ireland will ' … support international and national efforts to improve global governance of water and sanitation … including in the area of water resources management, to local efforts to protect current and future water sources from contamination … ' (Ireland: Voluntary National Review 2018). However, most recent statistics (Environmental Protection Agency (EPA) 2019) show that water quality is not improving in

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line with the requirements of the Water Framework Directive (WFD) (2000/60/EC), which is legally binding and was developed by the EU to establish a framework for the protection of all waters and their dependent wildlife/habitats (European Parliament and Council 2000). Human pressures are cited as the main reason for this decline, including increasing populations, agricultural intensification and inadequate wastewater treatment. Recently, the global climate change issue and protection of biodiversity has dominated the environmental agenda. There has been little discourse related to water quality despite many indications that surface waters already under stress are especially vulnerable to the impacts of climate change. Several markers of climate impact on the biodiversity of freshwater ecosystems have already been observed (Markovic et al. 2017).

As water is a pre-requisite for life on earth, water education should be a key goal of any Environmental Education (EE) initiative. Ireland's climate model projections are predicting increases in the likelihood of extremely dry summers and wet winters which will bring significant challenges for those involved in water resource management (Matthews et al. 2016). Future generations will need to be 'water science literate' as they will be forced to manage water resources and make informed decisions to protect our aquatic ecosystems (Covitt, Gunckel, and Anderson 2009).

From a policy perspective, the WFD requires all European citizens to understand and integrate information about their individual catchments. Catchments are the areas of land around our lakes, rivers or water bodies where we all live. Consequently, in Ireland, water resource management has adopted a more inclusive, participatory approach to engage with stakeholders including the general public. This has been facilitated through the establishment of stakeholder bodies including An Fóram Uisce (The Water Forum 2020), the Local Authorities Water Programme (LAWPRO 2020) and others.

As Ireland's future environmental custodians, children are key stakeholders. The advancement of environmental literacy through STEM-based education is crucial to provide them with the necessary skill-sets to ensure that environmental awareness becomes a building block in the future economic and social development of their country. The UN Convention on the Rights of the Child (1989) Article 12 states that children should 'be provided the opportunity to be heard' and that their views should be 'given due weight' appreciating that children are active, competent agents and can be influential in families and communities (Lundy 2007). Children can be active agents in EE and influence their parents' environmental beliefs and actions (Lawson et al. 2018). However, there are limited published data on intergenerational and intercommunity influences in EE programmes (Ballantyne and Packer 2009; Vaughan et al. 2003; Ballantyne, Fien, and Packer 2000; Ballantyne, Connell, and Fien 1998).

Engaging children in science

Research shows a steady decline in the number of students who choose to study scientific subjects at all levels and take up scientific careers (Kearney 2015). Many studies have reported that interest in science declines with advancing school years, so creating positive attitudes towards science early-on is important (Potvin and Hasni 2014). Research has shown that young children are open to learning about science and positive about hands-on science activities at school (Agranovich and Ben-Zvi Assaraf

2013). However, many children have little understanding of the wider impact that science has on society and find science hard to relate to their everyday lives (Littledyke 2004). Education initiatives need to focus on building science capital which is positively linked to academic performance, motivation and aspiration in science rather than just improving children's engagement and 'increasing their interest' (Archer et al. 2013). Science capital can be defined as the sum of all the science-related resources (capital) that a person builds up through their life. This includes their science knowledge, opinions about science, people they know who have an understanding of science and their day-to-day engagement with science (DeWitt, Louise Archer, and Mau 2016).

Children's attitudes towards science and science aspirations are influenced by many factors including age, gender, social class, ethnicity, attitudes of peers and friends, classroom, pedagogical and teacher variables (Agranovich and Ben-Zvi Assaraf 2013). Parental involvement and family structure has a direct effect on science perceptions of children, a key factor affecting the likelihood of a student aspiring to a science-related career is the amount of 'science capital' a family has (Archer et al. 2012).

Intergenerational learning and influences

Intergenerational learning is learning that occurs between two or more generations. It involves the 'sharing of information, thoughts, feelings and experiences between two generations that can enrich both', much intergenerational learning takes place informally (Istead and Shapiro 2014; Istead 2009). The influence that older generations have on younger people is widely accepted, but research indicates that this influence can be bi-directional with children influencing the behaviour of adults (Lawson et al. 2018). Through intergenerational and intercommunity learning, children have the potential to be educators, and even inspire community environmental action (Vaughan et al. 2003). EE as it is currently practiced does not necessarily equate to environmental action and intergenerational learning is not a given (Istead and Shapiro 2014). In order for there to be an intergenerational influence, there must be deeper learning and effective communication. EE programmes must be designed appropriately to promote communication and encourage child to adult intergenerational learning (Vaughan et al. 2003; Ballantyne, Fien, and Packer 2000). Parents must be willing to listen to the child and there are many factors which can have an influence on the child's perceived status in the family including gender and birth order. More research is needed about the kinds of educational activities that help children to develop the skills and self-confidence needed to share knowledge with adults and family members.

The study

This paper evaluates the impact of an EE programme called H_2O Heroes. H_2O Heroes unlike other EE programmes uses a catchment-based framework to explore the links between human activity, water quality and water use not just in an individual water body but in the wider catchment. H_2O Heroes is an initiative designed not only to foster environmental understanding but to connect children with their catchments to achieve long-term changes in attitudes and behaviours. There are limited studies on the efficacy of school-based EE outreach programmes; it is suggested that children can achieve a better appreciation of the natural world by hands-on experiential, integrated learning activities (Breunig et al. 2014). This paper examines the hypothesis that educating and engaging children in the 'H_2O Heroes' EE programme can have a wider impact, transferring its reach and environmental message to a wider audience through intergenerational learning. The research was focused around two questions and explored the views of a range of stakeholders in relation to:

1. Can an H_2O Heroes outreach programme promote EE in a primary school setting?
2. How effective is the H_2O Heroes outreach programme in promoting intergenerational communication and learning about the environment?

