



Expanding adaptive capacity: Innovations in education for place-based climate change adaptation planning

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ABSTRACT

The IPCC emphasises the need to centre climate change adaptation in climate actions due to a lack of progress on meaningful climate change mitigation. This requires the expansion of adaptive capacity across many sectors, including education. Research asserts the key role formal education plays in increasing the learning and cognitive aspects of adaptive capacity and associated capabilities, but further work is required to understand the impacts of attempts to enact such changes, specifically in relation to climate change adaptation planning. Drawing on impact data collected from an experimental place-based digital educational resource – Climate Smart – that includes a serious online role play game, designed with and for second level students aged 15–17 in Ireland, this paper outlines the challenges of, and opportunities for, engaging young people in learning about climate change adaptation planning. We conclude that while such educational innovations are impactful in the short-term and essential for developing foundational knowledge and skills, as well as shaping individual and social norms, they will be insufficient alone to optimise capabilities for long term adaptive capacity for climate change adaptation. Wider complementary structural changes across multiple systems which support people to enact their learning and functionalise their capabilities are required. Finally, a prospective agenda for progressing adaptive capacity for climate adaptation planning with education at its core is outlined.

1. Introduction

The IPCC 2022 report (Pörtner et al., 2022, p. 28) emphasizes the importance of public participation in the development and implementation of climate adaptation policies and measures. Engaging communities in the decision-making process can foster a sense of ownership and responsibility, ensuring that adaptation strategies are context-specific, equitable, and responsive to the needs and priorities of diverse stakeholders (Cunningham et al., 2016). Public participation can also strengthen social cohesion and facilitate the exchange of knowledge, experiences, and resources among community members, enhancing the overall effectiveness and resilience of adaptation measures by expanding adaptive capabilities (Chu, 2018a; Pelling and Garschagen, 2019).

Participatory approaches to climate adaptation can take various forms, such as community-based adaptation initiatives, stakeholder consultations, and the integration of traditional and indigenous knowledge in adaptation planning. These approaches have the potential to empower local communities, build adaptive capacity and capabilities,

and promote the development of innovative, place-sensitive solutions to the challenges posed by climate change. However, there are significant challenges to developing effective and inclusive participation approaches (Hügel and Davies, 2020). These include: inadequate representation (E. Chu et al., 2016); limited resources and capacities (Fila et al., 2023); pre-existing power dynamics and conflicts (Nightingale, 2017); coordination and integration complexities (Trein et al., 2021); and knowledge gaps and uncertainties (Bahauddin et al., 2016; Chu, 2018b; Kabisch et al., 2016). Given these challenges, education in particular, will play a critical role in fostering societal adaptation to climate change by raising awareness of the issues at hand, enhancing understanding and a sense of agency in relation to decision making, as well as building the capabilities needed to navigate the complex and uncertain landscape of a changing climate (Krasny and DuBois, 2019; Lutz et al., 2014).

Climate change education for adaptation places an emphasis on knowledge and skills to respond to current risks and reduce climate-related vulnerability while building adaptive capacity to deal with climate-changed futures (Mochizuki and Bryan, 2015; Selby and

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Kagawa, 2010; Stevenson et al., 2017). Adaptive capacity is generally understood at a societal level to include the interlinked domains of: assets, flexibility, social organization, learning and agency, with feedback and interactions occurring among any of the domains (Cinner et al., 2018). Formal education, meanwhile, has been mooted as increasing the learning and cognitive aspects of individual's adaptive capacity and their capabilities to act (Walker et al., 2022). Further evidence of the nature, extent and durability of this impact at an individual level is required, as well as consideration of the extent to which such individual capacity translates into improvements in wider societal adaptive capacity. This paper responds directly and empirically to the first issue by focusing on an innovative educational intervention being rolled out in Dublin, Ireland with secondary school level students aged 15–17, and, based on these findings, provides a framework for approaching the second.

We first present current knowledge around adaptive capacity and capabilities in the context of place-based education for enhanced participation in climate change adaptation planning, before drawing on impact data collected from an experimental digital educational resource – Climate Smart – that includes a serious online role play game focused on adaptation planning set in Dublin, Ireland (see Davies and Hügel, 2021; Hügel and Davies, 2022). Using adaptive capacity through capabilities as a lens, we analyse the results of a series of in-class, online workshops run with young people in secondary schools in Dublin, culminating in a serious game – iAdapt – which allows them to test their knowledge through online decision making. From this research, we identify a suite of challenges and opportunities for 1) engaging young people in learning about climate change adaptation planning and 2) ensuring that expanded adaptive capacity developed in the classroom can be practiced beyond that institutional setting and into the future.

2. Expanding engagement with climate change adaptation

The literature related to public participation in climate change adaptation has increased dramatically since 2011, with a particular focus on risk, risk perception, and flooding (Davies et al., 2020; Hügel and Davies, 2020), as well as an expanding body of scholarship related to issues of justice and just transitions (Malloy and Ashcraft, 2020). It remains the case that while research and practice in the area of 'just' adaptation (Davies and Hügel, 2021) has established the normative and pragmatic conditions for participation in adaptation planning, increased attention to inclusion has not yet resulted in an expansion of procedural, distributional or restorative justice (Holland, 2017). Such a transition is contingent upon changed interactions between those who require increased agency, and the institutions which are responsible for shaping that agency (Adger, 2016; Chu, 2018a), with education systems playing a key role (Trott et al., 2023). The remainder of this section sets out key features of interrelated debates in relation to: adaptive capacity for climate change adaptation; climate change education and adaptive capacity; capabilities for adaptive capacity and the role of place in climate change adaptation.

2.1. Adaptive capacity for climate change adaptation

Given the ongoing need for climate change adaptation, building adaptive capacity is of fundamental importance (Gunderson et al., 2015; Nykvist et al., 2017; Pahl-Wostl and Knieper, 2014). High levels of capacity enable adaptation and support resilience (Folke et al., 2005; Johannessen and Hahn, 2013), while low levels contribute to vulnerability and crises (Reed et al., 2013; Smit and Wandel, 2006). Capacity, here, refers to the ability to act, which can be conceptualized as the availability (or lack thereof) of different forms of capital (i.e., built, financial, human, natural and social) – either pre-existing or accumulated – that can be used to accomplish some objective (Donoghue and Sturtevant, 2007; Plummer et al., 2018).

Further, adaptive capacity as a concept is relevant to different

contexts, systems, scales and socio-political strata, e.g., people, households, groups, communities, sectors and governance regimes (Armitage, 2005; Cooper and Wheeler, 2015; Pahl-Wostl, 2009) and has been conceptualized and defined in various ways (Phuong et al., 2017). In its more general definition, adaptive capacity refers to "the preconditions necessary to enable adaptation and the ability to mobilize these elements" (Adger et al., 2011, p. 758). Referring to resource governance systems, Pahl-Wostl offered a definition inclusive of both incremental and transformative adjustments: the ability of the system "to first alter processes and if required convert structural elements" (2009, p. 355) in response to actual or anticipated social or environmental change.

In climate change research, a widely accepted definition of adaptive capacity was established by the Intergovernmental Panel on Climate Change as the ability of a system "to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (Intergovernmental Panel on Climate Change, 2014; Parry et al., 2007, p. 869). As such, enhancing adaptive capacity can involve investing in the resources, or determinants, that make adaptation possible. These determinants include knowledge and information, technological options, leadership, infrastructure, economic and financial resources, and human, social, institutional, political, cultural and natural capital (Adger et al., 2007; Engle, 2011; Reed et al., 2013; Smit and Wandel, 2006).

At an individual level, as outlined by Walker et al (2022), a person's adaptive capacity in relation to climate change is partly determined by learning and cognition. That is the ability to "process, assess and react to a changing climate" (2022, p. 409). While learning and cognition is further explored in the section below in relation to education and climate change, Walker et al (2022) also flag that systemic issues may limit the potential of formal education to improve adaptive capacity. This raises important issues regarding the influence of structures and agency in relation to building adaptive capacity (Fazey et al., 2007; Fullan and Loubser, 1972) and the limitations of adopting only an information-deficit approach to climate change adaptation; matters to which we return later.

2.2. Climate change education and adaptive capacity

As Pelling et al note (2008), formal education can itself be considered an element of adaptive capacity in relation to climate change, but only when it cumulatively addresses multiple dimensions of the challenges preventing climate action. A similar point has long been reiterated with respect to engaging publics and shifting practices around environmental matters more broadly in critiques of an information deficit model which presumes that simply providing information will lead to people taking action (Blake, 1999; Burgess et al., 1998; Owens, 2000). The information deficit model, as Owens (2000, p. 1141) states, assumes that "laypeople are ignorant of environmental science and irrational in their response to risks: the public must be engaged in order to be better informed and converted to a 'more objective' view". This approach ignores core issues of [mis]trust around the purveyors of information. Moreover, it assumes that a lack of information or understanding is the key barrier to action, ignoring the effects of problem framing, socio-political context, institutional and personal constraints (Blake, 1999).

