



**QUEEN'S
UNIVERSITY
BELFAST**

An exploration of parents' engagement with learning about climate change through science education: learnings for future practice

Broderick, N., Kelly, O., Murphy, C., Kerr, K., & Whelan, J. (2024). An exploration of parents' engagement with learning about climate change through science education: learnings for future practice. *Environmental Education Research*. Advance online publication. <https://doi.org/10.1080/13504622.2024.2403398>

Published in:
Environmental Education Research

Document Version:
Peer reviewed version

Queen's University Belfast - Research Portal:
[Link to publication record in Queen's University Belfast Research Portal](#)

Publisher rights

Copyright 2024 the authors.

This is an accepted manuscript distributed under a Creative Commons Attribution License (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the author and source are cited.

General rights

Copyright for the publications made accessible via the Queen's University Belfast Research Portal is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The Research Portal is Queen's institutional repository that provides access to Queen's research output. Every effort has been made to ensure that content in the Research Portal does not infringe any person's rights, or applicable UK laws. If you discover content in the Research Portal that you believe breaches copyright or violates any law, please contact openaccess@qub.ac.uk.

Open Access

This research has been made openly available by Queen's academics and its Open Research team. We would love to hear how access to this research benefits you. – Share your feedback with us: <http://go.qub.ac.uk/oa-feedback>

An exploration of parents' engagement with learning about Climate Change through science education: Learnings for future practice

Dr Nicola Broderick¹, Dr Orla Kelly^{1,3}, Dr Cliona Murphy¹, Dr Karen Kerr², Dr Joan Whelan¹

¹ School of STEM Education, Innovation and Global Studies and Centre for the Advancement of STEM Teaching and Learning, Dublin City University, Ireland

² School of Social Sciences, Education and Social Sciences at Queen's University Belfast, Northern Ireland

³ Corresponding author: orla.kelly@dcu.ie

Abstract

Climate change education is crucial to addressing the climate crisis. Studies show that parents and guardians can play an important role in transmitting knowledge, competencies, and a pro-environmental orientation to their children. Whilst climate change education can span many disciplines, it has been effective within science education. In this paper we embrace evidence-based effective approaches to science education, with parents. Climate change education research literature published to date focusses on school-based interventions and there is a dearth of literature on parental involvement. This paper describes the development of, and outcomes associated with, a programme to promote engagement with climate change education for families from socioeconomically disadvantaged backgrounds. Data were gathered through post semi-structured interviews and reflections on posters and photos created and collected throughout the programme. Findings indicate that this approach engaged parents in climate change education with their children and successfully addressed various misconceptions. The programme presents a real opportunity to engage parents in their children's formal education.

Key Words

Climate Change Education, Science Education, parental involvement, inquiry-based science education

SDG Keyword

SDG 4: Quality Education

Introduction

Parental engagement in the education and school life of primary aged children is well-cited in the literature and supported in the policies of many countries. Whilst the term parental engagement specifically includes the word “parent”, internationally this is understood to include all those with a role in bringing up and caring for children and is often referred to as “family engagement” (Whitaker, 2019). For the purposes of this paper, we are taking “parent” as all those with a direct role/responsibility for bringing up and caring for the children in our sample. These included parents/guardians/grandparents/carers. Both nationally and internationally, it is well accepted that there are positive associations between certain types of parental involvement in children’s education and student outcomes, including academic achievement and desirable student behaviours (e.g. Desforges and Abouchaar, 2003; Goodall, 2017). Many studies have also indicated that parental engagement leads to positive impacts including improved student mental health, motivation, self-efficacy, and social skills (Froiland, 2021; Jeynes, 2017; Moè et al., 2018; Green et al., 2007; Hill & Craft, 2003).

Parents’ rights as primary educators of their children are enshrined in the Irish Constitution (Government of Ireland, 1937). However, despite numerous policy initiatives, parent involvement in an Irish context can be considered quite limited. For instance, while Bleach (2010) reported high levels of parental involvement with homework for children in the junior classes, parents **stated** that they believed they had very little influence, either locally or nationally in their children’s education. Indeed, fewer than one-in-ten students in Ireland, compared to one-in-six on average internationally, had parents who participated in school governance activities (Nelis et al. 2021). Eivers and Creaven (2013) reiterated that parental involvement at Irish primary school level is largely limited to helping with homework and receiving updates about school accomplishments. PISA (2015) stated that Irish parents also reported less participation in school-related activities, such as volunteering to support school activities, than parents on average across OECD countries (Shiel et al., 2016). Barriers to greater school involvement, reported by parents in Ireland from PISA 2018, were not being able to get time off work; inconvenient meeting times; parents being unsure how to participate; and their child not wanting them to participate (Nelis et al 2021).

Possible explanations for such limitations are well-cited. For example, teachers and schools are sometimes limited in what they think effective parental engagement should be (Hindin and Mueller, 2016) and encourage the aspects they think parents need to do (Dauber & Epstein, 1993). Parental engagement is often measured in relation to parental visibility and involvement within the school, other than engagement with children’s learning and development at home (Kim, 2009). Thus, researching how parents can be supported to become actively involved in their child’s learning is warranted. Furthermore, the recently published Irish Primary Curriculum Framework supports a partnership approach to education with parents recognised for the key role they should have in their child’s education (DE, 2023). The framework advocates that children’s learning should be extended and supported at home through a range of diverse and enriching learning experiences.

Climate change education is considered one of the most important and effective means of developing capacity to address the climate crisis (Stevenson et al., 2017). While climate change education cuts across disciplinary boundaries, science education has been recognised as key if we want young people to become informed, active citizens capable of responding to the climate crisis (Sharma, 2012; UNESCO, 2019; Yacoubian, 2018). However, research suggests that many youth do not understand basic climate science (Leiserowitz, Smith, and Marlon 2011; Shepardson et al. 2009; Taber and Taylor 2009). One of the overall goals of science education curricula worldwide is the development of students' scientific literacy which encompasses not only the development of disciplinary science content knowledge but also connects science to students' everyday perspectives and develops their ability to make decisions on societal and environmental issues as informed, active citizens (Broderick, 2023). Science education therefore has the potential to not only promote the development of climate science content knowledge but also an understanding of the social, cultural, economic and political influences that impact climate change policies, discussions and actions (Zeidler, 2014).