H_2O Heroes EE programme

H_2O Heroes takes place in the classroom and is facilitated by enthusiastic Environmental Scientist role models who engage in hands-on science activities with the participants. Each child gets a laboratory coat, becomes a scientist and works in small groups which facilitate one-to-one interactions. The 3 h workshop includes a brief presentation and lots of hands-on activities based on real science (Figure 1). The use of water samples from the local river/lake encourages a sense of ownership, connecting the children to their local environment (Duvall and Zint 2007). Focusing on local issues and connectedness to nature has been documented as an important predictor of environmentally responsible behaviour (McPherson Frantz and Mayer 2014). The hands-on structure of the activities fosters the development of important skills, concepts and knowledge, through which students can observe, question, investigate, understand and think logically about the world around them. Finally, the 'take home' aspects have been designed to promote parental participation and stimulate discussion between children and family members (Lawson et al. 2018).

Participants

This study was conducted in May 2019 in a primary school located close to a large lake in Co. Cavan Ireland. Cavan has been identified by Science Foundation

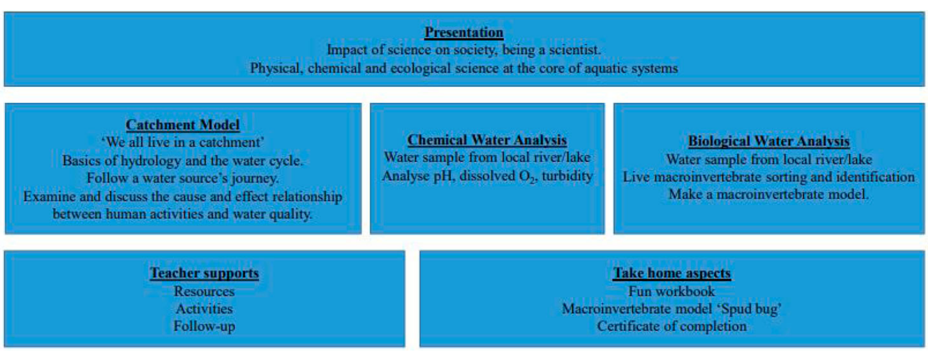


Figure 1. Schematic diagram of the structure of the H_2O Heroes programme.

Ireland (SFI) as one of six potentially underserved areas of Ireland in relation to STEM engagement (Science Foundation Ireland (SFI) 2018). Two class groups from the school were selected for participation based on their age, as the ages of 8–9 are a core time to target children in terms of science education and a critical period in their attitude development towards science (Potvin and Hasni 2014). A total of 41 children took part in the study, their ages ranged from 7 to 10 years and the mean pupil age was 7.75 ($SD = 3.34$, mode = 8). Gender distribution was almost equal with 54% females and 46% males. A sub-sample of 8 parents/caregivers of the children who participated in the programme were selected randomly and interviewed to establish their views and perspectives on science and EE. Considering the purpose of this study, a small sample size is consistent with similar studies cited in the literature and was regarded as appropriate (Istead and Shapiro 2014).

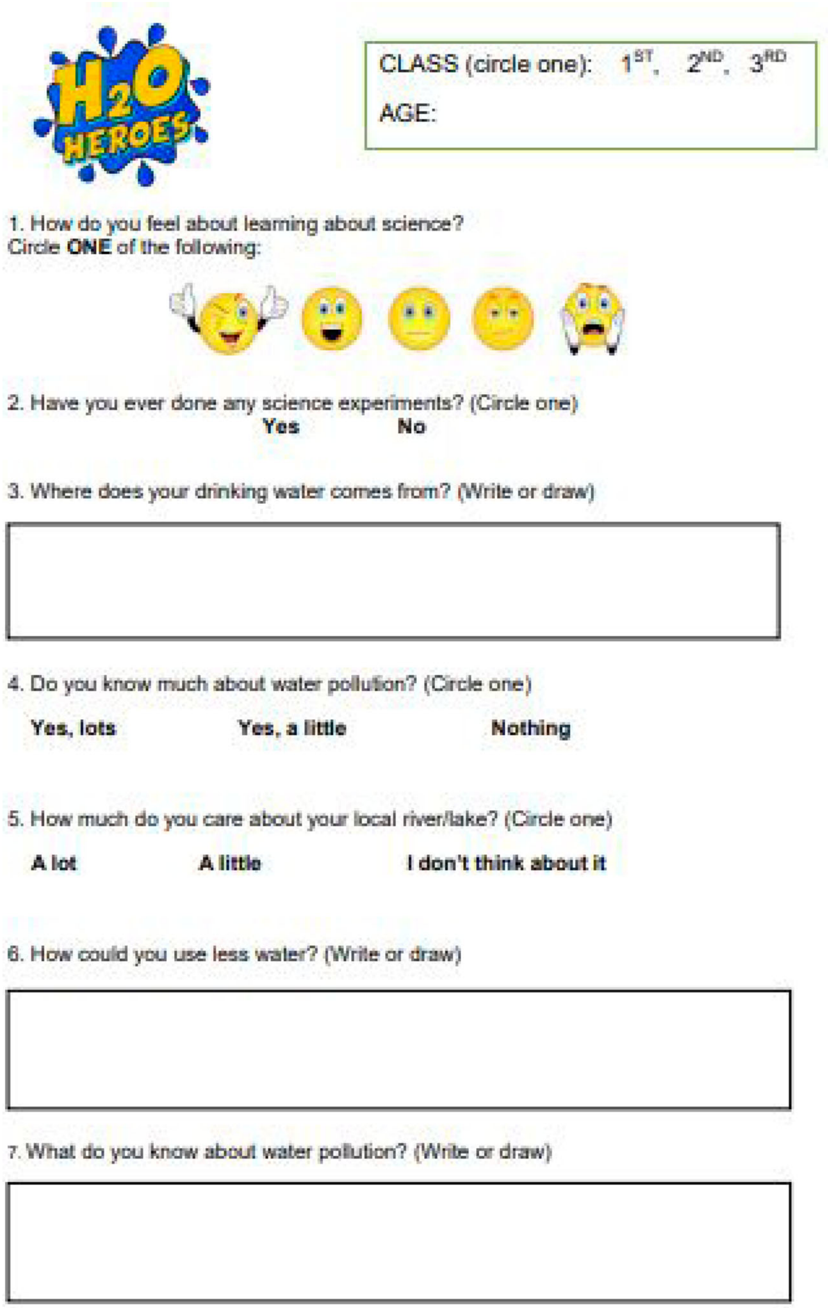
Methods

Due to the multifaceted nature of this study, the research questions were answered using a mixed-method approach. A key feature of this method is that the qualitative and quantitative findings are integrated. In this study, qualitative stakeholder interviews were analysed in parallel with questionnaire data and then merged to secure an in-depth understanding.