Recent research shows that though information about climate change is increasingly being conveyed in the classroom, its political dimensions remain largely absent (Jorgenson et al., 2019) and social justice issues are underplayed (Waldron et al., 2019). However, in the field of environmental education, increasing scientific knowledge alone is not correlated with increased pro-environmental behaviour (Dijkstra and Goedhart, 2012). Despite this, climate change education in secondary schools – the focus of this paper – tends to highlight scientific knowledge, conceptualization of climate change within the climate system, including internal and external causes of climate and their interconnection, and their linkage to external responses or climate

variability (Shepardson et al., 2012, p. 329) and individual agency (Rousell and Cutter-Mackenzie-Knowles, 2020; McNeill and Vaughn, 2012; Shepardson et al., 2012). For example, one study of 49 climate change-focused educational interventions across the United States found that none focused on justice, and only six focused on adaptation (Monroe et al., 2019, p. 806). Meanwhile, an international review of interventions from 2012 to 2018 conducted by Jorgenson et al. (2019), found that most of the 70 cases they reviewed focused on actions in the private, rather than the public, sphere, with Kranz et al. (2022) describing how the majority of the 75 educational interventions they examined focused on the scientific components of IPCC reports and the implications of a 1.5° C warming limit.

Certainly, understanding ‘what’ constitutes climate change is important, but climate change adaptation also requires skills and understandings in terms of ‘how’ to respond and ‘why’ certain responses are more difficult to enact than others. Without this wider framing for climate change education the risk of perpetuating an ‘information deficit’ approach to combatting climate change is high (Suldovsky, 2017). Despite its limitations the deficit model has been identified as the most common adaptation policy response in Europe (Biesbroek and Delaney, 2020). However, as the IPCC itself notes (Masson-Delmotte et al., 2022), the approach lacks effectiveness, and does not represent participation or engagement in any meaningful sense (Rowe and Frewer, 2000, 2005). As Whitmarsh has demonstrated, using the example of scepticism towards climate change, information provision alone can and will be “evaluated and used in diverse ways according to individuals’ values and worldviews” (Whitmarsh, 2011, p. 698). Without further intervention, the deficit approach can effectively bolster pre-existing practices, rather than serving to change them (Cook and Overpeck, 2019). An alternative approach, often described as a civic or deliberative model (Owens, 2000), calls for more fundamental engagement in the “formation and articulation of values and in policy formation and implementation moving beyond prescribed responses to predefined problems” (Owens, 2000: 1143). Of course, establishing such processes is itself challenging, requiring that people “have the capacity to act as informed citizens at a time when the crucial interrelated components of this process – knowledge, capacity and citizenship – are all subject to critical interpretation and renegotiation” (Owens, 2000, p. 1145).

Ultimately, information provision is necessary, but alone insufficient to create adaptive capacity. Attending to, and educating about, the socio-technical and socio-ecological complexities, politics, power and justice dimensions of climate change adaptation – all crucial elements of building adaptive capacity – remain at the periphery of educational interventions. Building capabilities in these areas will be crucial for the transformative potential of education for climate change adaptation to be realised; emphasising the need to promote a range of capabilities beyond content knowledge to critical thinking, creativity and problem-solving skills.

2.3. Capabilities for adaptive capacity

A capabilities approach to climate change adaptation has emerged as part of broader debates about climate justice that ascribe moral importance to the freedom to achieve well-being, and which see people’s capabilities and functionings (the realisation of capabilities) as key to well-being (Robeyns and Byskov, 2023). Within these debates capabilities refer to the doings and beings that people can achieve if they choose to do so (see Kronlid, 2014), with capabilities dependent on a range of conversion factors comprising personal, but also socio-political, and environmental conditions. As such, a capabilities approach provides a productive conceptual framework for considering climate change adaptation education impacts on individual well-being, as well as for evaluating and assessing adaptation arrangements, policies and proposals in context. For example, Owens et al. (2022) adopted a capabilities approach to examine the challenges faced by teachers in higher education institutions seeking to engage learners with environmental

crises. They found that while teaching resources are essential, other personal, material and social factors such as institutional policies and management cultures dramatically affect teachers’ capabilities. While this study focused on capabilities amongst higher education teachers, the conceptual point that capabilities are relational and unavoidably shaped by, and situated within, specific contexts has wider application (Owens et al., 2022). In particular, a capabilities-based (Sen, 2011) approach to increasing adaptive capacity aims to bring both social and political recognition to bear on the potential vulnerabilities of traditionally under-represented demographics. As Schlosberg (2012, p. 446) states, such an approach “bridges the gap between ideal and abstract notions of climate justice theory on the one hand, and the reality of policy-making on the other”. Further, capabilities-based approaches are seen as appropriate to understand and take action at both the individual and community scale (Schlosberg, 2012) – a particularly urgent factor as the effects of climate change are experienced not just by individuals, but also collectively and therefore responses will require both individual and collective actions. It is thus imperative for responses to ensure that communities can continue to function and retain their identities as the effects of climate change increase. These kinds of justice – procedural and restorative – can only be achieved when communities have opportunities to help determine what they require in order to function and indeed thrive, and participate in the governance of adaptation efforts that can help to achieve this.

Allowing individuals and communities to develop and enact capabilities must be preceded by first recognising them (Malloy and Ashcraft, 2020). Recognition, here, refers to the inclusion of traditionally under-represented demographics, who are typically excluded – deliberately or otherwise – as participants in decision-making processes (Young, 2011). Thus, enacting just adaptation processes requires attending to those aspects which encourage, reinforce, and perhaps even guarantee their participation (Fraser, 1997). As Malloy and Ashcraft note (2020, p. 5), “institutional interactions that promote political capabilities may advance just adaptation through processes that give decision-making power to socially vulnerable populations, rather than a symbolic ‘seat at the table’”. Responses to climate change ultimately depend on the participation of non-expert publics (Cook and Overpeck, 2019). Understanding the mechanisms and sites of action of this participation are a crucial component of education for climate change adaptation. As outlined by Lambert et al. (2015), the capabilities approach offers a new framing for geography teaching and curriculum development in second level education that is particularly relevant for climate change adaptation. While Lambert et al. (2015) focus on teacher capabilities, in this paper our focus lies on evaluating the impact on capabilities of learners’ engagement with the place-based Climate Smart platform and its resources.

2.4. Place and climate change adaptation

There has been increased interest in the idea of place as a site for the delivery of climate action projects, and as a means through which to increase climate literacy among individuals and communities. The nature of place, a core concept for geographical enquiry (Cresswell, 2008), affects both the need for, and type of, adaptation as well as adaptive capacity. However, there is no stable concept of place: rather, it can be seen as the confluence of “agencies, objects and relationships which give meaning to particular locations” (Murtagh and Lane, 2022, p. 16). Despite this definitional flexibility, the assignment of value to place by individuals and communities can powerfully shape their identity and attachment to it.

The concept of place identity was first proposed by Proshansky (1978, p155) who defined it as “dimensions of self that define the individual’s personal identity in relation to the physical environment by means of a complex pattern of conscious and unconscious ideas, beliefs, preferences, feelings, values, goals and behavioural tendencies and skills relevant to this environment”. Similarly, Paasi (1986), articulated place

identity as a means to describe how individuals exist within a place; their “sense of place”. This can in turn influence both behaviours and activities and contribute to individual and collective well-being (linking back to debates about capabilities). However, [Fresque-Baxter and Armitage \(2012\)](#) note that there has been a tendency to focus on material interventions when discussing place-based adaptive capacity, with less attention to subjective aspects, such as identity, beliefs, and values. Yet, these aspects can help to illuminate the most important aspects of

peoples’ everyday lives, and how these – primarily social – values are likely to be affected by climate change. Values-based approaches to climate change adaptation are attempting to refocus attention on these subjective dimensions of adaptive capacity in an attempt to more effectively engage individuals and communities ([Ramm et al., 2017](#)).

