Serious Games for Empowering Teenagers: A STEAM Approach to Climate Change Reflection and Communication

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Abstract

As a wide-ranging societal challenge characterised by complexity and uncertainty, confronting the problem of climate change can be an overwhelming experience for teenagers too young to vote, but too old not to care about the altered world of their inheritance. Consequently, some become activists, more disengaged, yet others become despondent in the face of this formidable predicament.

This chapter responds to the needs of this cohort and their teachers by showcasing a design-thinking focused, transdisciplinary, pedagogical framework to enhance the climate change knowledge and communication skills of mature minors (14-17 years old). Coalescing around the co-design of a climate change adaptation game 'by' teenagers 'for' teenagers, the chapter describes a process-centred, self-paced STEAM pedagogy of problem solving. Drawing from a nationally funded work research project and illustrated via a case study, the chapter describes a replicable series of innovative pedagogical methods for stimulating collective creativity in resolving complicated climate change issues.

The chapter will be of interest to educators and youth workers seeking to improve the engagement of teenagers with climate change, enrich the experience of those already interested in the topic, and reduce the sense of anxiety some may feel regarding the seemingly insuperable challenge left to their generation.

Keywords
STEAM, Design Sprint, Climate Change, Serious Gaming, Teenagers

INTRODUCTION

The emergence of STEAM (Science, Technology, Engineering, Arts and Maths) education could be considered a recent pedagogical approach. Indeed, the acronym was only coined in 2011 during funded workshops at Rhode Island School of Design (RISD). However, it may be argued that STEAM represents a return to holistic epistemologies and methodologies for learning in a world increasingly siloed into discrete disciplines. As the boundaries and edges of our world - the physical, mediated, augmented or parallel - become increasingly blurred, this chapter presents an example of how STEAM education offers opportunities for the synergistic integration of the natural and social sciences with art to facilitate multidimensional ways of approaching challenging issues, such as those characterising teaching about climate change. In the 'Century of the System' (Gawande, 2014) no field or discipline in isolation can adequately meet the needs and challenges of contemporary society (McKeown, 2018). Accordingly, this chapter shares an approach to facilitating climate change knowledge acquisition and skills development that are relevant and transferable to all sectors of society.

Specifically, this chapter details and discusses a pedagogical project called 'Climate Change Engage'(CCE)[1]. The impetus for the team to come together to seek funding for the project was the 'climate strikes' that culminated on 20th September 2019 when millions of people united across 185 countries to participate in demonstrations to highlight their dissatisfaction with progress on tackling climate change. Such protests shared an overwhelming concentration of young people anxious about what they perceived as the forfeiting of their right to the benefits of the benign environment enjoyed by previous generations. The Irish public, and in particular children of school going age, mobilised in their tens of thousands across Ireland to add their voices to the growing roar of anxiety. Too young to vote but too old not to care, such school children were frustrated by inaction to protect the planet that is theirs to inherit.

Resonant with the United Nations Sustainable Development Goals (SDG) numbers 11 (Sustainable Cities & Communities) and 13 (Climate Change), the CCE project thereby sought to enhance the agency of such stakeholders by giving them the knowledge, skills and judgement to effectively engage with, formulate responses to, and communicate their solutions with respect to the climate change crisis. A central aim of the project was to empower students to communicate their knowledge on the topic with their peers.

The first section of this chapter briefly introduces the integration of Art with Science Technology Engineering and Maths through the foundation of 'STEAM', a deliberate pedagogical approach formally established in 2011. The evolution of STEAM methodologies are then introduced and an

[1] The project was funded under the Irish Research Council's NEW FOUNDATIONS programme and was led by University College Dublin (UCD) Earth Institute Member Mick Lennon with Anita McKeown and Rebecca White from the SMARTLab Skelligs. Other Earth Institute members of the project team include UCD academics Aura Istrate, Paula Russell and Tamara Hochstrasser. The project completed a pilot game design sprint that with the Muinín Catalyst Sustainable STEAM project funding from Science Foundation Ireland's Discover Programme / Department of Education was further developed into a full teaching unit targeted at mature minors (15-17 years old).

overview is provided of the methods used in the CCE project. An analysis of the methods used forms the central part of the chapter. This is based on reflections from both the learners and educators. The chapter concludes with a discussion on the benefits of STEAM as a pedagogical approach to climate change.