Pre- and post-workshop assessment

Children completed pre- and post-workshop questionnaires that assessed ecological knowledge, enjoyment of the workshop and interest in learning about science (Research Question 1). The use of questionnaires with primary school students is considered an appropriate research tool; however, the young age of the participants and their literacy was taken into account. To aid understanding, the teacher read aloud the questions and stressed that the questionnaire was not a test and children did not have to answer all questions, questionnaires were kept short to avoid fatigue (Scott 2002). The draw and write technique widely cited in the literature in environmental studies allows children to effectively articulate their responses avoiding language barriers (Horstman et al. 2008; Kalvaitis and Monhardt 2012). Questions were varied with both open ended, where space was provided for them to write in their own words or draw pictures and closed options. A number of questions were structured using a five-point 'smiley face' Likert scale – as recommended by Hall, Hume, and Tazzyman (2016) who demonstrated the effectiveness of this method for children to provide judgements in response to scaled quantitative questions.

The pre-workshop questionnaire (Figure 2) consisted of seven questions, four of which were closed (choice and scaled) where children were asked to rate their interest in science and experience of science. The post-workshop questionnaire (Figure 3) consisted of eight questions, five of which were closed (choice and scaled) and allowed children to rate the workshop in terms of enjoyment and as a learning experience. To measure knowledge of water conservation and pollution, both questionnaires contained the following three identical open-ended 'knowledge'-based questions 'Where does your drinking water come from?' 'What do you know about water pollution?' and 'How could you use less water?'.


CLASS (circle one): 1ST, 2ND, 3RD

AGE:

1. How do you feel about learning about science?
Circle **ONE** of the following:

2. Have you ever done any science experiments? (Circle one)
Yes **No**

3. Where does your drinking water comes from? (Write or draw)

4. Do you know much about water pollution? (Circle one)
Yes, lots **Yes, a little** **Nothing**

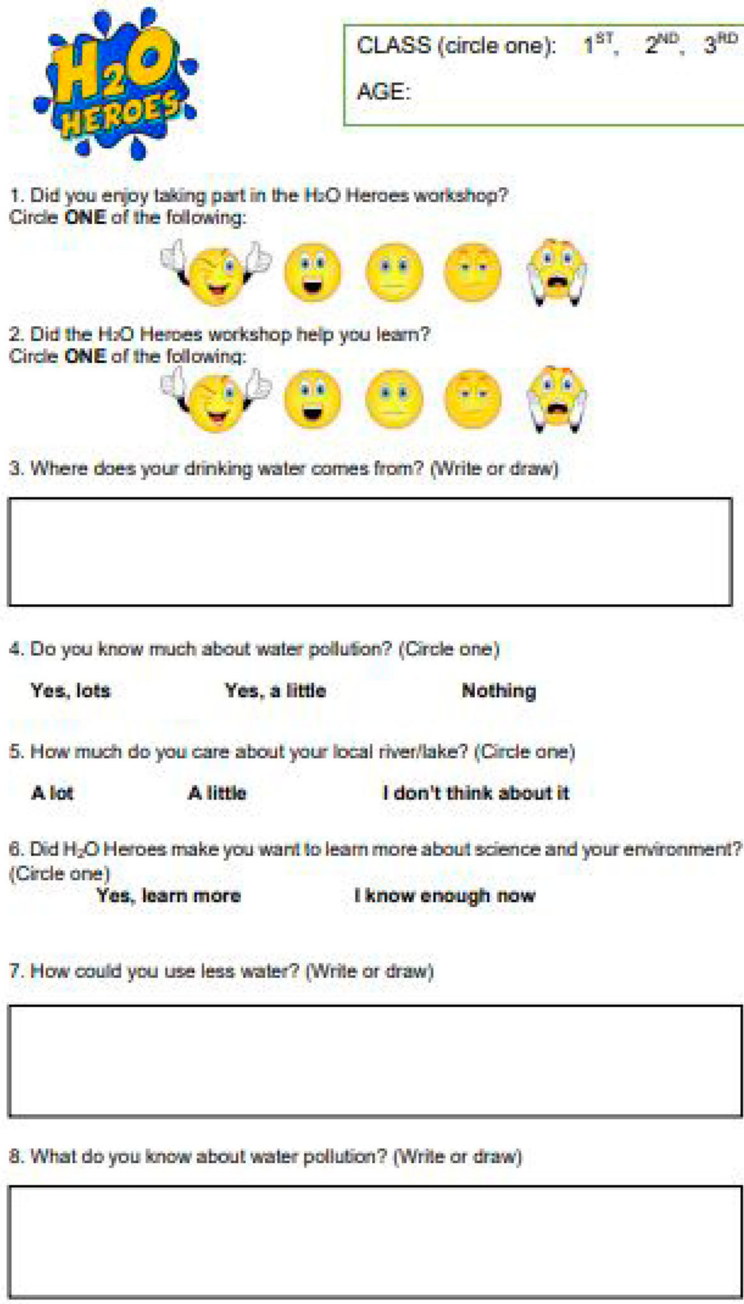
5. How much do you care about your local river/lake? (Circle one)
A lot **A little** **I don't think about it**

6. How could you use less water? (Write or draw)

7. What do you know about water pollution? (Write or draw)

Figure 2. Pre-workshop student questionnaire.

Quantitative data from the questionnaires were analysed statistically using Minitab. The children's qualitative responses were analysed as outlined in Figure 4 (adapted from Franquesa-Soler and Serio Silva 2017; Kalvaitis and Monhardt 2012).



H2O HEROES

CLASS (circle one): 1^{ST}, 2^{ND}, 3^{RD}

AGE:

1. Did you enjoy taking part in the H_2O Heroes workshop?
Circle **ONE** of the following:

2. Did the H_2O Heroes workshop help you learn?
Circle **ONE** of the following:

3. Where does your drinking water comes from? (Write or draw)

4. Do you know much about water pollution? (Circle one)

Yes, lots **Yes, a little** **Nothing**

5. How much do you care about your local river/lake? (Circle one)

A lot **A little** **I don't think about it**

6. Did H_2O Heroes make you want to learn more about science and your environment? (Circle one)

Yes, learn more **I know enough now**

7. How could you use less water? (Write or draw)

8. What do you know about water pollution? (Write or draw)

Figure 3. Post-workshop student questionnaire.