However, [Herrick \(2018\)](#) notes that discussing sense of place can contribute to an “imaginative intangibility”, or “difficulty in engaging in anything other than superficial discussion” ([Herrick, 2018, pp. 81, 83](#)),

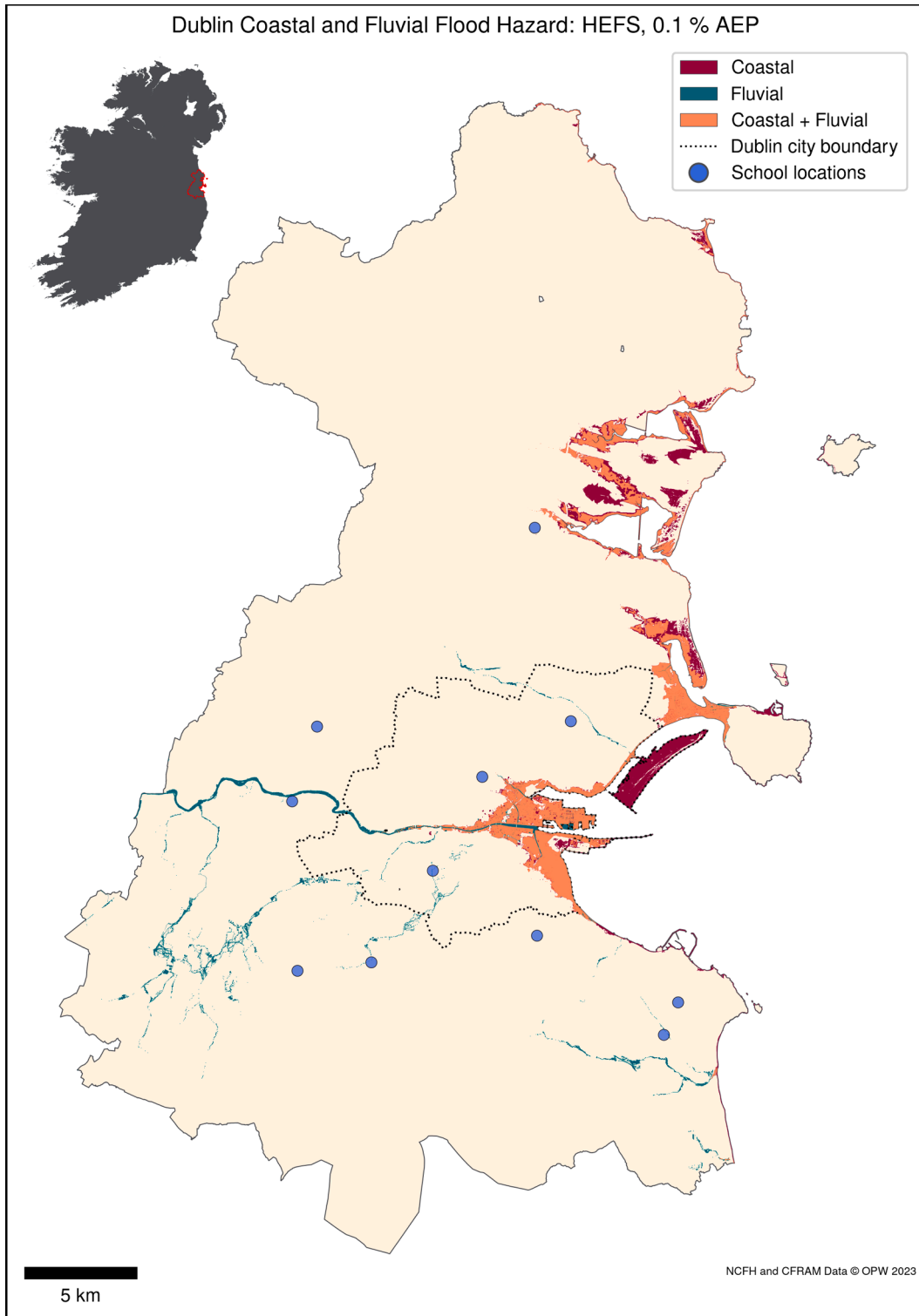


Fig. 1. Coastal and Fluvial flood hazards in County Dublin, High-end future scenario (HEFS). Source: Author.

especially regarding adaptation, and this can hinder attempts to visualise alternative futures. Communities' self-perceptions must thus be sensitively and meaningfully addressed in order to create locally appropriate adaptation policy regimes. Adaptation actions can in turn affect individuals' sense of place (Devine-Wright and Quinn, 2020), with so-called hard engineering solutions being particularly likely to heighten residents' awareness of their own risk, while undermining their attachment to place. This occurs by reframing what was previously a positive feature (e.g. a river) as a source of danger and damage (Harries, 2017). In the case of managed retreat – arguably the most radical form of adaptation (Adger et al., 2020; Agyeman et al., 2009; McMichael, 2020) – place attachment can act as a brake on residents' willingness to relocate (Khanian et al., 2019).

In the context of this paper, bringing climate change adaptation planning 'closer to home' for participants through interactive place-based educational interventions focused on Dublin, Ireland, provides one mechanism through which to bring both material and non-material considerations together, with the goal of building adaptive capacity through expanding capabilities (Amundsen, 2015; Bardsley and Bardsley, 2007; Edwards et al., 2019).

3. Case study: climate smart Dublin

At the time of writing, Ireland's National Adaptation Framework: Planning for a Climate Resilient Ireland (Government of Ireland, 2018) lays out in stark terms the risks that the country needs to adapt to. Placing Ireland's actions within the global and supranational policy context set out in The Paris Agreement, Agenda 2030 Sustainable Development Goals, the Sendai Framework for Disaster Risk reduction and EU Adaptation Strategy, the document details that the "most immediate risks to Ireland [...] are those predominantly associated with changes in extremes, such as floods, precipitation and storms..." (Government of Ireland, 2018, p. 7). Beneath this national framework, Local Authorities prepared adaptation and mitigation strategies for their constituencies – Climate Action Plans – to be completed by 2024.

Dublin, the capital city of Ireland, is already experiencing the effects of climate change. It is very likely to experience increasing intensity and frequency of adverse weather events in the future, as shown in Fig. 1 which visualises modelled flood extents for high-end future scenarios (extreme rainfall depth increasing by 30 % and sea level rise of 1000 mm) and risks of coastal flooding around Ireland (Dublin City Council, 2020). Indeed, the city-region's Climate Change Action Plan (2019–2024) notes that Dublin Bay's average sea level is rising faster than initially forecasted and by twice the global average rate over the last 20 years. This is coupled with increases in the number of days with heavy rainfall and extreme flooding events. Adaptation is, of course, far more complex than flood prevention and the Dublin Climate Action Regional Office recognises the need to engage residents in an array of mitigation and adaptation issues, however the focus of the plan remains squarely within the information deficit model described earlier. Indeed, the plan explicitly states, "Dublin City Council commits through this plan to address the current knowledge-gap and will encourage citizens to act on climate change through a range of awareness and behavioural change actions" (Dublin City Council, 2020, p. 5). However, while education is mentioned 11 times in the plan as an aspirational site of action, only one educational action point is proposed to "[d]evelop and implement an education programme to tackle climate issues related to the water sector" (Dublin City Council, 2020, p. 105) by 2027. Beyond this, education is mentioned only generically e.g. to "Develop education and awareness initiatives for the public, schools, NGOs and other agencies engaged in driving the climate change agenda" (Dublin City Council, 2020, p. 24).

In part, this municipal reticence for enacting detailed climate change education actions is explained by the rigid hierarchical national educational structure in Ireland which is highly prescriptive at the secondary level in terms of curriculum content, slow to change and

relatively conservative in its approach to emerging issues. At a general level, the education system in Ireland is made up of primary (students aged between 4–12) and secondary schools (students aged between 12–18). There is mandatory education until 16 or until students have completed three years of post-primary education. There are two sets of national exams taken at second level. The junior certificate taken by students aged 14–15 and the leaving certificate taken by students aged 16–18. Between these two examination points is the Transition Year (TY), a one-year programme between the junior and senior cycles, which is designed to develop a more independent self-directed learning approach. While there is a national curriculum for the two cycles, programmes for Transition Year are set by individual schools allowing for more flexibility around content and focus. Following second level schooling there are higher education options available either through further education or third-level institutions (university and technical colleges).

As Waldron et al., (2020, p. 234) note, Irish education has long been "framed predominantly by the needs of the economy, neglecting other more social and civic perspectives". While there has been positive progress at the post-primary level, including the incorporation of concepts such as sustainability, well-being, and student voice (Department of Education, 2019), as well as a commitment to fostering active citizenship (Department of Education, 2015), there remain challenges. In 2019 the Department of Education recognised that "the scope for addressing content related to specific Sustainable Development Goals [including climate change] is largely dependent upon the professional capacity, interest, and disposition of the teacher" (2019, p. 89), leading to concerns about uneven access to essential knowledge and skills in relation to existential challenges like climate change. Indeed, research indicates that teachers require extensive knowledge to address the wicked challenge of teaching climate change (Favier et al., 2021). They also need skills and strategies for engaging with students around the emotional impacts that living with and through climate change creates (Ojala, 2023), with teachers' knowledge and attitudes found to be significant predictors of students' development (Scharenberg et al., 2021). There are also concerns about the bundling together of climate change with education for sustainable development goals when the goals remain wedded to an economic growth narrative which assumes growth can be decoupled from resource consumption (Kopnina, 2020).

While a new senior cycle subject on Climate Action and Sustainable Development (Department of Education, 2022) is due to be piloted in 2024, it will not be compulsory and the extent to which it will address climate adaptation is unclear. It is also uncertain how new and existing teachers will be equipped to deliver the subject in a way that transcends the limitations of the information deficit approach and move towards more transformational learning; incorporating critical thinking, inquiry- and problem-based learning, reflection and the mapping and deliberation of fundamental values (Tschakert et al., 2016). Such transformational learning approaches require significant preparation and flexibility on the part of teachers in the short term. It also requires teachers to convey alternative approaches beyond current mainstream capitalist responses, something that may be problematic in places like England where anti-capitalist organisations are considered extreme and not to be taught in the classroom (Busby, 2020). Nonetheless, when applied to real-world problems like climate change, transformational approaches offer possibilities for greater long-term engagement with students as problem solvers as well as active learners (Leichenko et al., 2022).