THE STEAM APPROACH

Integrating the Arts and Sciences

Since the enlightenment, the scientific method of knowledge acquisition has heavily influenced the trajectories of pedagogical approaches through a decoupling of the sciences and the arts. This empiricist approach is grounded in observation, research and testing of ideas through experimentation. In this instance, science and the arts represent two different perspectives on knowing the world. Yet both perspectives have more in common than many consider. Early adoption of new ideas are explored as much within the arts as in science, whether this be the mixing of pigments for cave paintings, the use of geometry within perspective, lenses in renaissance paintings, scientific concepts within futurism and developments within design. More recently the blending of art and science through the creative use of technology has allowed these perspectives to intersect. Today 3D printing, virtual, augmented and mixed realities reflect the increasing entanglement of art and science that evidence the myriad of possible ways that these perspectives thread together the human story. As mixed realities merge and converge, we will need to balance these physical and non-physical worlds and their threats and opportunities with our humanity.

With the climate crisis as the defining challenge of our time, it is clear that no single knowledge domain or sector can solve this problem. We will need inclusive systemic approaches to solving global challenges which require inclusive inter and transdisciplinary education that builds confidence and competence to integrate knowledge from wide-ranging contexts and apply it, strategically, tactically and with agility.

From SMET to STEM

Initially, SMET was an acronym used as shorthand for the disciplines of ‘Science, Math Engineering and Technology’. In the 1990’s the STEM acronym began to emerge from educators in preference of SMET largely as a result of the work of Charles E. Vela (CAHSEE 2022, NSF 2022). Since then, the promotion of STEM subjects and careers has become widespread. This has led to a focus on STEM education, which is more prevalent in the USA where there is no national curriculum, with curricula managed state by state and by independent school boards. This also enables charter schools, independent public schools in the USA, to ‘chart’ their own course, often with highly focused STEM curricula. While STEM subjects do contribute to a deep understanding of the world around us, this approach to knowledge production negates our psycho-social understanding of the world. If we are to develop approaches to creative problem solving and innovative agile knowledge production applied across contexts, then a more integrated and applied approach will be necessary. For example, this will require a deeper understanding of context and human behaviour if we are to address anthropogenic / anthropocentric climate change and effective adaptation.

Indeed, critics of STEM education contend that its in-depth and challenging focus on the four STEM disciplines reduces the opportunity for other learning experiences, which it is argued have value both for academic and personal growth. Increasingly, research into art, music, literature, and writing as both activities and subjects evidence their contributions to the development of critical thinking, communication, collaboration and resilience (Liu and Wu, 2022; Miller, 2018; Winter et al, 2012; Catterall, 2002).

The emergence of STEAM

STEAM education (Gaskins, 2021, 2014; Henriksen, 2014; Maeda, 2013, Rose and Smith, 2011) provides a pedagogical response by some educators to the perceived asymmetries in the learning opportunities presented to students by STEM oriented curricula. STEAM is still an emergent field building on nascent work in STEMarts (Catterall, 2002; Chavez, 2009 – 2014; Ito et al, 2008; Chavez and McKeown, 2012, 13) wherein those advocating for educational approaches more sensitive to different learning styles have championed the inclusion of ‘arts’ focused pedagogy within otherwise STEM dominated programmes, not as a challenge to them, but as a creative complement. Hence, the letter ‘A’ was inserted into STEM to reflect the inclusion of ‘arts’, thereby producing the acronym ‘STEAM’.