Stage 1 involved a descriptive analysis of the drawings and any annotations made by the children. In Stage 2, a word cloud based on the description of the drawings was created that allowed common themes to be visualised and identified. In Stage 3, children's responses were coded by identifying and noting all the items/features included in the drawings, counting and analysing their frequencies and the context in which they appeared, categorising them. Stage 4 involved assigning numerical values to codes and calculating a total knowledge score for each question to assess the difference before and after the workshop. Given answers were scored correct (1–4 points depending on the accuracy of response/level of knowledge) or incorrect/no answer (0 points); the maximum score was 4 per answer, the minimum was 0 (Dieser and Bogner 2016; Franquesa-Soler and Serio Silva 2017). Finally, in Stage 5 for a deeper understanding of the data, identified themes were explored and analysed (Figure 4).

Parent/caregiver interviews

A sub-sample of 8 parents/caregivers of children who participated in the workshop and who consented to participate in the interviews were selected randomly and interviewed by the researcher (Cohen, Manion, and Morrison 2011). The purpose of these interviews was specifically in relation to Research Question 2 'How effective is the H_2O Heroes outreach programme in promoting intergenerational communication and learning about the environment?' Interviews were conducted 6 weeks after the workshop had taken place (July 2019) to explore how the children had communicated their experience of the workshop. Key to determining if the workshop had been effective in affecting change through intergenerational learning was responses to the following questions:

- Do you think/feel that this programme has influenced your child in any way?
- Do you think your child's interest in water and the environment has changed since taking part in the H_2O Heroes programme?

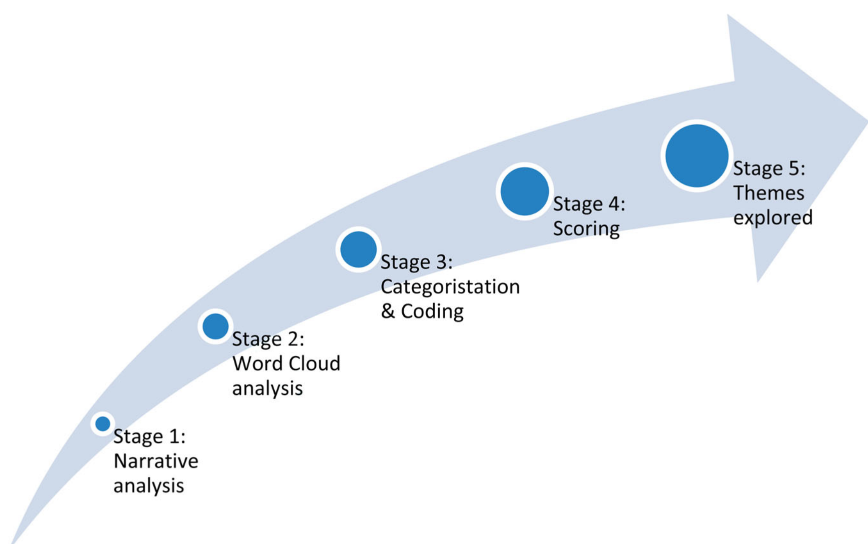


Figure 4. Sequence of analysis of children's drawings conducted.

- Has your family's behaviour or attitude towards water conservation changed since your child participated in the H_2O Heroes workshop?

The semi-structured interviews contained suggested topics and open-ended questions intended to guide the interview proceedings, ensuring that all topics were addressed, while still allowing a degree of flexibility in scope. All interviews were conducted in person in the interviewees homes. On average, the interviews lasted 20 min. Interviews were audio recorded with the participants' consent, transcribed verbatim, anonymised and imported into Microsoft Excel for data analysis as outlined by Bree and Gallagher (2016), transcripts were thematically analysed to identify themes/trends and interpret the data effectively (Istead 2009).

Ethics and consent

The research underwent a full, thorough institutional ethical review and was conducted in accordance with Standard Operating Procedures (SOPs), adapted from the model SOPs developed by the Association of Research Ethics Committees (Association of Research Ethics Committees (AREC) 2013). As this research involved children, special attention was given to ensure that their rights and needs were protected at all times. Two weeks prior to the workshop, a letter with information for participants was distributed to parents/legal guardians and teachers with the details and motivations of the study, including an opt-out for those who did not wish to participate. No information was withheld and the minimal risks were clearly explained. Teachers explained to children that they could withdraw from the study at any point and that completing the questionnaires was optional. To ensure confidentiality, anonymity was assured at all times. The interviews were digitally recorded and once transcribed into written minutes, all digital records were destroyed. All audio recording transcripts were anonymised. All data were stored safely and securely in accordance with institutional policies.

Results

Did the children enjoy taking part in the H_2O Heroes programme?

A number of questions on the children's pre- and post-workshop questionnaires were designed to examine attitudes towards science, if they enjoyed taking part in the workshop and to see if the children viewed the workshop as a learning experience.

Table 1. Children's attitudes towards Science.

Question	*N*	Mean	Median	Range	Mode
Pre-workshop: How do you feel learning about science?	41	1.6	2.5	1–4	1
Post-workshop: Did you enjoy the H_2O Heroes workshop?	36	1.3	2.5	1–4	1
Post-workshop: Did the H_2O Heroes help you to learn?	36	1.9	2.5	1–4	2

Note: The scoring system used was: 1, strongly agree or like it a lot; 2, agree or like a bit; 3, neither agree nor disagree/like or dislike; 4, disagree or dislike a bit; 5, strongly disagree or dislike (Silver and Rushton 2008).

Likert scales are a successful tool for obtaining attitude information from young children and were used (Pell and Jarvis 2001; Jarvis and Pell 2002; Silver and Rushton 2008). Initial analysis of the Likert response questions consisted of calculating the mean, median, mode and response distributions for each question using the scoring system outlined in Table 1. A mean rating of <3 indicated a mean positive response and a mean rating of ≥3 indicated a mean negative response (Silver and Rushton 2008). As evident in Table 1, 84.6% of children already had a positive attitude towards science (mean rating 1.6 < 3), and 88.6% enjoyed participating in the H_2O Heroes workshop (mean rating 1.3 < 3). 77.1% of children felt that taking part in the workshop helped them to learn (mean rating 1.9 < 3); however, there was some uncertainty with 14.2% unsure. Seventy-seven per cent of children responded positively that they now wanted to learn more about science and the environment.