The development of the Climate Smart platform described below has transformational learning approaches seeking to foster adaptive capabilities at its core, for while education, as one facet of Irish climate action, is increasingly recognised in policy it remains underdeveloped in practice.

3.1. Climate Smart platform: methods, mechanisms and analysis

In alignment with adaptive capacity and capabilities methodologies internationally (Kronlid, 2014), this paper draws on a combination of qualitative and quantitative methods including interviews, surveys and group discussions to explore the impacts of the Climate Smart educational platform. This approach enables the identification and assessment of key capabilities, establishes barriers to expanding these capabilities and assists with developing strategies to remove these barriers through ongoing monitoring of impacts via the Climate Smart platform.

The Climate Smart digital resource platform was developed and rolled out in eleven schools in Dublin by the authors of this paper, building on the success of place-based, face-to-face workshops on climate adaptation carried out with young people in a single Dublin school (Davies and Hügel, 2021, p. 103), and a co-design process to produce a serious game with young people, teachers, scientific, policy, and games experts (Hügel and Davies, 2022). A pre- and post-module questionnaire to capture short-term impacts on participants was designed (see Table 1) and built into the module platform with students entering their responses on a Likert scale from strongly agree to strongly disagree. Teachers were provided with support prior to and during the module roll-out. Semi-structured interviews with teachers from the participating schools were also conducted post-module delivery to capture their experiences and to identify potential areas for improvement of the resources, with key themes focusing on learnability, usability and playability of the resources (See Lowry et al., 2013; Olsen et al., 2011).

Eleven Dublin-based schools were recruited to follow the Climate Smart programme. The programme includes six online modules with videos and quizzes and additional optional in-class activities (such as developing flood awareness posters and flood plans for their school). The module culminates in a map-based online role play game where participants adopt the persona of Dublin Mayor and have five years to protect the city (see Table 2). School recruitment was driven by two criteria: geographical location in Dublin and DEIS (Delivering Equality of Opportunity in Schools) status.

Being designated a DEIS school in Ireland signifies that it is located in an area of socio-economic deprivation and is therefore provided with greater resources by the National government than other schools to offset the challenges for students that living in such areas can bring. A key criterion for the project was to recruit a minimum of 50 % DEIS schools in order to ensure the resources provided were accessible for all. Schools were contacted by email, via a call for participation listed in a quarterly electronic newsletter distributed by the Irish Department of Education to all secondary schools, and through an electronic newsletter distributed by An Taisce, the National Trust for Ireland, which also

Table 1
Pre-workshop and post-game questionnaire survey for students.

| Question | Content |
|----------|--|
| 1 | I think about climate change: |
| 2 | I think the world's climate is changing: |
| 3 | I'm worried about the effects of climate change on my community |
| 4 | I think it's too late to do anything about climate change |
| 5 | I know about the history of flooding in my community |
| 6 | I know what the government and local authority are doing to help my community to cope with climate change |
| 7 | I understand the difference between climate change mitigation and climate change adaptation |
| 8 | I think technology is the most important tool we have to help us to adapt to climate change |
| 9 | I think interactive maps are a useful tool for talking about and demonstrating the effects of climate change |
| 10 | Games are a good way to help us to imagine the effects of climate change |
| 11 | Imagining what our lives will be like in the future is a good way to discuss adaptation to climate change |
| 12 | I think that changing my own behaviour can help to limit the effects of climate change |

Table 2
Workshop content.

| Workshop Name | Workshop Content | Support |
|-------------------------------------|--|-----------|
| 1. Introduction to climate change | Intro to climate change as a concept Defining adaptation and mitigation Introduction to climate science Global climate policy context Irish climate policy context | In-person |
| 2. Flooding in Ringsend | Introduction to flooding History of flooding in Ringsend Defending against flooding Defending against coastal flooding Planning and building flood defences | Remote |
| 3. Future Floods | Introduction to flood monitoring Using flood data Flood modelling and uncertainty | Remote |
| 4. Sensing Floods | Visualising flood impacts Flood impacts in Ireland Floods and feelings Taking flood action | Remote |
| 5. Adapting to Our Changing Climate | Irish flood management practice Grey infrastructure interventions Nature-based interventions Policy and behavioural adaptation | Remote |
| 6. How We Adapt | How we adapt Citizenship Uncertainty | Remote |
| 7. The iAdapt Game | Introduction to the iAdapt game Gameplay and discussion | In-person |

maintains an environmental education unit and co-ordinates Ireland's Green Schools programme.

Interested teachers were invited to an online introductory workshop in order to establish a relationship with them, introduce the platform and its features, and demonstrate the game. This was an important first step in building the confidence of participating teachers. Due to the design of the Transition Year programme, teachers taking this cohort may not have any background in matters related to climate change. This introductory session allowed teachers to ask questions related to the workshops that would be taking place, interact with the platform, and experience the gameplay alongside the team who designed and implemented it.

In-person workshops then took place in 11 schools between September and November 2022. Members of the research team attended the school for its first workshop session in order to help teachers to register pupils, ensure that the pre-workshop survey was completed by all students, and complete the first set of educational materials, consisting of videos and multiple-choice questions. Teachers would then run the workshops alone for the following five sessions (see Table 2), remotely supported by the research team if necessary. As the teachers' schedules had been agreed ahead of time, it was possible for a team member to be instantly available in case technical support was required or other questions arose. Team members then attended the schools once more for the final session, which involved students playing the serious game, discussing their actions, and completing the post-game survey. At the end of the session, teachers were asked to complete an interview in which they were asked about their experience of the workshops and had the opportunity to provide feedback. The interviews were recorded, and thematic summaries produced.

Students were given the survey before the first workshop (n = 374)

and following the final workshop (n = 239)¹ during which they played the serious game. The answers were converted to ordinal values and analysed using the Mann-Whitney *U* test.

4. Climate smart platform: impacts

The Climate Smart educational resource was designed to be followed in order. Workshops (Table 3) build upon knowledge which has been gained in previous sessions, in order to produce a comprehensive knowledge base encompassing climate science, global and local climate policy, and key institutional actors and events. Learners are then introduced to a case study in Dublin which has experienced repeated flood events – the most urgent climate-related hazard facing the country as a result of climatic change (DCC, 2019). Educational materials emphasise the whole-society approach to adaptation, with a particular focus on public institutions.

According to research, these adaptive capacity elements then need to be underpinned by a suite of capabilities. In the following sub-sections, we explore the extent to which capabilities were supported through the Climate Smart programme.

4.1. Capabilities elements

There are ongoing theoretical debates about selecting and weighting various capabilities (See Robeyns and Byskov, 2023 for further discussion), which means there is no definitive list to draw from in empirical settings.² In response, a suite of broad capability categories prevalent in the literature were first distilled as: physical, psychological, material, social, political and cultural. From this, specific capabilities for adaptive capacity in climate change adaptation were then identified as: knowledge and learning; agency and empowerment; social networks and support; and resource access and management (Table 4). The Climate Smart programme, as an educational resource, focuses primarily on knowledge and learning and agency and empowerment, although it also provides elements which support social and institutional capabilities and matters of resource management in relation to climate change adaptation.

The selected categories of capabilities outlined above are considered in relation to the design and delivery of the Climate Smart module in the following section from the perspectives of students and teachers. Pre- and post-workshop survey data were analysed using both the Mann-Whitney *U* and *t* tests and a Hedge's *G* classification was assigned to statistically significant results (See Hügel, 2023 for complete analysis). Analysis and visualisation of the results is presented in relation to each capability.

5. Capabilities elements: student perspectives

5.1. Knowledge and learning

Knowledge and learning in the Climate Smart module is multifaceted, encompassing content, analytical skills, simulated experiential skills, problem solving and experimentation. Subject content ranges from geography and maths to history and politics in relation to climate change science, policy and politics. The causes and consequences of flooding and mechanisms for responding to flood risk (materially and psychologically) are also delineated. These responses are categorised

¹ The pre- and post-response rate varies due to differing attendance rates in individual schools on the days of the surveys; there was no guarantee that a given student present for the first workshop would be present for the final workshop and the nature of the Transition Year programme means students may be away on work experience or exchanges at various points in the year.

² Due to the need to recognise and value local contexts, cases and participants (Sen, 1993; 1999).

into grey, green/blue, mixed and policy interventions and explanations for these categories provided.

Multiscalar policy processes are outlined and provide knowledge of decision-making systems which are then activated through the adopted persona of Dublin mayor by players in the serious game. In this game-play context the mayor receives advice from social, economic and environmental experts and the general public responds to interventions during the consultation phase via a 'popularity rating', which if it drops too low and is not heeded during the revision phase of planning can lead to eviction from office.