In a primary science education context, numerous studies have reported the effectiveness of science education interventions in enhancing primary school students' environmental knowledge, sustainable action and competencies, and positive attitudes towards the environment as reported in the systematic literature review by Murphy et al., (2023). For example, Lombardi and colleagues (2013) reported a significant conceptual change was evident and maintained six months after a climate change education intervention. Findings from several studies also highlight the impact of environmental studies on children's pro-environmental behaviours (Kos et al., 2016; Murphy et al., 2021). Furthermore, Murphy et al. (2023) highlighted the key role inquiry-based learning plays in science education in curricula internationally and when coupled with social constructivist principles, it emerged as one of the key themes in terms of effective approaches to science education, with positive impacts on students' conceptual learning and scientific skill development reported among other benefits. Inquiry based science education is an inductive approach giving more space to observation, experimentation and the teacher-guided construction by the learner of his/her own knowledge (Rocard et al. 2007). Murphy et al's (2021) study focussed on an inquiry-based approach to teaching sustainability and proved effective.

It is clear from the literature that teachers can impact children's learning about climate change and indeed most of the climate change education research literature published to date focusses on school-based interventions. However, there appears to be a dearth of literature on parental involvement in children's climate change education. For instance, out of the 49 intervention studies identified in the Monroe et al. (2019) systematic literature review, no study focused on parents as the target participants. That said, a number of other studies have concluded that parents have a strong influence on their children's attitudes and behaviour towards the environment and climate change (Arnold et al., 2009; Corner et al., 2015; Leppanen et al., 2012; Mead et al., 2012). Arnold and colleagues (2009) for example, conducted interviews with young environmental leaders (n=12) and identified parents as one of the dominant influences on their environmental action. Corner et al. (2015), in their review of international studies pertaining to climate change education, identified a few studies that highlighted the

significant positive role that parents have on their children's climate-relevant beliefs and behaviours. In Finland a significant correlation between mothers and fathers ($n=212$) and their child's/children's ($n=237$) attitudes towards the environment was reported (Leppanen et al., 2012). According to Mochizuki and Bryan (2015) families and communities benefit when individuals share what they have learned especially in relation to climate change adaptation and mitigation. Mead et al. (2012) concluded that climate change-related interventions can maximise their impact by using the family as the significant unit of intervention. In a study by Stevenson et al. (2019), the frequency of discussion with friends and family was the second strongest predictor of climate change concern for adolescents, with families having more influence than friends in their study. Furthermore, Lawson et al. (2019) in their study with adolescents and their families suggest that promoting climate-related conversations within households may promote climate action even when parents are apathetic about climate change. Interestingly, in a recent study by Madden et al. (2023) on parents' perspectives on climate change education, parents expressed concerns about their own readiness to support this instruction at home. Furthermore, several respondents voiced concerns about how to approach climate change discussions in a way that is mindful of children's developmental and mental health needs. This is supported by an NPR study, reported by Kamenetz (2019), where more than 80% of parents in the US support the teaching of climate change yet fewer than half of the parents had discussed the issue with their children.

In the context of science education there is research that explores parental involvement in children's education. Strickler-Eppard et al. (2019) for example, assessed the impact of engagement with a science education pack on families' experiences of inquiry-based science activities. They concluded that this diverse group of families were "very capable facilitators of science experiences for their young children when provided with carefully designed supportive materials" (p. 663). In an Irish context, Gilligan and colleagues' 2020 study strongly advocates the importance of early engagement with scientific concepts particularly for marginalised groups including families living in poverty/disadvantage. According to Gilligan (2020), young children learn whether science is important through the extent of parental involvement in early science education, through informal activities such as visits to museums and parks, reading and talking about science at home.

It is apparent from the literature that involving parents directly in climate education and inquiry-based science education can have positive effects on parents' and children's scientific literacy, climate-relevant beliefs and behaviours. To this extent, the current study explored parental engagement in a programme that was designed to enhance parents' climate change understanding and, as a consequence, to better enable parents to support their children's learning about Climate Change in their homes. This study also offers practical insights to how parents can be supported to become actively involved in their child's learning at home, beyond homework, to more tangible engagement with curriculum learning and development. This work supports Sustainable Development Goal 4: Quality Education. In line with this focus, the following research questions were explored:

How can primary school parents be supported to engage their children in climate change education and science education in their homes?

What are the features of an effective programme for supporting parents in helping their children learn about Climate Change while engaging in science inquiries in their homes?

Methodology

The Programme

The overall aim of the programme was to enhance participants' (parents) engagement with science education, understanding of climate change and engagement with climate action. To this extent two, three-hour workshops were developed that aimed at supporting the development of participants':

- conceptual understanding of climate change through experiential learning
- confidence to engage in scientific inquiries
- confidence to discuss scientific issues with each other and with their children
- understanding of actions that can be taken to mitigate climate change at local levels in their homes.

This was followed by a celebration event where families got to share and celebrate their learning and climate actions.

Features and overview of the Programme

The workshops were underpinned by Monroe et al.'s (2019) strategies for effective climate change education pedagogies in that they were designed to:

1. make climate change information personally relevant and meaningful for the learners
2. engage learners
3. provide opportunities for discussion to develop personal understanding and to listen to others' viewpoints and knowledge about climate change
4. provide opportunities to interact with scientists and to experience the scientific process
5. uncover and address misconceptions about climate change/science
6. support participants in designing and implementing community (home) projects to address an aspect of climate change.

Specific examples regarding how the workshops addressed Monroe and colleagues' strategies are provided in Table 1.

Table 1: *Examples of how the workshops were underpinned by Monroe et al 2019 features of effective CCE*

Monroe et al. (2019) effective climate change education strategies	Exemplars from the programme
--	------------------------------

The programme focused on making climate change information personally relevant and meaningful for the learners.	The Energy Audit from workshop 1 provided opportunities to examine energy use in their own family contexts. Parents were asked what topics they would like to address in workshop 2. Bees and biodiversity and Fast Fashion emerged as two key themes which informed both workshop 2 and the ‘at-home’ activities for workshop 2.
The activities or educational interventions were designed to engage learners.	Workshops provided opportunities for all participants to engage in hands-on activities. During workshop 1 participants completed an insulation fair test¹ investigation in small groups of 3/4 participants.
Educators used deliberative discussion to help learners better understand their own and other’s viewpoints and knowledge about climate change.	Each workshop provided opportunities for participants to respond to key questions and discuss possible mitigation actions that could be taken in response to the climate change issues addressed during the workshops. Small group discussions were a core pedagogy used throughout each workshop.
Learners were given the opportunity to interact with scientists and to experience the scientific process for themselves.	Each participant was provided with opportunities to engage in the scientific process through science inquiry-based investigations and scientific observations.
Programs were specifically designed to uncover and address misconceptions about climate change.	Some common misconceptions pertaining to climate change were identified during workshop 1 - for example the melting of sea ice contributes to rising sea levels was identified as a climate change misconception. Participants then conducted a scientific inquiry to investigate this.
Learners were engaged in designing and implementing school or community projects to address some aspect of climate change	The ‘at-home’ activities provided opportunities for the participants and their children to address a number of aspects of climate change. For example, participants and their children assessed (i) how they travelled to school, (ii)

¹A fair test is a scientific investigation where attempts are made to control all variables except the one being tested. For example, the length of slope and the vehicle used would be kept constant when investigating the effect of different materials on how fast a car goes down a slope.

	discussed whether this was the most environmentally friendly way to travel to school and (iii) identified/took action to travel in a more sustainable manner.
--	---

The programme was developed and delivered by science education academics, with extensive experience in science education, education for sustainability and climate change education. The workshops were held in school grounds, as The Delivering Equality of Equal Opportunities in (Irish) Schools (DEIS): An Action Plan for Educational Improvement (DES, 2005) highlighted the importance of involving parents and the wider community in the learning process and that this is likely to be more successful if it was in a school or classroom setting.