What did the children learn from taking part in the H_2O Heroes programme?

Children's responses to questions related to concepts demonstrated in the workshop were analysed to assess knowledge and comprehension. Question 1 (Q1): Where does your drinking water come from? dealt with drinking water sources (Figure 5); and Question 2 (Q2): How could you use less water? was concerned with water conservation strategies (Figure 6).

A total knowledge score was calculated for each question and statistical analysis carried out in Minitab using two-sample *t*-tests. Both overall knowledge scores and differences in the responses given before and after the workshop were examined to identify items that indicated if the workshop had changed the children's level of awareness and knowledge. The knowledge score was seen to increase after the workshop for both questions, an increase of 30% for Q1 and an increase of 40% for Q2. This result was seen to be a significant increase in terms of the Q2 exhibiting a *p*-value = .005 (a *p*-value < .05 was considered significant). Children also exhibited a

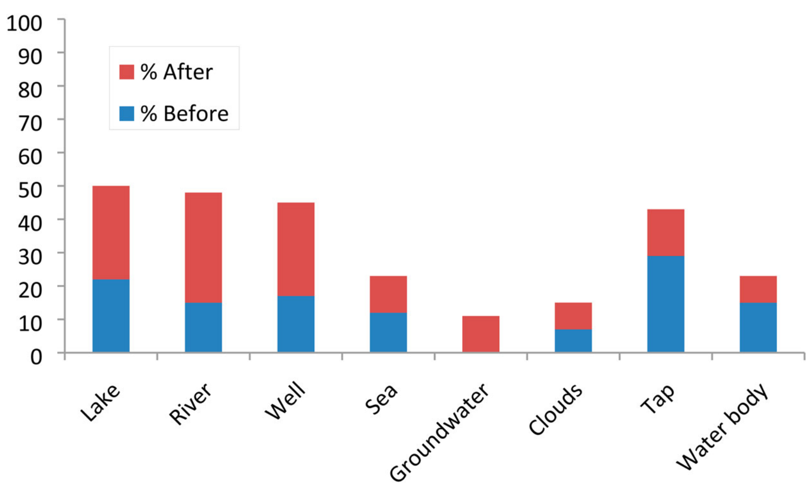


Figure 5. Where does your drinking water come from?

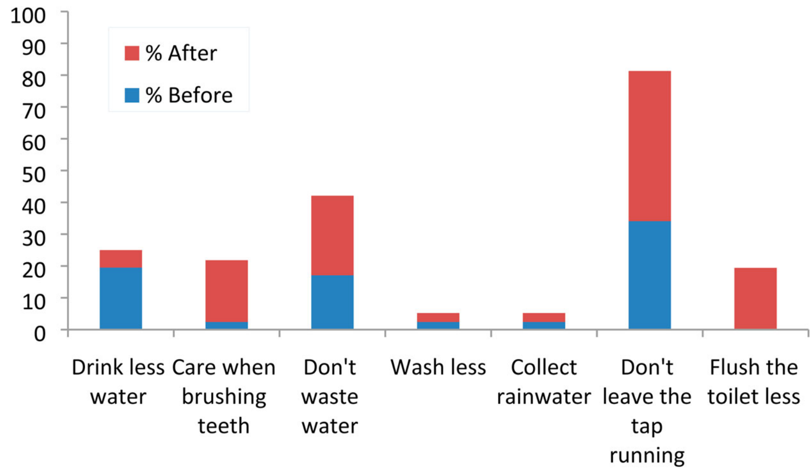


Figure 6. How could you use less water?

wider breath of knowledge after the workshop, for example, 16% more children provided 2 or more answers to Q1 after the workshop compared to before. Water conservation strategies specifically mentioned during the workshop, like ‘Flushing the toilet less’ saw an increase of 19% after the workshop while ‘turning off the tap when brushing teeth’ saw an increase of 17% in responses to Q2.

The children themselves acknowledged that their knowledge of water pollution increased as a result of the implementation of the workshop with almost 30% more children responding that they know ‘lots’ about water pollution after the workshop than before. Parents were asked if they had observed any changes in their children since the workshop and were appreciative of the knowledge gained by the children, e.g. ‘he wouldn’t have known that the year before’.

Analysis of children’s drawings

Drawing has been described as a ‘child-centred’ research method and can give children the opportunity to reveal ‘qualities of understanding’ that can be otherwise difficult to ascertain (Franquesa-Soler and Serio Silva 2017; Nedelcu 2013). Drawing is a familiar activity for children and for many can be a preferred method of communication (Nedelcu 2013). Drawing may not be a suitable technique to use with all children, some children simply do not like to draw and there is the possibility that children’s drawings may be influenced by teachers or their peers, particular care must be taken not to misinterpret the children’s drawings (Punch 2002).

In advance of the workshop, children were asked ‘What do you know about water pollution? Forty-nine per cent of children did not respond or responded ‘don’t know’ showing a distinct lack of knowledge. Research has shown that children do consider water an important environmental resource, but that they underestimate the impact of human activity on water resources and aquatic ecosystems (Kenney, Militana, and Horrocks Donohue 2003). Only five children depicted people in their responses to the water pollution question, many of them drawing ships and the sea, which suggests them not associating water pollution with their locality and their own activities.

Word clouds give greater prominence (text size) to words or phrases with a higher frequency of use and were used as a visualisation technique to communicate an ‘overall picture’ of the content of the children’s drawings in response to the question ‘Where does your drinking water come from? (Heimerl et al. 2014). Prior to the workshop taking place the most frequent drawing was that of a non-descript water body (13) or a tap (12), examples shown in Figure 5.

After the workshop, both word cloud analysis and analysis of drawings illustrate that the children have gained knowledge of where their water comes from with much less variation in responses (Figures 6 and 7). Many children were very specific in their drawing, a number even drawing a version of the hydrological cycle which was covered during the workshop, with lake (11), river (9) and well (11) being the most frequent responses. Mountains (3) and groundwater (3) also made an appearance showing an advanced level of knowledge and that the children were making connections between different water bodies, rather than just giving one answer. After the workshop, the items that scored highest on the question ‘Who needs clean water? were people (12), us (7), everyone (8), animals (9) and fish (11), suggesting that children strongly recognised the need for clean water for everyone including themselves (Figures 8 and 9).