Budgetary skills are required in the game play session as players are given €10 million a year to purchase a suite of adaptation options (going into debt is not permitted and no transfer of budget from one year to the next is allowed). Some items are expensive (e.g. Dublin Bay tidal barrage), consume all the annual budget and take three years to be constructed and provide protection. This gives players experience of the challenges and risks around balancing protections, costs and timelines. Content knowledge is assessed through quizzes and the serious game, which also provides a space for decision making, budgeting and knowledge application in a simulated planning context.

Analysis of impacts in relation to knowledge and learning, derived from quiz and questionnaire responses found that there was a statistically significant change in respondents' understanding in relation to the question "I understand the difference between climate change mitigation and climate change adaptation" (see Fig. 2), corresponding to a Hedge's *G* classification of a medium effect size.

Analysis of the other questions relating to this capability reveal that while the changes are not statistically significant at the $p < 0.05$ level, following the workshops and game, students thought about climate change more often overall. A greater proportion of them thought that the world's climate is changing to some degree, and a greater proportion thought that technology is the most important tool we have to help us to adapt to climate change. The latter question is particularly interesting as although technological interventions – broadly defined – are discussed extensively in the workshop materials, there is an emphasis on the non-technological aspects of adaptation (Ramm et al., 2017), and indeed it is necessary to implement these in order to do well in the game. As discussed in the literature review, there is a need to move beyond the information-deficit model, however there is no question that in order to do so, a baseline of knowledge concerning climate processes must be established, and the focus of the knowledge-provision in climate smart is on collective, and public – as opposed to individual – processes and actions, which is not the norm in climate education currently (Jorgenson et al., 2019).

5.2. Agency and empowerment

Climate Smart fosters agency and empowerment through a number of its workshop modules. This involves detailing the ways in which individuals can take meaningful climate action, how they can participate in the climate adaptation planning actions taken by their local authorities, by identifying climate concerns in their local area, and participating in Ireland's Green Schools initiative. This knowledge is tested and reinforced when playing the serious game, which places players in a position of considerable power and agency as the (hypothetical) mayor of Ireland's capital city. By setting up a "feedback loop" in which societal adaptation actions, such as putting in place citizens' assemblies, creating local adaptation plans, and adaptation awareness campaigns, are essential to performing well in the game, their centrality to effective adaptation planning is emphasised. Finally, the optional class-based activities documented in the teacher module handbook, such as creating a flood-awareness poster for their fellow students, helps to build agency, as participants assume responsibility for communicating a complex and emotive topic to their peers.

Analysis of impacts in relation to agency and empowerment, derived from quiz and questionnaire responses found that there was a

Table 3
Adaptive capacity elements and their locations within the Climate Smart resource.

| Adaptive Capacity Category | Element | Workshop | Game | Both |
|---|---|----------|------|------|
| Knowledge and information | The science of climate change and differences between mitigation and adaptation | | | |
| | About climate change adaptation and planning processes etc. | | | |
| | About different types of flood events | | | |
| | About flood probabilities | | | |
| | About flood management measures | | | |
| Technological Options | Different types of adaptation interventions (grey, green, blue, mixed, policy) | | | |
| Leadership | Mayoral role Expert advisers | | | |
| Economic and financial resources | Annual budgets Differential costings and timelines | | | |
| Human, social, institutional, political, cultural, and natural capital | Political affiliation of voters | | | |
| | Popularity barometer Protests on streets | | | |

statistically significant change in respondents' understanding in relation to the question "I think it's too late to do anything about climate change" (see Fig. 3), corresponding to a Hedge's G classification of a small effect size. Post-intervention answers to the other two questions were not significantly different at the $p < 0.05$ level, but this is an interesting finding in itself: it is an aim of the Climate Smart resource to stimulate discussion about the likely future effects of climate change without resorting to doomsday scenarios or inducing fear and helplessness in participants. In addition, the resource emphasises the importance of collective, multi-scalar action rather than individual responsibilities.

The game and the in-class discussion led by the Climate Smart researchers are a key component in the process of moving beyond the information-deficit model (Cook and Overpeck, 2019) toward the civic, deliberative model discussed in the literature review (Owens, 2000) and these results – particularly in relation to a complex, emotive question (whether it is "too late") are of particular interest.

5.3. Social networks and support

Information on social networks and support is provided by Climate Smart's first and sixth modules which emphasise the roles of active citizenship, protest, and the importance of collective action. The serious game tests and reinforces this knowledge in two ways. First, by providing feedback – both positive and negative – to players in the form of their popularity rating, which rises and falls according to the reaction of the electorate – the composition of which is randomly determined for each game – to players' adaptation actions. Second, players receive a score "boost" by putting in place specific networks of interventions, such as bioswales and community adaptation plans. Individual interventions of these types are small, but can be built up to span the city, strengthening a collective sense of adaptation as multiple communities each participate in localised adaptation actions. These game mechanics are designed to 1) encourage the re-framing of coastal areas and rivers as

positive features, as opposed to sites of risk (Devine-Wright and Quinn, 2020), encouraging place attachment and 2) allow players to experience the impact of differing identities, beliefs, and values (Fresque-Baxter and Armitage, 2012).

Analysis of impacts in relation to social networks and support, derived from quiz and questionnaire responses found that there was a statistically significant change in respondents' understanding in relation to the question "Games are a good way to help us to imagine the effects of climate change" (see Fig. 4), corresponding to a Hedge's G classification of a small effect size. While the reported changes in relation to government action and imagining climate-changed futures are positive, they do not reach the significance threshold. While there are multiple possible reasons for this (as will also be discussed in relation to resource access and management, below), these results indicate a possible need for a revision of the material related to these questions.

5.4. Resource access and management

Climate Smart provides information on resource access and management in its third and fifth workshop modules, which address flooding processes in Ireland. Following introductory sections which explain the phenomenon of flooding, the third module then details the three main types of flooding and how they can occur and explains how flooding can be defended against using grey, green and blue, and hybrid interventions. The fifth workshop module builds on this, introducing the idea of nature-based solutions and their role in enhancing ecosystem services and supporting adaptive capacity.

This knowledge is tested and reinforced in the serious game by the provision of a category of green and blue interventions, the deployment of which is crucial to achieving a high score, as these interventions are explicitly taken into account as they bring additional "co-benefits" such as enhancing biodiversity and expanding access to green spaces. The questionnaire results reveal an overall positive change in students' self-

Table 4
Capability categories for adaptive capacity and climate change adaptation.

| Capability | Description | Key References |
|---|--|-------------------|
| Knowledge & learning | Knowledge and learning capabilities are considered key as they enable individuals and communities to better comprehend the causes and impacts of climate change, as well as appreciating (and potentially also co-designing) adaptation strategies. While we focus on formal education contexts in this paper, this category of capabilities expands beyond this into informal settings and to lifelong learning and experimentation. | Bardsley, 2015 |
| Agency & empowerment | Agency and empowerment encompasses capabilities related to freedoms for individuals and communities to have some control of adaptive processes and take (or contribute to taking) decisions about how to respond to climate changes. This set of capabilities includes engaging in decision-making process, having access to relevant resources and supports to achieve this, and exercising self-determination. | Vincent, 2023 |
| Social networks & support | Social networks and support systems, which might be formal or informal, can expand adaptive capacity by providing new sources of information and resources. These supports are particularly important in times of crisis and change indicative of climate change. Being networked through a range of social ties (weak or strong) has also been identified as a core capability central to bringing people together over collective action on climate change. | Adger, 2003 |
| Resource access & management | Building capabilities around resource access and management enables individuals and communities to access and manage natural resources in a sustainable and equitable manner. With the Climate Smart platform this relates to knowledge, skills and understandings of water and flood management, land use planning, and nature-based adaptation solutions. | Ford et al., 2006 |

assessment of their knowledge of flooding in their community (see Fig. 5). While this result is not statistically significant there are some explanations for this. In particular, a number of participating schools had students visiting from overseas for three months and so English was a second language and the focus on ‘my community’ for these visitors would not be the same as the remainder of the students, which may have influenced the results here.

6. Capabilities analysis: Teachers’ perspectives

Teachers who supported the delivery of Climate Smart in the classroom provided important feedback on their experiences of the materials and how students engaged with them. It was also important to capture how the supporting resources we provided teachers with, such as the module handbook and the platform dashboard, were experienced. Overall, teachers found the handbook resources helpful, but did not overly refer to it throughout the module. The handbook seemed to be most used as a technical step-by-step guide to registering students on the platform dashboard at the start of the module. Most teachers said that the programme was straightforward once they “got the hang of things”. While positive for usability, this meant that some aspects of the module detailed in the handbook were lost, with not all teachers undertaking additional classroom or external activities which were presented as optional extras.