The programme comprised two, 3-hour workshops where participants (parents) engaged in a number of hands-on scientific inquiries that afforded opportunities to develop their scientific content knowledge and skills, and knowledge about climate change and climate action. Throughout the workshops scientific content and inquiry skills were highlighted, links were made to climate change and climate action where relevant, and there were frequent opportunities for discussion, reflection and sharing of experiences. The workshops were designed to enable parents to experience several inquiries and activities and build their confidence to subsequently conduct these with their children at home. Booklets, containing activities, instructions and scientific content knowledge for parents, and hands-on resources were provided to support parents in implementing the at-home activities. An overview of the content of the workshops and at-home activities can be found in Table 2.

Table 2: *Overview of Content of Workshops*

Workshop A	Workshop B
Introduction: Aims of programme. Paper Spinner Investigation: Introducing the participants to scientific fair test investigations. Focus of investigation is on the development of scientific skills. What is Climate Change Discussion Activity: Participants discuss in small groups. North Pole (Sea Ice) V South Pole (Land Ice) Melting investigation: Participants predict in groups which has an impact on rising sea levels. Participants complete a scientific experiment to investigate this.	Introduction: Review at-home activities. Provide opportunities for discussion. Bees and Biodiversity: Explore participants' prior knowledge of bees. Discuss why bees are in decline. Conduct a number of activities to mitigate the decline of bees in their own contexts: (ii) Plant bee friendly plants. Participants will investigate what conditions are required for growth. (iii) Design and make a bee hotel. (iii) Discuss other actions that could be taken: For example avoid cutting grass; create habitats for solitary bees. Reduce Reuse Recycle: Discussing how

Conducting an Energy Audit: Participants discuss the completion of an energy audit in their homes. Insulation Activity: Conduct a fair test investigation to identify which is the best insulator.	this can be used in their own contexts. Investigate the life cycle of everyday materials (e.g. coffee cup). Observing materials and identifying which can and cannot be recycled. Fast Fashion: Developing understanding of fast fashion. Participants research problems associated with fast fashion. Travel Wisely: Participants discuss how they travel and what forms of energy they use.
At-home Activities (after Workshop A). To be completed with the participants' child/children	At-home Activities (after Workshop B). To be completed with the participants' child/children
Spinner investigation Introducing children to fair test investigation and development of scientific skills. Climate Change Research Activities A range of online resources where participants and their children can research climate change. Energy Audit: To be completed at home with their child/children. Participants identify actions to reduce energy consumption at home. Insulation investigation: As part of the energy audit, participants identify where their homes are insulated. To investigate insulation, participants conduct a fair test investigation to identify which material/s are the best insulators.	Planting Science Activities: Parents and their child/children plan how to create biodiversity friendly zones for bees in their own context. They complete a number of science activities and observations: (i) Planting and then transplanting bee friendly seeds. (ii) Creating a self-watering plant for herbs. (iii) Design and make a bee hotel to create a solitary bee habitat. Decomposition Investigation: Participants investigate how long it takes common household items to decompose. Travel Audit: Participants audit how they travel and what energy sources are being used. Participants identify and take actions, where possible, to travel in a more sustainable manner.

There was a two-week gap between the first and second workshop and a six-week gap between the second workshop and the celebration event. These gaps were deliberately designed to afford the participants opportunities to carry out the investigations and action projects associated with the programme in their homes. To facilitate communication and sharing between workshops, a WhatsApp group was set up for each of the participating schools. This also served to promote a community of practice between the participants, facilitators, and

teachers in each school. Using the WhatsApp forum parents shared photos of their investigations, their action projects and asked questions about the learning activities and climate science literacy.

The programme culminated in a celebration event that brought 18 parents and 19 children from both schools into the university where they gave short presentations about what they had learned over the course of the project. At this event parents and children shared their co-created posters and co-presented about the different scientific inquiries and actions they had taken to take steps towards mitigating climate change in their homes as part of the project. Parents and their children also participated in a workshop which aimed to further develop their understanding of the interconnectedness between our actions and the climate. Parents and their children worked collaboratively in small groups to complete investigations and activities. Finally, opportunities to discuss further mitigation and action were provided.

Sampling and Participants.

10 DEIS (Delivering Equality of Opportunity in Schools) schools from the Dublin region were identified through purposive sampling and invited to participate in the programme via email. Two schools agreed to participate. Through collaboration with the Principals, Home School Liaison² (HSCL) and the Parents' Association in both schools, invitations were sent out to children in senior classes (3rd class - 6th class, ages 8 - 12) to participate in the programme. This resulted in 40 parents (representing 40 families) from the two schools agreeing to participate in the programme. The HSCL worked alongside the programme team to organise the workshops and send regular reminders to the participants. Following consultation with the parents, two workshops were scheduled during the school day, in the mornings just after participants had dropped their children to school.

Data Analysis

Data comprised two post-programme semi-structured interviews with four participant parents; researcher reflections on seven posters, co-created by parents and children, and 12 photos, of the at-home activities shared by the parents on the WhatsApp group. All adult participants were invited to participate in the post-programme interviews, however only four were available and interested. The A4 posters and the photos illustrated the various aspects of the programme which the parents and children wished to highlight. Thematic analysis (Miles Huberman and Saldana 2016; Saldana, 2016) was used to analyse the interview data. A pre-coding process comprised professional transcription of the interviews and the collection of the visual data by one member of the research team. All data were anonymized.

² HSCL - The primary role of the HSCL Coordinator is to focus directly on the 'significant adults in children's lives' (p.7) in order to improve educational outcomes for children and to provide direct benefits to those children. A key element of the HSCL co-ordinator role is home visitation; the role also involves the provision of relevant courses and classes for parents to promote their own learning and in turn that of their children, with a particular focus on literacy and numeracy. A key element of the methodologies is empowering parents to work with other parents toward these goals.

The first cycle of coding comprised an initial exploratory inductive coding of the interview data by one member of the research team and the writing of memos, independently, by three members of the research team of their initial reaction to the visual data, that is the posters and the photos (Saldana, 2016). One member of the research team (who had not participated in this process) then collated this document and identified some exploratory themes. Each member of the research team then read the complete document independently. Emergent themes were discussed at a subsequent meeting. This enabled the research team to begin to capture the processes used by the parents at home when engaging in the tasks and activities.