Those promoting a STEAM education argue for the inclusion of a broader knowledge base and skills set, not only to support learners thriving, but to enable the application of knowledge more effectively. Focusing specifically on the evolution of STEAM as a pedagogical approach, the work of Christopher Rose and Brian Smith, Rhode Island School of Design (RISD), sought to place Art & Design at the centre of STEM education. In January, 2011, Rose and Smith, hosted an NSF-funded, two-day RISD workshop entitled ‘Bridging STEM to STEAM: Developing New Frameworks for Art-Science- Design Pedagogy’. The workshop brought together sixty experts working in Science, IT, Engineering, Art and Design, Maths and Education to progress an innovative educational agenda through an inter-relational approach to art, design and STEM. Their aim for the workshop was to develop transdisciplinary interactions for their potential to develop new educational approaches to creative problem solving (Rose and Smith, 2011).

A consensus emerged from within the workshop that the existing formal education system inhibited access to the sciences and in some instances, cultural, gendered and specific learning modalities in STEM actively excluded or discouraged learners. A STEAM education potentially afforded greater opportunities for more inclusive and accessible approaches to learning and applying scientific concepts (Rose and Smith, 2011).

A STEAM pedagogy also recognises multiple learning modalities and perspectives encouraging enquiry-based methods and an active learning approach that is experiential and physically engaging. This enables learners to engage in deep learning that follows relational connections driven by their own curiosity and perspective, yet grounded in a larger system or context. In turn, this can lead to understanding the ‘bigger picture’ as well as developing the skills to find the information required, lending itself to building capacity for curious and informed citizens. It should be noted there are also nuances within the STEAM education process and the development of STEAM curriculum. These are often absent or overlooked if the developers have no arts / design training, or simply focus on how the arts can serve the STEM agenda. STEAM education moves beyond artistic self expression to furnish learners with creative skills and competencies; this aspect can be neglected if the arts are only used to illustrate STEM concepts. Francis Whitehead’s seminal compilation, ‘What do artists’ know’, (Whitehead, 2006) summarises some of the tacit skills and competencies that are not only prevalent within art / design processes, but are actively taught.

What do Artists Know?

Frances Whitehead © 2006

Beyond a wide range of material practices, histories and techniques, concepts and theoretical frameworks, artists are trained to use a unique set of skills and methodologies. These include:

- **Synthesizing diverse facts, goals, and references – making connections and speaking many "languages". Artists are very "lateral" in their research and operations and have great intellectual and operational agility.**
- **Production of new knowledge as evidenced by the 100+ year history of innovation and originality as a *top criterion***
- **Creative, in-process problem solving and ongoing processes, not all up-front creativity: responsivity.**
- **Artists compose *and* perform, initiate *and* carry-thru, design *and* execute. This creates a relatively tight "feedback loop" in their process**
- **Pro-active not re-active practice: artists are trained to initiate, re-direct the brief, and consider their intentionality.**
- **Acute cognizance of individual responsibility for the meanings, ramifications and consequences of their work. (The down side of this is that artists are not always team-oriented or willing to compromise due to the high premium placed on individual responsibility and sole authorship.)**
- **Understanding of the language of cultural values and how they are embodied and represented – re-valuation and re-contextualization.**
- **Participation and maneuvering in non-compensation (social) economies, idea economies, and other intangible values (capital).**
- **Proficiency in evaluation and analysis along multiple-criteria -- qualitative lines, qualitative assessment.**
- **Making explicit the implicit -- making visible the invisible. Artists have keen pattern and system recognition, which makes them valuable at seeing potential areas of convergence and connectivity.**
- **Artists do not think outside the box-- *there is no box.***

Figure 1

What do Artists Know?, Frances Whitehead(2006), Image: permission of the artist

Further, many of these skills are not only transferable and critically relevant in other sectors, they are actively sought in academia and industry (DES, 2016) and extensively cited in national educational strategies and economic policy (DSIG, 2022; ESGFSN, 2020). As a systemic approach occuring at the intersection of 5 disciplines, STEAM education allows for a blended learning environment and approach to teaching that synergistically integrates aspects from multiple disciplines. Moreover, STEAM education does not simply use artistic outputs as a vehicle for the accessible articulation of scientific concepts e.g. posters, videos, metaphor. Rather, STEAM learning occurs at the intersection of the disciplines (Chavez and McKeown, 2012; Gaskins, 2014). It transforms both how we investigate and understand the world (McKeown, 2018). While the arts can serve to disseminate STEM knowledge in a more accessible way, it is the orientation towards 'making connections between diverse ideas and provok[ing] unexpected conversations' (Wellcome Trust, 2017, para 3) that lies at the heart of a STEAM approach.