The project dashboard, which sits on the Climate Smart webpage and is accessed once registration is complete, was of particular interest as it requires teachers to engage with a digital platform. The teachers involved had different levels of experience and confidence in technical activities, but all found the dashboard and registration unproblematic. They particularly appreciated the information provided in the dashboard which allowed them to monitor students’ progress through the platform. Indeed, one teacher requested further information and statistics on what questions students got wrong and right so that they could be discussed in class. Some technical issues arose because teachers were unaware of the control they had over what and when workshops were made visible to students, but this was quickly resolved remotely. However, technical glitches can quickly undermine the confidence of non-technical teachers to run such programmes autonomously. An intuitive dashboard that can provide granular feedback on students’ progress and help to identify areas of weakness across the cohort is considered a key factor in bolstering teachers’ capabilities (Lambert et al., 2015; Scharenberg et al., 2021).

6.1. Knowledge and learning

It should be noted that teachers had a certain degree of flexibility regarding how they delivered the module so not all experiences were common. Some teachers let students work autonomously and independently. This was effective but requires a hands-on approach from teachers to ensure everyone is engaged. Most teachers showed the videos to the whole class at once, which helped familiarisation with the content for the teacher and prevented students skipping ahead. The teacher felt they had more control in these contexts. This was particularly important when students attempted to answer quiz questions without watching the videos. Certainly, the differential abilities of students meant that some found the quizzes hard and others easy.

Teachers were asked specifically about the appropriateness of the content provided for their classes. Unsurprisingly, given the diversity of students, there were different experiences and thus opinions about this. Some teachers found it the perfect level for their students; not too complicated but as a new topic it stretched them in places. Nonetheless, others found the language could be challenging for some. Teacher confidence to be able to step in when confusion arises was seen as important and those with some level of climate literacy felt more comfortable in these situations. Easy fixes can be made to increase the complexity of quiz questions, increasing the number and variety without requiring structural changes to the platform. Additional provision of content in alternative formats was also discussed, such as scripts for videos (captions are already provided on videos), to support those with hearing and reading difficulties and for the teacher in case technical issues mean the videos fail to run. Such mechanisms could also include translations of the script in other languages. Research has clearly established the importance of attending to differences in student cohorts’ abilities in the context of climate education (Dupigny-Giroux, 2010; Kuthe et al., 2020) when designing educational materials, making this a key area of concern when considering changes to the platform.

As mentioned above, the additional activities provided in the handbook were not used universally. However, those that did utilise the resources found them helpful and the activities interesting. They found certain activities, such as the poster (see Fig. 6), a good way to express their understanding in a different medium, which helps to ground learning and skills in practice.

In terms of material format, the game was a clear draw for students. Teachers said students found the end goal of the game novel and were keen to get through the module content in order to play. Posting students’ positions compared to their class and all players of Climate Smart was identified as being “great for motivation” and a “highlight”. This was particularly appreciated by teachers as the game format meant that players topping the class leaderboard were not always those with the strongest academic skills, but rather those who were willing to engage

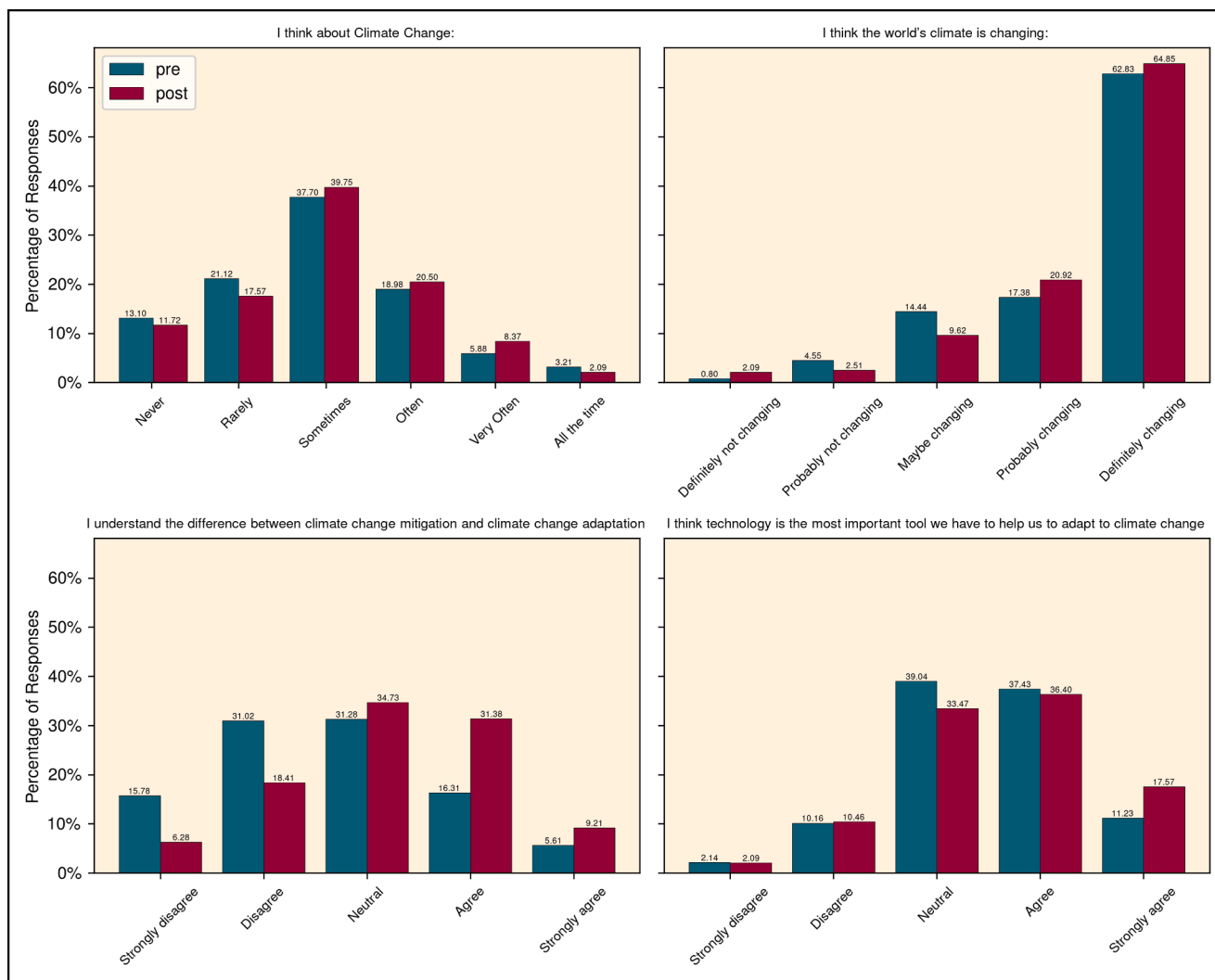


Fig. 2. Pre-workshop and post-game responses to the “knowledge and learning” capability.

with the game process intensely. Students’ reported enthusiasm and engagement with the game across all surveyed schools is clear evidence of the efficacy of the game in the context of education (Madani et al., 2017; Michael and Chen, 2005). Indeed, most teachers said they had a generally high level of engagement for a transition year class – they maintained good student numbers and found that students were interested and curious. Most commented that every week students came to class, logged straight into the platform, and seemed happy to “get on with it”.

One teacher from a DEIS school noted that engagement sometimes varied. Students were engaged when they recognised where they lived as something familiar they can relate to (Stern et al., 2023), but found that some of the generic content on climate change was still somewhat abstract. Nonetheless, they appreciated the content related to the illustrated interventions, such as green roofs, because they could picture it happening around them. Playing the game was felt to solidify and reinforce learning through doing (Angel et al., 2015), even under simulated conditions. Taking time to discuss issues in videos within the class, going slowly through workshops and undertaking the additional activities outlined in the handbook, all contributed to higher learning outcomes. Being a decision maker in the game pushed players out of being passive learners to be more active participants in the issues they were engaging with; identified as a key element of transformational learning (Tschakert et al., 2016).

Other elements of capability development from the teacher’s

perspective would need more time to bed down and so matters of agency and empowerment, social and institutional capabilities and resource management implications were not identified by teachers in the feedback session which occurred directly after completion of the module. Such matters need to be explored over longer time scales and in settings beyond the classroom and are therefore hard to trace and quantify.

6.2. Teacher capacity

All teachers said they will be running the module again with another cohort, and that they are comfortable running it without support from the research team. Most teachers plan to run it slightly differently now that they are comfortable and familiar with the content and would have more class discussions and be better prepared themselves to spend more time on each topic and allow the students to explore the content in more detail outside of the framework of workshops and videos. This confidence to more freely use and in some sense “remix” the platform and its materials can be attributed to an increase in teachers’ capabilities following supported use of the platform (Owens et al., 2022).