Second cycle coding was an iterative process of moving towards an interpretive stance (Miles et al. 2014). This involved refining the codes and naming themes and establishing the credibility of the initial impression (as written in the memo) of the images through writing analytic memos. One member of the team carried out an initial stage of this process. Following this the team met and discussed the naming of the themes and further revisions were made. Following this process, four interconnected themes relating to the programme design were identified: Positive Impacts and New Perspectives; Not Everything Worked; Everything is Connected; Pedagogy Matters.

Ethical considerations and trustworthiness

Institutional ethical research approval was granted by the Research Ethics Committee, Dublin City University (DCUREC/2022/045) and all ethical protocols were strictly adhered to. A consent form that included a plain language statement that clearly outlined the research aims was sent to the participants in advance of the interviews. The interviews did not ask the participants to divulge any personal information; nevertheless, the participants were assured confidentiality. Participants were assured that all data were anonymised and consent was sought to analyse the photos of the home activities that were shared on WhatsApp.

The trustworthiness of the analysis was ensured by an ongoing process of inter-rater reliability as described above and by adherence to the ground rules of ethical qualitative research (Miles et al 2014; Saldana, 2016).

Findings

Positive Impacts and New Perspectives

All interview participants (n=4) described the positive impact the programme had on themselves, their families, their community, and their workplace. The programme helped them to see issues relevant to their lives from a climate change perspective towards consideration of taking mitigating actions. One parent summarised the programme as *‘very insightful. I learnt an awful lot in the short space of time and I will take those things with me’*. Others agreed with this statement with another saying the programme impacted *‘not just my child but my whole family. And everyone I’d meet, [anyone] I’d come in contact with since I started the project’*. These parents were very enthusiastic about the opportunity to educate their children and

communities; one said ‘...*the more you know you are more prepared and you can pass more to your child and then well to your family member*’. A mother talked about the ‘*excitement of being able to pass the information [she had learnt at the workshops] to the kids when they're playing*’ [in the] ‘*home atmosphere*’.

The analysis demonstrated explicit links between the workshop activities and the parents’ understanding of, and attitudes towards, climate change issues. One parent described the impact one aspect of workshop 2 (to do with fast fashion) had on her attitudes towards buying clothing. She described herself as being ‘*really shocked*’ by the manufacturing process and highlighted the importance of this information being more widely accessible. Similarly, another parent made explicit reference to having a greater appreciation of food waste and associated this with growing her family growing their own fruit and vegetables as part of the ‘at-home activities’ in workshop 2. This parent felt her daughter was now aware of the growing process; ‘*it’s not like they [fruit and vegetables] grow only in Lidl or Tesco*’ and through that she developed a greater appreciation of not wasting food.

A future-oriented focus was evident when these participants talked about what their families could do to reduce the impact of climate change. Ideas suggested by the participants ranged from managing food waste through ‘*shopping wisely*’ ie shopping every few days to minimise waste; finding new ways to conserve electricity, such as using a flask to keep water hot; turning off switches on the computer; minimising plastic bottle use by using a soda stream maker; and recycling. One described how the project had encouraged her to explore getting her home insulated. Many of these actions were explicitly linked to the ‘at-home’ activities, for example the energy audit. Three of the parents discussed how the programme made them aware of additional reasons (beyond economic ones) for monitoring electricity usage at home and more importantly encouraged them to share that information with their children. One parent described asking her children to turn off lights at home prior to the project ‘*I didn’t even think about climate itself, I have to be honest but I was thinking about money, but now they know another reason you know we all know another reason why we do that*’. Another mother concurred and went on to describe how the family used the savings from the electricity bill to have a day at the zoo, but it also helped them to ‘*think of the future, like every single step matters*’.

The programme motivated actions that extended beyond the programme. One parent spoke about taking ‘*my girls and the other kids*’ [in the neighbourhood] to go pick rubbish in their local park as a way to help her children and their friends to appreciate the responsibility they have for caring for their local green spaces. While this was not a specific topic of the programme, it appeared that her actions were motivated by participation in the programme. Two participants described benefits to their workplaces through their increased awareness of climate change issues. One described ‘*...every time I look at the people cooking in work, I get really sad now regarding the use of paper cups and plastic cutlery ie ‘like we use disposable cutlery and it comes wrapped up in little [plastic sachets] Can we just go back to real knives and forks?’*’ Another parent also talked about her workplace, a sports facility, in some detail and how, following workshop 2, she had a conversation with one of the greenkeepers about

bees and how the greens were managed and the importance of the facility becoming '*more environmentally aware*'. Both parents were keen to encourage 'change' in their retrospective workplaces: *Yes, I think I'm going to make my boss do that now.*

Some of the climate change issues were already of concern to participants. For example, one parent said about her daughter, '*We always did recycle, we always have filled composting bags...but she's more aware now*'. A second described herself as always having been '*very environmentally aware*' and involved in Greenpeace during her secondary school years. Her own mother '*used to recycle glass before there were bottle banks*'; however, following the programme she was '*...even more so now and more aware of what we can do*'. While these parents indicated that the programme further enhanced their understanding of climate change, it does provide some insight into why some of the parents may have self-selected to participate in the programme in the first instance.

Not Everything Worked

All four parents tried out most of the activities, as evidenced in both the interviews and the visual data, something that demonstrated their engagement with the project and their enthusiasm. However, there were two interlinked inhibiting factors identified and expressed by participants: personal preferences and conceptual understanding of the science underpinning the various tasks.

Personal preferences: Where parents did not complete the activities, this seemed to be to do with personal situations and preferences. For example, one parent was fearful of bees and concerned about her daughter's allergies, '*we made the bee house but we didn't put it on the balcony cos I am not a bee friendly person*'. Making a bee habitat was an explicit feature of workshop 2 and linked with the theme of biodiversity and climate change. However, in mitigation this parent gave the bee house to a friend with a garden. In turn, her friend sent her photos of it in her garden. Another described going out to buy a bee motel [in preference to making one] and how she and her daughter are now aware that purple and pink flowers are some of the best pollinators. It was apparent that despite some parents' initial reservations about particular activities they wanted to educate their children about these matters. One parent described how she overcame her lack of interest and enjoyment in planting but '*I had to because my kids enjoyed it*'.