Did the children discuss their learning at home?

Interview transcripts were analysed thematically using a data-driven inductive approach following Braun and Clarke’s (2006) framework. Analysis of individual

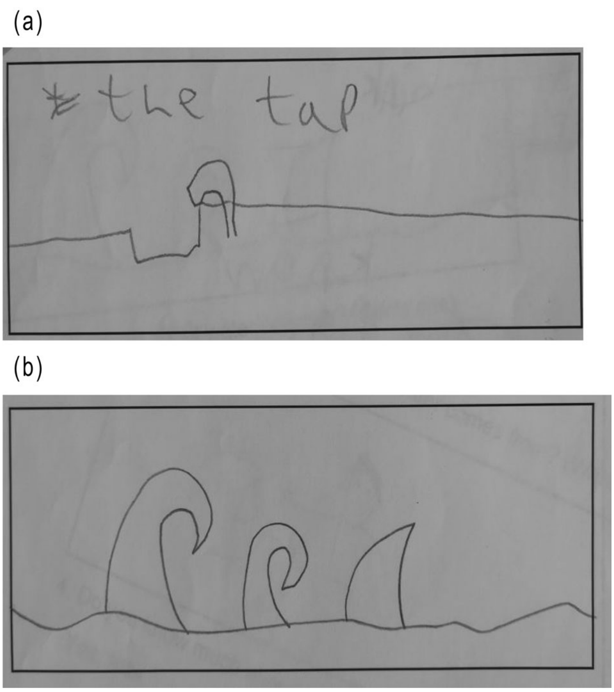
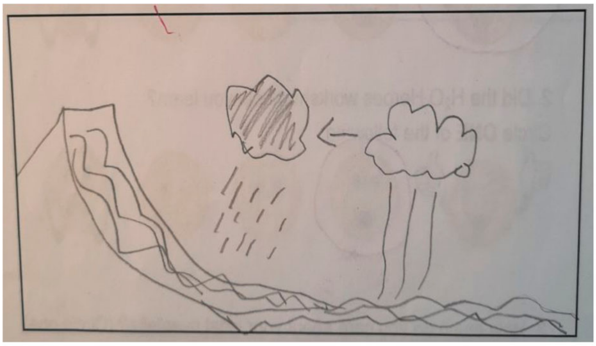


Figure 7. First class (Age 7) pre-workshop drawings in response to the question ‘Where does your drinking water come from?’.

(a)



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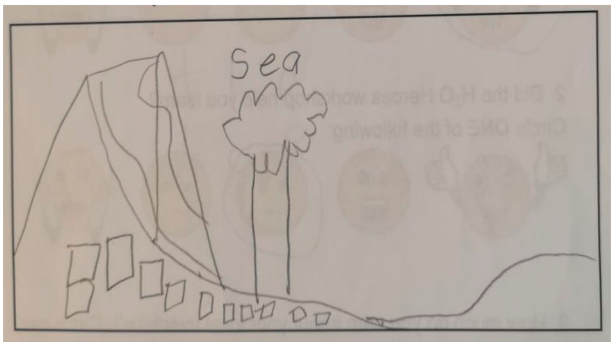

Figure 8. First class (Age 7) post-workshop drawings in response to the question 'Where does your drinking water come from?'.

transcripts commenced with open coding and an initial coding framework was developed, refined and themes were identified (Maguire and Delahunt 2017). Thematic analysis of interview data led to the development of a mind-map representation of themes which visually represents the relationships between the themes (Figure 10). Three overarching themes emerged from the interviews, each incorporating two to four sub-themes: (i) Engagement; (ii) Communication and (iii) Change.

Theme 1: engagement

The themes of 'Engagement' and 'Communication' are intrinsically linked as children are more motivated to share and communicate information if they have engaged with the educational intervention and enjoyed the experience (Istead and Shapiro 2014). Parents/caregivers gave consistently positive feedback about the workshop and all described it as a positive experience for the children. They reported that the workshop was informative, exciting and engaging with the children enjoying the experience: 'came home excited', 'It was very good, they enjoyed it'. All interviewees displayed a positive attitude towards the workshop and its activities. Many welcomed and appreciated the environmental message, one explaining that 'they need to know what's going on in the world' with another 'just delighted they are learning these

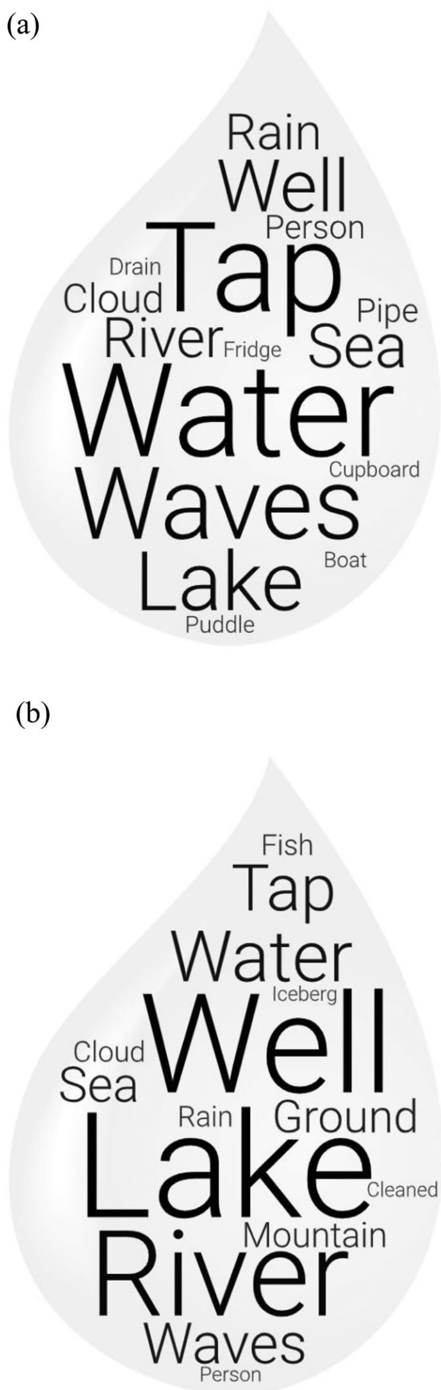

Figure 9. Word cloud analysis showing children's (a) pre-workshop responses and (b) post-workshop responses to the question 'Where does your drinking water come from?'.