It is clear from the feedback that the transition unit has been well-received by teachers. Though there are suggestions for minor improvements, they centre on one area: catering to a greater range of abilities. It is certainly possible to add further supports and context for deeper engagement with the material for cohorts who wish to push themselves and add additional supports for students who require them. These could

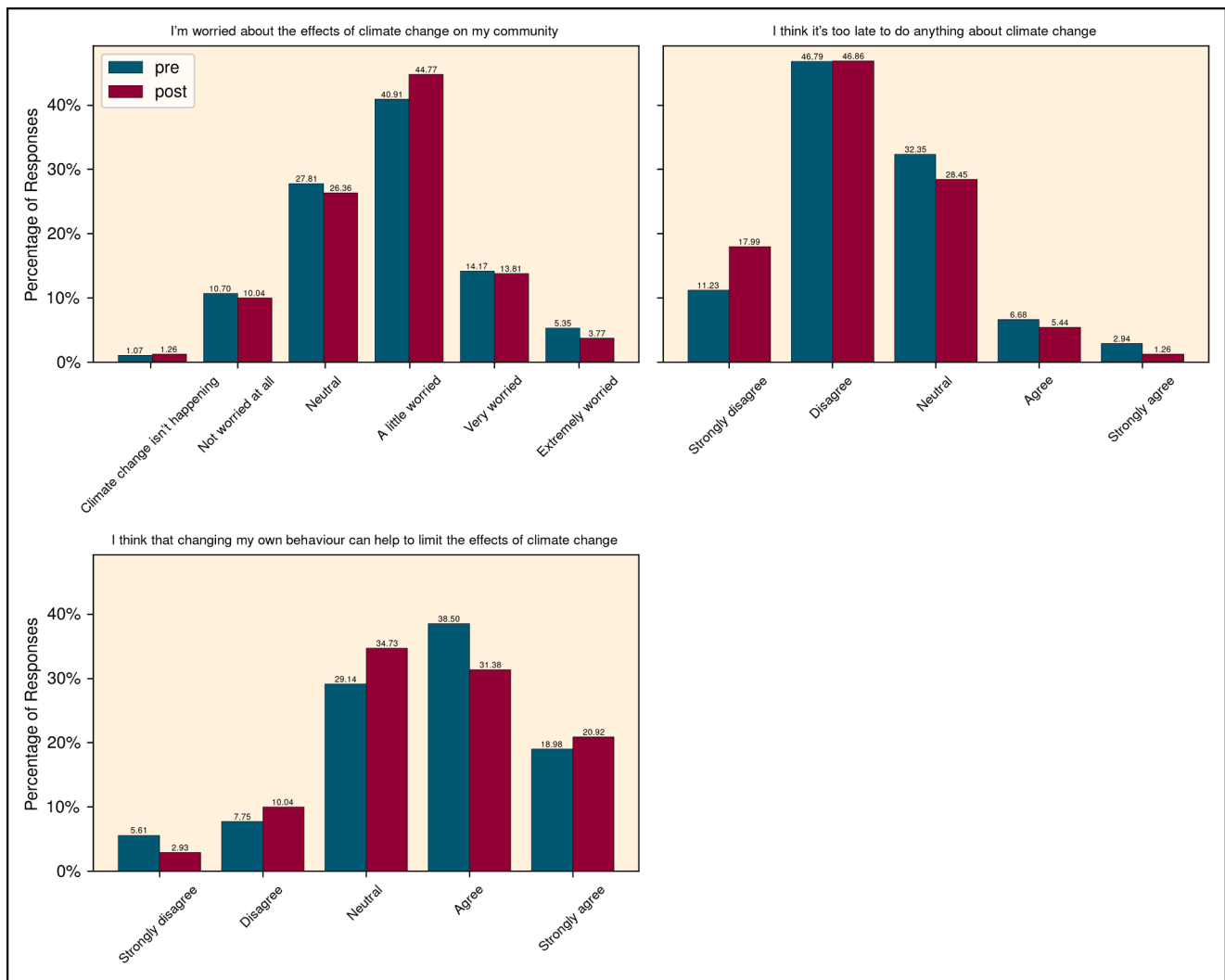


Fig. 3. Pre-workshop and post-game responses to the “agency and empowerment” capability.

take the form of more optional multiple-choice questions, broader discussion-based questions, and more easily-accessible explanations of technical terms across the written material. In addition, the material comprising the first five workshops can be easily made available in structured text form to teachers who wish to use it as a scaffold for a class which is not based on the videos and quiz format. An emphasis on flexibility and suggestions for using the platform and its materials as building blocks for a more tailored approach will be a key component of continuing professional development workshops for teachers which the research team will roll out between 2023 and 2024.

The Climate Smart platform provides a novel, interconnected and mutually reinforcing programme which aims to support students to engage in climate change adaptation planning. However, knowledge and learning alone cannot overcome a lack of conversion factors (whether they are personal, socio-political, or environmental) that are needed to move from capabilities to functionings; that is to enact capabilities. As noted by Schischka et al (2008) participant agency will be essential.

7. Conclusion

The co-design of the Climate Smart resource platform has been hugely productive in terms of engaging teachers, students, learning innovators and policy shapers with the issue of place-based climate change adaptation planning in Ireland. The online nature of the platform

provides flexibility for teachers and students in terms of pacing and delivery, opening up possibilities for distributed leadership within schools and school communities. Since the initial evaluative analysis presented in this paper, more than 1600 students have completed the module and in excess of 2200 gaming sessions have been completed. The process of co-design has ensured the needs and interests of students have, where feasible, been accommodated and teachers’ insights into positive learning environments have improved the module handbook and online user guides.

Analysis of impact data confirms the value of adopting a place-based approach to adaptation education; literally bringing the issue home to participants (Amundsen, 2015; Edwards et al., 2019). The scope to develop further Climate Smart games for other locations within Ireland is underway but will require further investment and research into local debates about the suitability, cost, and location of interventions in order to maintain the fidelity of the game. The question of who will fund the long-term maintenance of the on-line platform and how that funding will be sourced remain to be resolved (Davies et al., 2024).

Additional qualitative research will also be needed to drill down into the impacts identified by the survey. The testing of the module and serious game in the classroom, with pre- and post-questionnaires have shown that its short-term impacts are promising with regards to expanding students’ capabilities for adaptive capacity. However, engagement with one module alone is clearly insufficient to create and sustain the required capabilities across time, and longitudinal research is

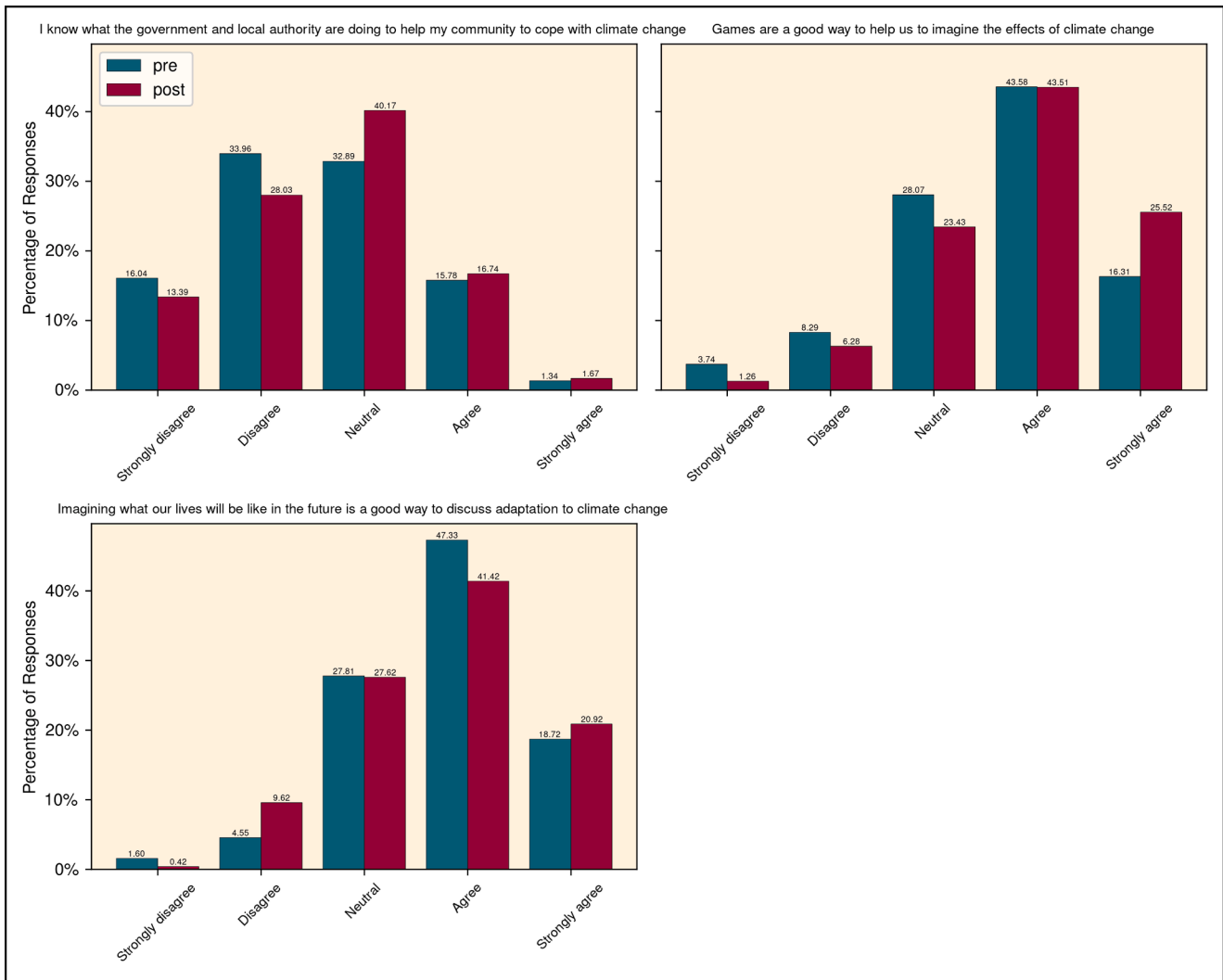


Fig. 4. Pre-workshop and post-game responses to the “social networks and support” capability.