Scientific complexity: Parents' confidence about their lack of conceptual understanding, meant that some of the at-home activities were less likely to be completed. This is perhaps not surprising as most of the parents noted that they had little experience of inquiry-based science education prior to this programme. It should be noted that the 'at-home activities' echoed the investigations that the parents completed as part of the programme workshops. Another parent described doing all of the activities except the planting because '*I'm not the best gardener in the world*'. It seems that this parent's conceptual understanding of planting was a determining factor as to why she did not complete some of the at-home activities. Three out of the four parents found the insulation investigation difficult. The parents investigated which material was the best insulator as part of a fair test investigation during Workshop 1. One parent stated

that the insulation task was more ‘*complicated*’ and required more time. However, he also went on to state: ‘*the biggest information [his children got] was ‘coming from the thermometers, temperatures, stuff like that*’. So, despite the (perceived) complexity of some of the tasks, the benefits were noticed. At the same time, parents did extend their conceptual understanding across a number of the scientific ideas presented during the workshops, specifically regarding the solitary bee, the insulation activity and the ice investigation which addressed the melting sea ice misconception. This was identified by one of the researchers, who wrote, in response to one photo image: *The experiment has been carefully organised and several people are getting involved - some evidence of fair test principles - e.g. all the containers are the same height.*

Despite the inhibiting factors identified above, these parents recognised and valued the opportunities for their children to engage in the science investigations and in some cases overcame their lack of prior experience with science or STEM in order to ensure their children were educated about climate change during the programme. All these parents highlighted the importance of children learning these ideas at home’ *...if they learn from home, they will be doing it later, and maybe they will teach another person, partners or colleagues or children.*

Everything is Connected

A key tenet of climate change education is grasping the interconnected and ecological wholeness of our lives on earth. However, the idea that everything is connected ecologically seemed quite new and quite powerful for these parents (n=4). Participation in the programme helped to establish a link for them between local action and global relevance. This was highlighted, in particular, by the spider web activity. One parent said: ‘*...the activity with the spiderweb, that was the top one I think...now I can see the bigger sense of my little work...everything in this world, every creature and every plant is connected to each other as well*’. A father described a conversation with his daughter following the spider web activity: *...it’s almost impossible for her to understand how one little person can change a lot but so yesterday’s activity gave her a bigger point that everyone is connected, if every little, every single person will do something small, even if it’s a small thing, turning off the lights or switch off the tap or energy ...it does matter, so that was kind of very nice*. A third said ‘*...What we’re doing in our small environment, but I think you’re looking for the bigger picture at the same time ...we should all be doing this you know so that it’s something natural*’. One mother said: ‘*I didn’t think of bees being, actually small bees, would be one of the biggest parts involved in the climate thing...I think the bees are more important now*’.

The programme helped these parents to connect the investigations and learning activities from their programme to their own local community and understand the impacts our actions have on the environment. These parents were critical of the lack of opportunities for children to spend time in local parks and nature during school i.e. ‘*I can see around our school there is a lot of gardening and plants and that’s lovely but if kids can be allowed to go in the real forest or little park and if they or whoever owns the park can let them grow actual trees there maybe that would be something...*’ In contrast, one of the parents described an example from her home

country, Poland, where *‘every year there is an earth day and the kids from school actually go into the forest and they have bin bags with them and they collect the rubbish and every single school goes to a different place.* This is important given a review of research demonstrates that positive, direct experiences in nature during childhood and role models of care for nature by someone close to the child are the two factors that contribute most to individuals choosing to take action to benefit the environment as adults (Charles et al. 2018 p. 4) Another who had an interest in gardening described issues with lack of access to local allotments. She described how she was interested in gardening and her husband had suggested how she should plant tomatoes and cucumbers in the allotment. However, she said, due to the area being locked *‘there’s no point, I either have to jump over the fence to go and water them because if [I only water them] twice a week there’s no point it’s a waste of my time, their land and the waste of the seeds.* Growing your own vegetables and fruits have a direct impact on our carbon footprint so can be a realistic action for some families to take towards climate change. This illustrates the importance of small practical actions that meet family’s needs while also identifying opportunities for communities to support climate change initiatives. One mother said *‘ I would like to show my children how you don’t have to go to the shop to get a strawberry, it has to grow and tomatoes and everything have to grow and to show that ok we have seeds, you have to water them wait, watering, wait and... yesterday ...it was four [strawberries], everyone had one strawberry and they were really, really happy’.*

The same parent was strident in her views about the role of parents in their children's education on matters related to climate change and how all of the activities were helpful: *‘...parents are responsible for the kids and when they are teaching the kids and learning and improving their knowledge and they actually show them ...it’s all environment, that’s all what builds and makes the life and the world itself, so every single workshop...it’s all brilliant.’* Another said, *‘Because as humans we’ve destroyed the world, like, we’ve absolutely raped it of its resources and totally destroyed the world and we need to stop. And we need to slow down, people need to be aware of what they are doing or my great grandchildren may not be part of Ireland, they may never be able to see it because they’ll be underwater’.* The video clips of the rising sea levels, as presented in one of the workshops, evoked a visceral response from one mother and a sense of the urgency of the task at hand for our very survival. She described the fate of the ocean animals and an appreciation of their sentience as fellow creatures, as they struggled to survive surrounded by plastic waste: *‘ they don’t scream [like humans] you know they don’t, they obviously do but in their language but they’re not heard and they’re not listened to and that’s awful...like we wouldn’t like to swim even in that kind of water...it’s very important about the animals because they cannot help themselves...because that’s their home which is destroyed.*

Pedagogy Matters

All interview participants (n=4) were positive about the pedagogical approach used to deliver the programme, associated with the provision of appropriate resources for experiential learning. The resources provided were well used and appropriate for use in the home environment. It was also evident that families extended their use beyond the initial expectation of the research team. One image shared by the participants illustrated the thermometer provided for the at-

home activities being used to test the temperature of a hot drink. One of the research team responded to this image *'it is really good to see this family using the thermometer provided in a different way. For me, this speaks to the power of providing one piece of basic equipment, which might not usually be found at home.* Another said: *'inspiring to think about the discussion happening here, in the middle of regular family life and among regular mealtime objects'.*

The experiential and practical nature of the activities and the sense of peer support this provided as well as the collegial atmosphere of the workshops were important. For the participants, their experience as adults learning science during this programme was very different and much more successful to their prior learning as children. One described her previous learning of science at school and how this project was different: *'For myself it's hard to understand [because when she learnt at school] we don't have at school like experiments, just everything was on the paper and ok you have to imagine this [changes from ice to water etc].* Participating in scientific experimentation seems to have contributed to a sense of empowerment felt by these parents. Another parent said *'I never did science at school. It wasn't an option. So, like to do even those small experiments. I was like Jesus, look, that's brilliant like'. My daughter does a load of them in school already. But I was like, but the ice is melting and it wasn't overflowing. It's brilliant, really enjoyed it.* Another described it as a *'real workshop, not just only speech, just sitting there and listening, actually we did something, all the experiments, like everyone was enjoying it, it was really really, really good for me and we can do it with our kids like homework club'.* Another said *'I'm not a fan of reading, writing down ok [at a workshop or information session], I can do that at home by reading a book, but no that was something else on top of that information which we were participating in, so that was great...it's another extra connection and bond [between parents and kids].* The use of audio-visual resources during the workshops acted as a powerful motivator as well - one described her experience of learning as *'we got the information on the telly, it's like a movie, we've got it chatting, we saw it in reality doing all those experiments, so that's all connected, that's all good'.*

Discussion

This programme set out to enhance parental engagement with science education, their understanding of climate change and their engagement with climate action. The programme was designed with several guiding principles drawing from the Monroe et al. (2019) study for effective climate change education as well as effective strategies for science education including inquiry-based science education. This study provides some insights into elements of the programme which may have contributed to meeting the aims of the programme.