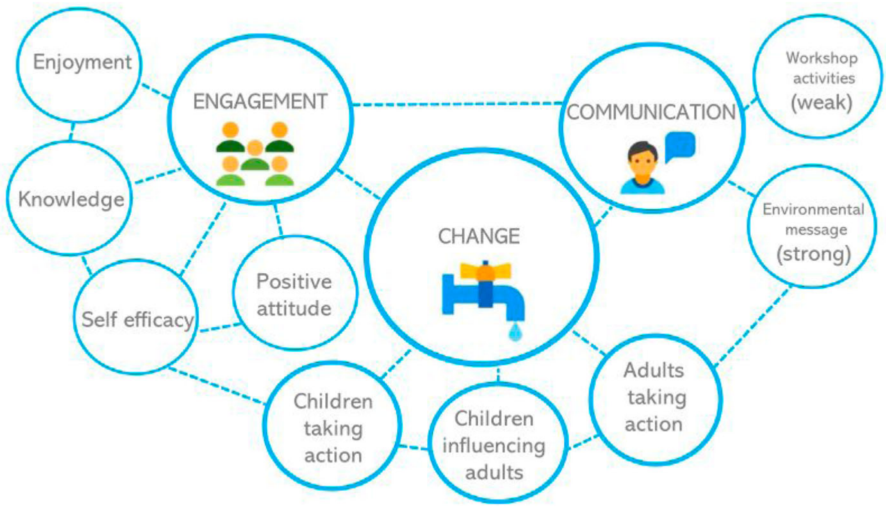

Figure 10. Mind-map representation of themes.

things'. Parents/caregivers in this study were encouraging and valued their children bringing home information about the environment. They appreciated that children had the capacity to absorb environmental information; 'just picking up stuff (information) left and right'. Parents/caregivers valued the workshop as a learning experience and were appreciative of the knowledge gained by the children. Many parents shared examples of how their children had become empowered by the knowledge gained through participation in the workshop with one child 'going around with a sword trying to save the environment', others were strongly challenging their parents to change their household practices in a way they hadn't done before, e.g.

> I am not sure exactly what you were doing in the workshop but I know that, that day, there was absolutely no way he was letting me put the car through the carwash we had to come home and wash it with a brush.

Children increased their environmental knowledge by actively engaging in the workshop and exhibited a belief that they could have an impact on environmental issues. Critically, their parents/grandparents were open to this and valued their opinions, the children were encouraged and this allowed them to develop self-efficacy becoming motivated to take action.

Theme 2: communication

All parents/caregivers were aware that a workshop had taken place, many children had commented on how they had enjoyed the activities with some discussing the activities. The detail of the workshop that was communicated to parents varied with some providing little detail:

> He mentioned you came to the school and was talking about water in particular. … … Had you some samples of water from the lake? and you let them look at bugs in the water and was telling me about the bugs in the water.

There was a mixed response to the ‘take home’ aspects of the programme which were specifically included to initiate communication with parents. The majority of parents were unable to recall seeing the activity booklet. Parents often attributed their child’s lack of communication about what happened in school to their personal characteristics and preferences. Several parents described their child as not being a ‘chatty’ type, ‘He doesn’t tell you what happened in school’.

Despite the ‘weak’ communication about the workshop activities, an encouraging finding of this study is that all children strongly shared the environmental message, discussing water conservation at home and how to take action. In most cases, this discussion was ongoing; it had been discussed on more than one occasion and was directly linked to adults taking action in relation to water conservation. Parents reported that discussion had arisen mostly as a result of their behaviour in relation to water use, with children sharing methods of water conservation with their parents and urging them to change their behaviour.

Theme 3: change

The children enjoyed the workshop, had a high level of engagement and communicated the environmental message to their families, only then was change possible. Assertiveness and determination was clearly evident in accounts of how the children’s attitudes and behaviours had changed since the workshop. One parent described how ‘He gave out to me for letting the water run when brushing my teeth’ and another ‘She has stopped letting the tap run when she is brushing her teeth’. Most participants reported an increased awareness of water use and the importance of water conservation: ‘He said that we were wasting water and damaging the environment’. All had noticed a change in the 6 weeks since the workshop took place, many parents reported significant changes in relation to children flushing toilets less and turning taps off.

> They are not now flushing the toilets as much as they should. You know it’s disgusting, they won’t flush, I don’t know if you told them … … they don’t flush as many times after a pee and turn off the taps, don’t leave them dripping … … Before they would always have been in and out washing their hands leaving the tap running, they would forget, so it has been a change big time.

Many parents articulated that after participating in the workshop, children had taken on custodian roles strongly reminding them about their water use. Many welcomed and appreciated the active role of children in transmitting information that they learned at school, explaining that, ‘When they learn something at school and bring it home we take it on board’. Many participants recognised that children hold environmental knowledge that they do not possess so will listen to what children have to say. Most participants recognised the role of children as educators; ‘they educate me about everything that is going on’, ‘it will come from the youth to educate us’. Participants valued the information communicated by children and viewed them as having up-to-date information, being as one participant described ‘very up with it’. One participant explained ‘We all should listen to our grandchildren because they are the future’.

Some participants reflected back on their own water use, when they noticed changes in their children’s behaviour: ‘thinking about it more’ ‘I am remembering more now'. The workshop led participants to evaluate their own relationship with water with many feeling guilty: 'I don't conserve as much as I should', 'we do use a lot of water we probably have to start looking at it', 'not as good as I should be'. All participants indicated their intention to do more in terms of water conservation because of involvement in this research study: 'I consciously am making changes more', 'only turn it on (tap) when we need it' and half of the parents interviewed had already changed their behaviour in relation to water use. However, some admitted that even though they had an increased awareness their behaviour had not changed:

> when I am flushing the toilet now, it's in my head, do you know it is in my head, I still flush it but I have more of an awareness.

Discussion

The biggest challenge facing a short-duration intervention strategy like H_2O Heroes, is how can there be a long-term, societal impact? H_2O Heroes was designed based on a change model, with the theory being that positive experiences with science, developing an enthusiasm around science, meeting scientist role models, and participating in hands-on activities would translate to longer term goals (Laursen et al. 2007).