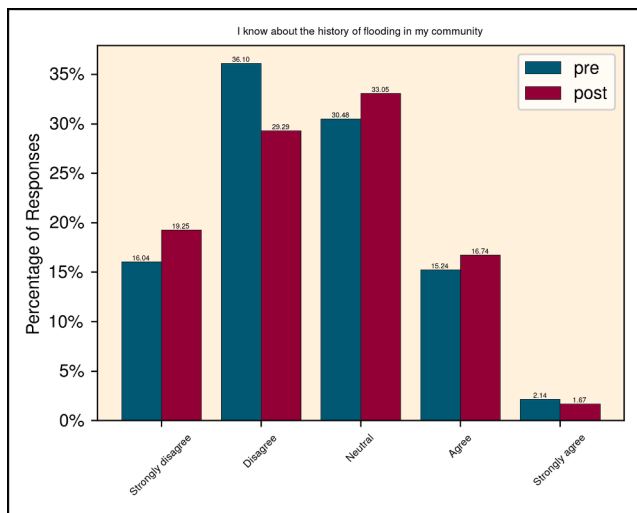


Fig. 5. Pre-workshop and post-game responses to the “resource access and management” capability.

needed to trace the legacy of that engagement with participants. Repeating the questionnaire survey with these students can be conducted annually for the next two years while they remain in the school. This could explore any drop-off over time of the capabilities developed immediately following engagement with the module. However, the lack of engagement with climate change in the Leaving Certificate curriculum (for students aged 16–18 years) which follows Transition Year means there is no continuation of adaptive capability development for all. The plans to develop a new Leaving Certificate subject in climate action and sustainable development could help if it includes material on climate change adaptation, goes beyond a simplistic information deficit approach, and is permitted to address an array of alternative socio-economic models beyond mainstream capitalist growth narratives.

Addressing not only the capabilities of students, but also teachers’ capabilities will be crucial. Continuing professional development workshops will be held for teachers in relation to Climate Smart, as well as introductory workshops with trainee teachers, but there are challenges with disseminating information about the resource nationally due to the individual school-led nature of the Transition Year curricula. This is compounded by a lack of Geography teachers in Ireland, as the subject specialists most likely to be familiar with climate change and most comfortable in running the module. Despite increased recognition of the need to address climate change by politicians and policy makers, including the Department of Education, Geography as a subject was removed from the compulsory list of subjects for Irish students at Junior

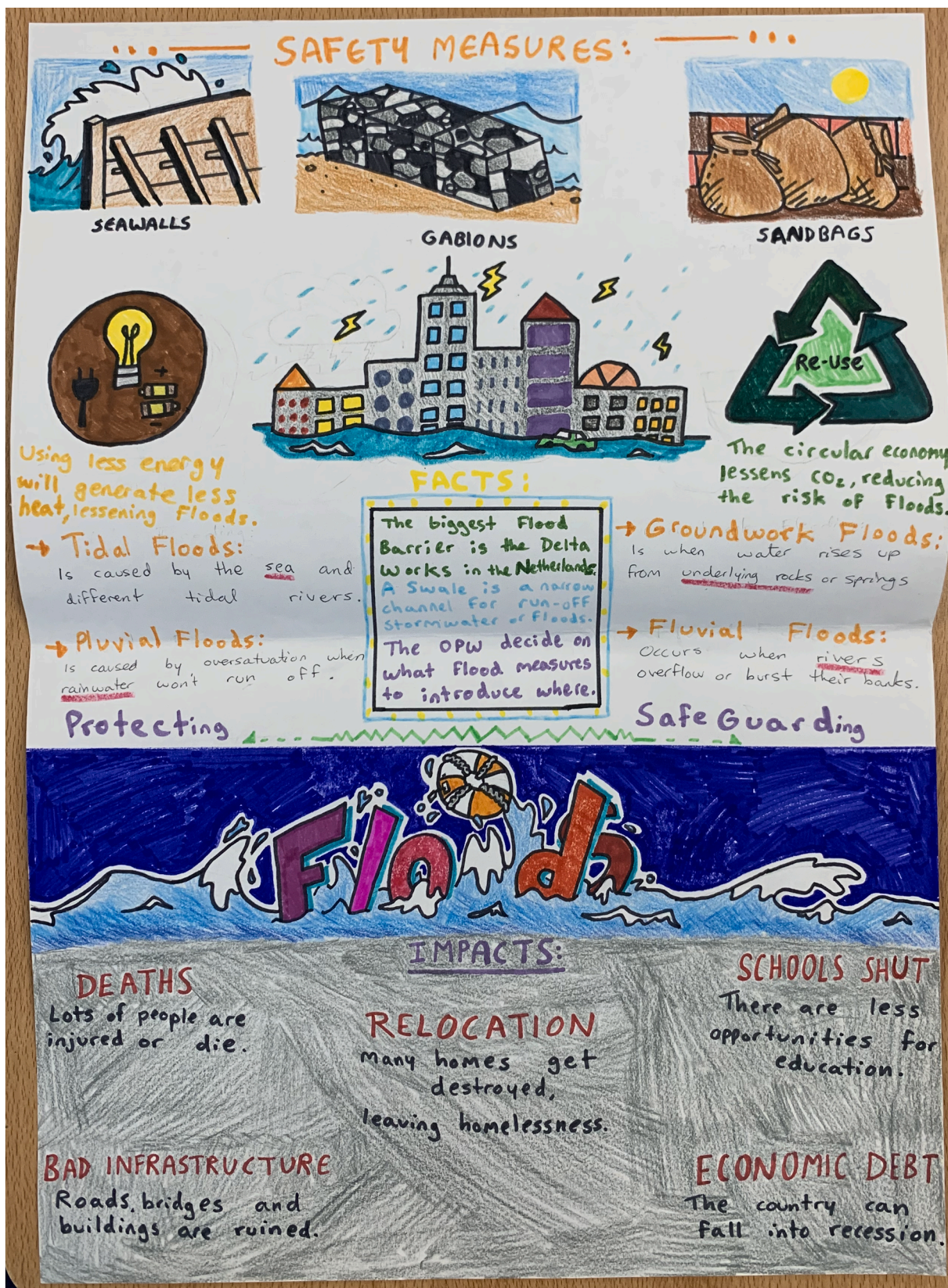


Fig. 6. Poster produced by a pupil based on the Climate Smart material.

Certificate level (taken by students aged 13–15) in 2018, further eroding the pipeline of capability development in relation to complex nature-society phenomena such as climate change.

Additionally, Climate Smart project funding will cease at the end of 2024, and it is essential that education around adaptation matters is embedded in formal education infrastructures, including teacher training courses. Beyond this, wider systems change in relation to opportunities for citizen engagement in adaptation planning (Chu, 2018b; Trott et al., 2023) are required to ensure capabilities catalysed by Climate Smart are reinforced and operationalised. While the Climate Action Regional Offices (CARO) liaise with councils in order to ensure visibility of local adaptation plans, there is considerable scope to expand this activity.

Finally, while testing has revealed the general accessibility of Climate Smart for all schools in Ireland (DEIS and non-DEIS), there are still improvements to be made around ensuring the assessment elements are flexible enough to meet a range of educational needs. Developing materials in different formats and translating the materials into Irish and other languages is also being explored. Expanding the suitability of materials to engage both more advanced learners and those who require additional supports, while developing an intuitive mechanism for teachers to choose a level which is appropriate for their students, is key to ensuring the broad usefulness of the Climate Smart platform as it continues to expand to more Irish schools.

We conclude that while such educational innovations are essential for developing adaptive capabilities, they will be insufficient alone to optimise long term adaptive capacity for climate change adaptation without wider structural changes across multiple systems. Further longitudinal research (Howlett et al., 2019; Scott and Moloney, 2022) on long term impacts is also required. An agenda for progressing adaptive capacity for climate adaptation planning with education at its core is needed.

CRediT authorship contribution statement

Stephan Hügel: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Visualization, Writing – original draft, Writing – review & editing. **Anna R. Davies:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

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

Data availability

Data have been made available. The dataset and its analysis (deposited using Zenodo) are cited in the article, and the analysis is provided as [supplementary material](#).

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.geoforum.2024.103978>.

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