Clearly, situating the programme in personally relevant and meaningful contexts for the participating parents had a positive effect. This connects with Dewey's theory of experiential education (1938) and is a cornerstone of a constructive approach to science teaching (Harlen, 2014). By situating learning in relevant contexts, it is motivational but also allows the learner to connect with existing ideas and develop their understanding. This is particularly important in the context of science and climate change conceptual understanding as misconceptions or alternative conceptions can only be addressed by connecting with existing ideas and

progressing from where the learner is. This is also the case for adult learners, in the current study they are parents, who may have carried misconceptions with them since their school days and are now better placed to support their children with their science learning.

Another successful feature of the programme was that it engaged the parents, and subsequently their children, both within the workshops but also at home and beyond with some parent participants making possible connections with their community and workplace. The experiential nature of the parents' workshops and the subsequent at-home activities, as well as the action projects, led to the participants engaging hands, minds and hearts as evident by the sometimes impassioned responses during the interviews. Ojala (2023) recognises the importance of educators taking emotions into account when teaching about global problems such as climate change.

Discussion played a crucial role in the success of this small-scale programme. During the workshops and celebration events, parent participants and their children were given plenty of opportunities to share their ideas with their peers as well as discuss with a knowledgeable other, in this case the academic members of the research team who facilitated the workshops. Discussion is a key aspect of a social constructivist approach to teaching, drawing from the work of Vygotsky (1978) who recognised the importance of social interaction in the development of cognition and meaning making for children. This is achieved through reasoning out loud and modelling by a more knowledgeable other who can be a peer or teacher or parent. Vygotsky's theories can also be applied in adult education (Mukhalalati and Taylor 2019 et al). In this programme, by grounding the workshops in discussion the parent participants had opportunities to think aloud their ideas and make meaning with peers and the workshop facilitators. Likewise, the children had opportunities to share their ideas and learning with their parents during the at-home activities and the celebration event. Whilst not the focus of the current paper, the children's social learning here is important as the parents also took on the role of "more knowledgeable other" (Vygotsky 1978).

The literature review highlighted the critical importance of science education in climate change education in terms of conceptual knowledge, skills, attitudes and values. In this programme, the parent participants, some of whom had limited experience of formal science education and when they did, it was often less positive, really enjoyed the opportunity to experience science, particularly as it was science that they knew was similar to what their children were doing in their schools. Experiencing science through an inquiry approach in particular was different to what the participants had experienced before or were familiar with. This was a positive aspect for them. As well as supporting their understanding conceptually, this approach also gave insight into the nature of science as was evident in some of the visual data from the activities carried out at home e.g., their consideration of variables when conducting their investigation. Understanding the nature of science is encapsulated in scientific literacy and this is crucial in climate change education so that citizens can engage in and make informed reasoned actions to combat climate change (Broderick 2023).

The programme was intentionally designed around known misconceptions e.g., that melting sea ice contributes to rising sea levels. Through the workshops, parents shared and discussed

their existing ideas and then through investigation and practical experimentation, these prior conceptions may have been challenged. This is a crucial aspect of a social constructivist approach learning to conceptual change. Research shows that misconceptions will remain unless they are actively challenged by the learner (Posner et al 1982). Simply telling learners will not suffice. They may be able to repeat the correct conception however, they will not have internalised the learning. However, it was evident from the interviews that some parents retained some misconceptions in terms of scientific conceptions. This highlights the challenges in developing conceptual understanding with limited time.

Finally, another key aspect of the programme was the action focus. Participants were invited to take action, with their children, to combat some aspect of climate change. Change in behaviour is crucial for climate change education (Kenis and Mathijs, 2012). Raising awareness and understanding and developing positive attitudes towards the environment are important starting points but without action, it won't be effective. In this programme we saw examples of parents, and as a result their children, making connections to their local communities and environments through their action projects. From the interviews, it was clear that the parents could see the connections between these smaller actions on a local scale to the bigger global issues (Sheppard et al, 2011)

Limitations

The parents involved in this programme and the resulting research are representative of only a small self-selecting sample from a wider population of parents of DEIS primary school children thus generalisations from the data set are not possible. Notwithstanding, the data provide some insights into the outcomes associated with a climate science education programme which has explicit design features which may be transferable to other schools and educational contexts. Furthermore, the post-programme interviews represented only 10% of the participants and they were all female and again as these were self-selecting to take part in an interview, there was likely to be a positive bias towards the programme. There were a small number of other participants who were willing to be interviewed, however it was difficult to schedule with other commitments. Language proficiency may have also been an inhibiting factor in the small sample. However, the interviews provided sufficient evidence of engagement with climate change and scientific inquiry. Furthermore, triangulation with data gathered from reflections on the co-created posters and photos provides some degree of concurrent validity. That said, generalisations cannot be drawn from the findings.

Conclusions

The findings presented here show a proof of concept for involving parents in their children's education in the areas of climate change education and science education. This was achieved through evidence-based approaches to inquiry-based science which were designed to be personally relevant and meaningful to the parents (and subsequently to their children), to engage them and to facilitate them to experience science in a way that their children learn in schools including through discussion. This programme tackled misconceptions pertinent to

climate change education and attempted to develop their understanding of climate change and engage them in science education and climate action.

This small-scale project demonstrated that the programme design was feasible and successful. Anecdotally the participants were keen for more workshops to be rolled out to continue their own learning and development and also recommended that it be available for more parents in more schools. To move such a programme forward on a larger scale, future research should focus on scalability of the programme to include, balancing time commitments (parents and school staff), recruitment and communication with HSLC (or similar personnel in schools) and how best to establish, maintain and support contact with parents.

This paper recognised from the outset the somewhat limited role parents can play in their children's formal education in contrast to the policy and rhetoric around the importance of this as well as the lack of research in this area. Given the enormity of the current global crises, namely climate change and biodiversity, it is crucial that children's formal experiences in these areas in schools are supported by their parents at home and through their community as the primary educators. This programme attempted to exemplify one approach to how this could be achieved, challenging the notion that climate change education and science education do not and must not only happen on school premises but in every home and community.