This has particular relevance for our current education system. Whilst distinct knowledge domains and specialisation will always have a place in education, there is a need to embrace exploration and experimentation if we are to move towards a post-siloed system capable of negotiating multidimensional challenges posed by problems such as climate change, the biodiversity crisis and the persistence of abject poverty. STEAM projects advance such post-siloed thinking by reflecting contemporary interdisciplinary artistic concerns that are not bound by traditional media. These projects employ STEM skills and knowledge, such as electronic engineering, programming, or biological processes, for their production. Yet these STEAM projects simultaneously reflect a situated sensitivity (the work emerges from the situation / whole context) and focus on expanded practices (beyond the gallery / self-expression) that both attend to and embed political, economic and eco-social justice acuteness in the learning experience. In this sense, a STEAM approach places value on the arts for their creative methodologies, ways of knowing the world, and tangible modes of knowledge production (McKeown, 2018)

In summary, the STEAM approach is a pedagogical innovation that promotes teaching and learning 'that encourages and facilitates unorthodox methods and strategies' (Rose and Smith, 2011, 8). These seek to enhance the creativity and innovation of STEM pedagogies by integrating into existing teaching and learning practises the creative risk-taking and exploratory processes inherent in art and design training and disciplines.

CLIMATE CHANGE EDUCATION IN POST-PRIMARY CONTEXTS

In recent years, there has been considerable debate surrounding climate change education in schools, not least stemming from the movement of student-led strikes around the world. Education is critical to promote climate action, an untapped opportunity to combat climate change (Anderson, 2021). However, climate change is a relatively new addition to the curriculum. In many cases, the study of climate change is conducted through single subjects such as science or geography, and focuses on impact and mitigation. Learners often have a superficial understanding of the consequences of the rising temperature and actions they can take to prevent further increases. They are not exposed to how these consequences have already (and will continue to) impact their local areas and lives. Much of the course material is outdated and irrelevant to the lives these young people may be living (Saeverot, 2021).

The world of learning and work is changing at a rapid pace. It is vital to prepare young people with the skills and knowledge required to prosper in the current and future world they will face, with an economic, political and technological landscape that is far different than the ones that their parents grew up in. These young people will likely be the ones responsible for developing solutions to climate change and driving the innovations needed for our communities to adapt to the impacts experienced. Ireland's National Council for Curriculum and Assessment National Review 2016-2020 (NCCA, 2019) describes an interest and need for citizenship and political education, sustainability and climate change education and opportunities for interdisciplinary learning and application of knowledge. Nevertheless, the majority of post-primary education systems focus on academic performance to the detriment of skills development (Darmody et al., 2020). Thus, meeting the challenge posed by climate change requires the incorporation of new pedagogical approaches into post-primary systems that empower learners with the knowledge, skills, values and attitudes necessary to act as changemakers.

An extensive literature exists on group-based methodologies to encourage deliberation on environmental issues (Bryson and Anderson, 2000; Weisbord, and Janoff, 2000). The core principle underpinning these is the potential of participant interaction to generate novel insights and innovative solutions based on a new shared understanding of issues. In recent years, there has been much focus on the use of scenarios and role playing in the arena of climate change communication (Wu and Lee, 2015). Research has demonstrated that 'serious games' in particular enhance engagement (Clark et al., 2003; Crookall, 2010; Eisenack, 2013; Scott et al., 2013), stimulate novel ideas and can provide a sense of empowerment among participants to effect change (Garris et al., 2002; Petranek, 1994). Hence, adapting and mobilising an existing STEAM method for the process of serious game design was identified as a potentially fruitful means to achieve the aims of the CCE project.