So were the goals of this project achieved, first of all, and did the H_2O Heroes programme enhance EE in a primary school? The mixed-methods design approach adopted facilitated the analysis of data from a number of perspectives. The majority of children enjoyed participating in the H_2O Heroes workshop and exhibited a positive attitude towards learning science. As one parent said 'they love Science and were really excited'. However, it must be noted that children can have different views on what 'science' actually is, often focusing on their experience of science at school and the difficulty in measuring children's attitudes towards science has been well documented (Osborne, Simon, and Collins 2003).

So, the children had fun but did they learn anything? To evaluate the effectiveness of the programme in meeting its goal of promoting science education, changes in children's environmental knowledge and their grasp of the workshops learning objectives were assessed. Evidence that children, after participating in the workshop, had an increased knowledge of where their drinking water comes from and water conservation actions included improved knowledge scores. Evidence that children had learnt the features of the hydrological cycle was seen on the post-workshop assessments, where children made connections between surface water, groundwater and precipitation. Evidence of learning was also obtained from parent interviews where children communicated methods of conserving water at home which they had not known before. The data confirm that participating in the programme had a positive impact on children's attitudes and environmental knowledge. Participation in the H_2O Heroes programme produced a knowledge increase immediately, the impact of which was still evident 6 weeks later as evidenced by the parent interviews. Well-structured education programmes have previously demonstrated learning potential and knowledge gains (Ballantyne, Fien, and Packer 2000; Dieser and Bogner 2016).

A number of studies have concluded that intergenerational learning has an important part to play in EE and that there is the potential for information to reach more people, thereby having a greater impact (Williams, McEwen, and Quinn 2017). Through intergenerational learning, children have the potential to be educators, educate their families and even inspire community environmental action (Vaughan et al. 2003). One of the key principles aimed to encourage child to adult intergenerational learning that was applied to the H_2O Heroes programme was the addition of 'take home' activities designed to promote parental involvement, stimulate discussion and to deepen the understanding and memory of the workshop (Lawson et al. 2018; Ballantyne, Fien, and Packer 2000). The take-home activity booklet was seen to have had little impact, with the majority of parents interviewed unable to recall even seeing it. A design limitation is that there is no way of ensuring parental involvement, as outside influences could influence how much time parents have to spend with the child engaging with the booklet. Timing could also have been a factor, the workshop took place at the end of the school year, and this meant that the children do not have homework which could have influenced this lack of engagement.

The children's lack of detailed communication about the workshop activities was surprising; it was clearly an enjoyable, fun experience for the children. It is evident, however, that the workshop was a positive learning experience for the children. The children's pictures in the post-workshop assessments are one example which demonstrates how they effectively absorbed and processed information. The means by which the children had learned was not shared or perhaps not recalled, but more importantly, the environmental message was recalled, understood and acted upon. Parents' comments about the instances that prompted dialogue with their children are helpful in revealing aspects of the programme that facilitated intergenerational knowledge transfer. Parents reported that discussion had arisen mostly as a result of their behaviour in terms of water usage which prompted the children to act. As described in the Results section, the analyses of parent/grandparent interviews clearly identified that the children communicated little to their parents in terms of the workshop activities; however, all of the children communicated the environmental message, that water needs to be conserved and behaviour had to change very effectively.

These results effectively demonstrate the intergenerational transfer of environmental knowledge from child to parent/grandparent. Previous research in the field points out that a key factor to intergenerational learning is the strength of the relationship between the child and adult. However, there are many factors which influence this transfer of knowledge that are not explored here, which is a limitation of this study (Ballantyne, Connell, and Fien 1998). All parents interviewed already had a positive attitude towards science, so not surprisingly they valued the educational aspects of the workshop and viewed it as a learning experience. Families with higher levels of science capital actively promote, develop and sustain their children's science interest and aspirations, through the grounding of science within everyday family life (Archer et al. 2012). A positive attitude towards science has a significant influence on learning, and research has shown that attitudes developed in primary school influence the choices of students later in their life (Osborne, Simon, and Collins 2003). Children need to be given permission, in order to become agents for change and the attitude of their parents and families is an important factor in intergenerational learning (Duvall and Zint 2007; Williams, McEwen, and Quinn 2017).

It is acknowledged that sources of environmental influences may be varied and multiple, so there is an assumption here that the source of influence is the fact that the children all participated in the H_2O Heroes programme. This assumption is strengthened by the fact that all interviewees cited the phrase 'If it's yellow let it mellow, if it's brown flush it down', which had been specifically communicated to the children during the workshop in relation to toilet flushing. All interviewees reported that children actively attempted to influence environmental behaviour at home, whether successful or not this is a form of active participation and shows environmental stewardship (Eilam and Trop 2012). In many cases, this was very successful with behavioural changes in terms of water usage. This follows similar patterns in the literature, where an EE curriculum did not directly target parents, but still led to measurable changes in knowledge, attitudes and behaviours at home (Vaughan et al. 2003). The results of the interviews with individual participants about their behaviours should be treated with caution as there is no guarantee that they were reporting their behaviour in an accurate and unbiased way. A number of studies present evidence that suggests systematic bias in self-reported behaviour (McPherson Frantz and Mayer 2014).

Conclusions

The findings from this exploratory study indicate that children who participated in the H_2O Heroes programme exhibited gains in their understanding of water pollution concepts as well as changed, more pro-environmental values, attitudes and behaviour. Specifically, children (a) demonstrated increased understanding of the hydrological cycle and water catchments; (b) experienced a statistically significant increase in water conservation knowledge; and (c) demonstrated pro-environmental values and attitudes and shared this knowledge at home which ultimately resulted in behavioural changes.

When the study was designed, the approach to integrating a plurality of voices, those of children and parents was considered as a strength; however, the small sample size and the focus on one school means that the findings cannot be generalised. The results of this study are encouraging and suggest that child to adult intergenerational learning is possible and this can be an effective way of engaging younger and older generations and achieving environmental change. Further research is required to obtain a deeper understanding of the intergenerational learning effect and this study will serve as the foundation for a larger scale study involving more schools in different regions of Ireland.

The importance of water education initiatives like H_2O Heroes is even more important when considered in the light of climate change predictions and other pressures that will impact water resources for future generations. Now more than ever, both children and adults alike need to connect with their local environment and embrace both science and education in order to build resilience for their futures.

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