Acknowledgements

This work was supported Science Foundation Ireland (SFI) under the SFI Discover Programme 2021 (21/DP/9719).

References

- Arnold, H.E., Cohen, F.G., & Warner, A. (2009). Youth and Environmental Action: Perspectives of Young Environmental Leaders on Their Formative Influences, *The Journal of Environmental Education*, 40 (3), 27-36, DOI: [10.3200/JOEE.40.3.27-36](https://doi.org/10.3200/JOEE.40.3.27-36)
- Bleach, M. J. (2010) *Parental Involvement in Primary Education in Ireland*. Dublin: Liffey Press
- Broderick, N. (2023) Exploring different visions of scientific literacy in Irish primary science education: core issues and future directions, *Irish Educational Studies*, DOI: [10.1080/03323315.2023.2230191](https://doi.org/10.1080/03323315.2023.2230191)
- Charles, C., Keenleyside, K., Chapple, R., Kilburn, B., van der Leest, P. S., Allen, D., Richardson, M., Giusti, M., Franklin, L., Harbrow, M., Wilson, R., Moss, A., Metcalf, L. and Camargo, L. (2018). Home to us all: How connecting with nature helps us care for ourselves and the earth. Minneapolis, MN: Children and Nature Network.

Corner, A. & Roberts, O. & Chiari, S., Völler, S., Mayrhuber, E.S., Mandl, S. & Monson, K. (2015). How do young people engage with climate change? The role of knowledge, values, message framing, and trusted communicators, *Wiley Interdisciplinary Reviews: Climate Change*, 6 (5), 523-534..

Dauber, S. L., & Epstein, J. L. (1993) Parents' attitudes and practices of involvement in inner-city elementary and middle school. In N. F. Chavkin (Ed.), *Families and schools in a pluralistic society* (pp. 53–72). New York, NY: State University of New York Press.

Department of Education and Skills (DES). (2005). The Delivering Equality of Equal Opportunities in Schools (DEIS): An Action Plan for Educational Improvement. Government Publications.

Department of Education (2023) Primary Curriculum Framework For Primary and Special Schools. Dublin: National Council for Curriculum and Assessment (NCCA).

Dewey, J. (1938). Experience and education. New York: Simon and Schuster

Desforges, C., and A. Abouchaar. (2003) *The Impact of Parental Involvement, Parental Support and Family Education on Pupil Achievements and Adjustment: A Literature Review* (Report RR433). London: Department for Education and Skills.

Eivers, E., and Creaven, A. (2013) "Home-school Interaction." *In National Schools, International Contexts. Beyond the PIRLS and TIMSS Test Results*, edited by E. Eivers and A. Clerkin, 105-128. Dublin: Educational Research Centre.

Froiland, J. M. (2021) A comprehensive model of preschool through high school parent involvement with emphasis on the psychological facets, *School Psychology International*, 42(2), 103-131. <https://doi.org/10.1177/0143034320981393>

Gilligan, T., Lovett, J., McLoughlin, E., Murphy, C., Finlayson, O., Corriveau, K., & McNally, S. (2020) 'We practise every day': parents' attitudes towards early science learning and education among a sample of urban families in Ireland, *European Early Childhood Education Research Journal*, 28 (6), 898-910, DOI: [10.1080/1350293X.2020.1836588](https://doi.org/10.1080/1350293X.2020.1836588)

Goodall, J. (2016) Technology and School-Home Communication, *International Journal of Pedagogies and Learning*, 11(2), 118–131. doi:10.1080/22040552.2016.1227252.

Government of Ireland. (1937) Constitution of Ireland. Retrieved from: <http://www.irishstatutebook.ie/eli/cons/en/html>.

Green, C. L., Walker, J. M. T., Hoover-Dempsey, K. V., & Sandler, H. M. (2007). Parents' motivations for involvement in children's education: An empirical test of a theoretical model of parental involvement. *Journal of Educational Psychology*, 99(3), 532–544. <https://doi.org/10.1037/0022-0663.99.3.532>

- Harlen, W. (2014) Helping children's development of inquiry skills, *Inquiry in primary science education*, 1, 5-19.
- Hill, N. E., and Craft, S. A. (2003) Parent-school involvement and school performance: Mediated pathways among socioeconomically comparable African American and Euro-American families, *Journal of Educational Psychology*, 95, 74-83.
- Hindin, A and Mueller, M. (2016) Creating home-school partnerships: examining urban and suburban teachers' practices, challenges, and educational needs, *Teaching Education*, 27(4), 427-445, DOI: 10.1080/10476210.2016.1208165
- Jeynes, W. (2012) A meta-analysis of the efficacy of different types of parental involvement programs for urban students. *Urban Education*, 47, 706-742.
- Kamenetz, A. (2019) Most teachers don't teach climate change; 4 in 5 parents wish they did. <https://www.npr.org/2019/04/22/714262267/most-teachers-dont-teach-climate-change-4-in-5-parents-wish-they-did>
- Kenis, A. and Mathijs, E. (2012) Beyond individual behaviour change: the role of power, knowledge and strategy in tackling climate change, *Environmental Education Research*, 18(1), 45-65, DOI: 10.1080/13504622.2011.576315.
- Kim, Y. (2009) Minority parental involvement and school barriers: Moving the focus away from deficiencies of parents, *Educational Research Review*, 4, 80-102.
- Kos, M., Jerman, J., Anžlovar, U. & Torkar, G. (2016). Preschool Children's Understanding of Pro-Environmental Behaviours: Is It Too Hard for Them?. *International Journal of Environmental and Science Education*, 11(12), 5554-5571.
- Lawson, D.F., Stevenson, K.T., Peterson, M.N., Carrier, S.J., Seekamp, E. & Strnad, R. (2019) Evaluating climate change behaviors and concern in the family context, *Environmental Education Research*, 25:5, 678-690, DOI: [10.1080/13504622.2018.1564248](https://doi.org/10.1080/13504622.2018.1564248)
- Leiserowitz, A., Smith, N. & Marlon, J.R. (2010). *Americans' Knowledge of Climate Change*. Yale University. New Haven, CT: Yale Project on Climate Change Communication.
- Leppänen, J.M., Haahla, A.E., Lensu, A.M., & Kuitunen, M.T. (2012). Parent-Child Similarity in Environmental Attitudes: A Pairwise Comparison, *The Journal of Environmental Education*, 43 (3), 162-176, DOI: [10.1080/00958964.2011.634449](https://doi.org/10.1080/00958964.2011.634449)
- Lombardi, D., Sinatra, G. M., & Nussbaum, E. M. (2013). Plausibility reappraisals and shifts in middle school students' climate change conceptions. *Learning and Instruction*, 27, 50-62. doi:10.1016/j.learninstruc.2013.03.001
- Madden, L., Joshi, A., Wang, M., Turner, J., and Lindsay, S. (2023) Parents' Perspectives on Climate Change Education: A Case Study From New Jersey. *ECNU Review of Education* <https://doi-org.dcu.idm.oclc.org/10.1177/20965311231200507>