Serious games can be used for addressing complex problems with no single solution (Abt, 1970) and so, are not played primarily for amusement, but have an entertaining component (Olejniczak et al., 2020). Because games are interactive, engaging and entertaining, they attract a wide audience and the gaming industry is currently developing at a faster rate than the film or music industries (BBC, 2019). Using part of the time spent playing commercial video games for engagement in solving real life societal problems, such as climate change issues, can potentially unleash new ideas and significant opportunities (Costanza et al., 2014). For example, among the multiple categories of serious games emerging, the category of 'games for sustainability' aims to particularly address societal problems in the sphere of sustainable development. Many of these games have been tested with youth e.g. Sustain (TABLETOPIA, 2022), Animal Crossing (Nintendo, 2022) and Sustainable Shaun (Aardman, 2022). Thus, the CCE project sought to harness and deploy the potential of serious games as a pedagogical tool for mature minors (15-17 year olds) in learning about, reflecting upon and communicating climate change causes, consequences and solutions. However, rather than learners simply 'playing' serious games, the CCE project sought to employ the potential of a STEAM approach by learners 'designing' a series of climate change orientated serious games. This more innovative pedagogical approach was targeted at enhancing the knowledge, reflective capacity and communication skills of those participating in the project activities.

EVOLUTION OF A POST-PRIMARY DESIGN SPRINT

Recognition of the relationship between creativity and innovation and its implications for attracting the brightest minds to research fields and contemporary problem solving is long-standing (Kuhn, 1962; Cziksentmahlyi, 1999). A STEAM approach creates conceptual and physical opportunities for trans and interdisciplinary research and education. Posing different questions based on knowledge exchange and insights from how different ways of knowing and exploring the world contributes to new ways of thinking. This fosters the best conditions for creativity and innovation within all the STEAM disciplines.

Educators are increasingly using tools and ideas borrowed from other fields in an attempt to develop best practices within and beyond the classroom. "Discovery" learning, where learners explore the problem with little instruction in advance, has been shown to yield results that include specific knowledge as well as confidence to self-direct their learning. Project and inquiry-based approaches provide supported learning opportunities that strike a balance between subject-specific knowledge and a wider range of skills and thinking abilities.

The CCE project reflected such pedagogical thinking by adapting an existing suite of design sprint resources from one of the project team member's research projects titled 'CoDesRes', which focused on co-designing for resilience using peer-to-peer learning networks and place-based STEAM interventions (McKeown et al 2022). Originally the concept of the 'Sprint' as a method was conceived as the core development method of the 'Scrum framework'. Developed by Dr Jeff Sutherland and Ken Schwaber, (2004), the Scrum framework is an agile project management framework most commonly used for software development projects, although increasingly the approach is applied in other product or service development sectors. The sprint, also called an 'iteration', 'timebox' or 'design sprint', (Sutherland and Schwaber, 1995) is a goal-orientated, structured, yet flexible, time-delineated activity in which teams focus on developing a solution or improvement on a product or service. Sprints usually last between one week to one month, averaging approximately two weeks. It involves sprint planning, daily short scrums to review and troubleshoot, with a review at the end of the process.

The first design sprint used within CoDesRes was developed in February 2018 and undertaken over a week within the context of 'Transition Year' work-experience, which gives additional framing that bridges the school versus the more autonomous learning environment of the sprint. Transition Year (TY) is an optional fourth year programme for learners, within the Irish education post-primary system, with 75% of Ireland's post primary schools running a TY programme. TY operates as an interim year between the two exam cycles, the Junior Certificate in 1st-3rd years, and the Leaving Certificate, 5th and 6th year. Established without a curriculum, TY's key objectives (DES, 1994) are as follows;

1. Education for maturity with the emphasis on personal development including social awareness and increased social competence.
2. The promotion of general, technical and academic skills with an emphasis on interdisciplinary and self-directed learning.
3. Education through experience of adult and working life as a basis for personal development and maturity