- Mead, E., Roser-Renouf, C., Rajiv N., Flora, J.A., Maibach, E.W., & Leiserowitz, A. (2012) Information Seeking About Global Climate Change Among Adolescents: The Role of Risk Perceptions, Efficacy Beliefs, and Parental Influences, *Atlantic Journal of Communication*, 20 (1), 31-52, DOI: [10.1080/15456870.2012.637027](https://doi.org/10.1080/15456870.2012.637027)
- Miles, M., A. Huberman, and J. Saldana. 2014. *Qualitative Data Analysis: A Methods Sourcebook*. 3rd ed. Los Angeles: Sage Publications Inc.
- Mochizuki, Y., & Bryan, A. (2015). Climate Change Education in the Context of Education for Sustainable Development: Rationale and Principles. *Journal of Education for Sustainable Development*, 9(1), 4-26. <https://doi.org/10.1177/0973408215569109>
- Moè, A., Katz, I. and Alesi, M. (2018) Scaffolding for motivation by parents, and child homework motivations and emotions: Effects of a training programme, *British Journal of Educational Psychology*, 88, 323-344.
- Monroe, M.C., Plate, R.R., Oxarart, A., Bowers, A., & Chaves, W.A. (2019). Identifying effective climate change education strategies: a systematic review of the research, *Environmental Education Research*, 25 (6), 791-812, DOI: [10.1080/13504622.2017.1360842](https://doi.org/10.1080/13504622.2017.1360842)
- Mukhalalati BA, Taylor A. Adult Learning Theories in Context: A Quick Guide for Healthcare Professional Educators. *J Med Educ Curric Dev*. 2019 Apr 10;6:2382120519840332. doi: 10.1177/2382120519840332. PMID: 31008257; PMCID: PMC6458658.
- Murphy, C., Smith, G., Mallon, B. & Redman, E. (2021). Teaching about sustainability through inquiry-based science in Irish primary classrooms: the impact of a professional development programme on teacher self-efficacy, competence and pedagogy, *Environmental Education Research*, 26 (8), 1112-1136, DOI: [10.1080/13504622.2020.1776843](https://doi.org/10.1080/13504622.2020.1776843)
- Murphy, C., Venkat, H., Leahy, M., Broderick, N., Kelly, O., Butler, D., Harbison, L., Lawlor, C., & Naughton, Y. (2023). *STEM Education: Curriculum & literature overview & Primary science education: Systematic literature review*. Dublin: National Council for Curriculum and Assessment.
- Nelis, S.M., Gilleece, L., Fitzgerald, C., & Cosgrove, J. (2021). Beyond achievement: home, school and wellbeing findings from PISA 2018 for students in DEIS and non-DEIS schools. Dublin: Educational Research Centre
- Ojala, M. (2023) Climate-change education and critical emotional awareness (CEA): Implications for teacher education, *Educational Philosophy and Theory*, 55:10, 1109-1120, DOI: 10.1080/00131857.2022.2081150
- Posner, G.J., Strike, K.A., Hewson P.W. and Gertzog, W.A. (1982) Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, 66 (2), pp. 211-227

Rocard, M., Csermely, P., Jorde, D., Lenzen, D., Walberg-Henriksson, H., & Hemmo, V. (2007). *Science education now: A renewed pedagogy for the future of Europe*. Brussels: European Commission.

Saldana, J. 2016. *The Coding Manual for Qualitative Researchers*. London: Sage.

Sharma, A. (2012). Global Climate Change: What has Science Education Got to Do with it?. *Sci & Educ* 21, 33–53. <https://doi.org/10.1007/s11191-011-9372-1>

Sheppard, S.R.J., Shaw, A., Flanders, Burch, S., Wiek, A., Carmichael, J., Robinson, Cohen, S. (2011) Future visioning of local climate change: A framework for community engagement and planning with scenarios and visualisation, *Futures*, 43, 400-412.

Sheppardson, D.P., Niyogi, D., Choi, S., & Charusombat, U. (2009). Seventh grade students' conceptions of global warming and climate change, *Environmental Education Research*, 15 (5), 549-570, DOI: [10.1080/13504620903114592](https://doi.org/10.1080/13504620903114592)

Stevenson, K.T., Peterson, M.N. & Bondell, H.D. (2019) The influence of personal beliefs, friends, and family in building climate change concern among adolescents, *Environmental Education Research*, 25:6, 832-845, DOI: [10.1080/13504622.2016.1177712](https://doi.org/10.1080/13504622.2016.1177712)

Stevenson, R.B., Nicholls, J. & Whitehouse, H. (2017). What Is Climate Change Education?. *Curric Perspect* 37, 67–71. <https://doi.org/10.1007/s41297-017-0015-9>

Shiel, G., Kelleher, C., McKeown, C. and Denner, S. (2016) *Future Ready? The Performance of 15-year-olds in Ireland on Science, Reading Literacy and Mathematics in PISA 2015*. Dublin: Educational Research Centre.

Strickler-Eppard, L., Czerniak, C.M. & Kaderavek, J. Families' Capacity to Engage in Science Inquiry at Home Through Structured Activities. *Early Childhood Educ J* 47, 653–664 (2019). <https://doi.org/10.1007/s10643-019-00958-0>

Taber, F. & Taylor, N. (2009). Climate of concern: A search for effective strategies for teaching children about Global Warming. *International Journal of Environmental and Science Education*, 4 (2), 97 - 116.

UNESCO. (2019). *Climate change education*. [https://en.unesco.org/themes/ education-sustainable-development/cce](https://en.unesco.org/themes/education-sustainable-development/cce)

Vygotsky, L. S. (1978) *Mind in society: The development of higher psychological processes*. Massachusetts: Harvard University Press.

Whitaker, M.C. (2019) The Hoover-Dempsey and Sandler Model of the Parent Involvement Process, In: S.B. Sheldon and T.A. Turner-Vorbeck (Eds) *The Wiley Handbook of Family, School, and Community Relationships in Education*, pp. 421-444.

Yacoubian, H.A. (2018). Scientific literacy for democratic decision-making, *International Journal of Science Education*, 40 (3), 308-327, DOI: [10.1080/09500693.2017.1420266](https://doi.org/10.1080/09500693.2017.1420266)

Zeidler, D. L. (2014). Socioscientific Issues as a Curriculum Emphasis: Theory, Research and Practice. In S.K. Abell & N.G. Lederman (Eds.), *Handbook of Research on Science Education* (pp. 697–726). Lawrence Erlbaum Associates.