The CCE sprint was developed using methodology and resources from a core learning module titled 'Problem to Pitch' (P2P). This used the stages of design thinking to support learners to develop a pitch on a prototype for a locally-based problem or issue. The sprint was developed around circular design thinking and a unique methodology for co-design; the permaCultural resilience (pCr)[2] framework that underpinned the CoDesRes Project (codesres.ie). Within these contexts the educational sprints were deliberately developed as an agile method for integrating skills and competencies to fill gaps in the current educational system based on earlier STEAM curricula developed and co-developed by one of the CCE research team (Chavez and McKeown, 2012; 2013, McKeown, 2016, 2018).

OVERVIEW OF METHODS

The key methods embedded in the sprint include aspects from art and design training, as well as cultural leadership sectors and open source contexts. These include working in teams, design / studio setting, project-based approaches, design processes, design briefs / problem solving. These provide an open yet supportive structure within the sprint that creates a hybrid environment of structured and open learning that is more relevant to 21st Century and VUCA world needs. The other key methods deliberately built into the model's environment to support this transition are as follows

- The educator-learner relationship is deliberately disrupted in a number of ways to facilitate a transition towards self-organised autonomous learning.
- Everyone is on first name terms and the learners are encouraged to share their knowledge as equals.
- Others' perspectives are treated with respect and it is acknowledged that they are potentially important for the problem-solving process. This introduces them to the value of different perspectives.
- Learners are taught key skills through structured activities. Yet for the most part they are self-led in the activities, thus, developing responsibility and accountability for their learning.
- Learners develop being comfortable with agile and iterative thinking and doing. There is no right or wrong answer. Rather, outcomes are contextualised by an understanding of the system in which the problem is situated.

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[2] The permaCultural Resilience framework (McKeown, 2015) was developed and trialled in 3 geo-political contexts and is a critical cultural praxis to developing eco-psycho-social interventions that are co-designed, locally-scaled interventions within the age of the Anthropocene. It embeds social, environmental and economic justice in its methods to ensure an equitable, accessible and appropriate solution-focused response to place-based challenges.

- Learners are expected to take responsibility for completing the task / project and they determine as a team how best they do this. This is a new experience for many participants, as it is only since 2014 that Irish learners have experienced more formal (Junior Cycle) classroom based assessments and project-based learning.
- Other aspects that can be unusual for learners are basic issues concerning etiquette and autonomy, such as no need to ask to go to the toilet or take a break (although there are structured breaks built-in). This facilitates a more independent learning environment.

These methods create a learning environment that encourages the application of knowledge for creative solutions within a more agile, and when appropriate, speculative design context. This context requires:

1. understanding and defining the problem
2. identifying whose problem it is
3. developing an awareness of the full concerns within a problem
4. seeking to identify the source of the problem
5. developing a solution to the problem system, rather than just a problem symptom.

Sprint Adaptation for Serious Games

The CCE sprint in March 2022 was the fifth time the sprint model was implemented. It was adapted to focus on climate change and integrated external expertise from educators who's core educational expertise is 3rd level. CCE's focus was on collaboratively developing a 'serious gaming' instructional pack for secondary school students and their teachers by integrating knowledge from the arts, sciences, engineering and social sciences. It was intended that the new instructional pack would facilitate experiential learning. The CCE sprint was offered to Coláiste na Sceilge, a co-ed non-denomination community college in South-West Kerry, where a relationship had been established through prior research. The sprint was offered to TY as a whole (75 learners), with 20 learners self-selecting to participate, under full, high-risk study, ethical regulations. Learners reported their motivation for selecting to participate were as follows:

- Likes gaming/xbox/computer technology (11 students)
- Interested in climate change or science (5 students)
- To try a new experiences (6 students)
- Year head told us about it (4 students)
- My friends were doing it (3 students)

The sprint process is structured across 3 phases - Research and Development, Experimentation and Exploration, Implementation and Maintenance, providing learners with the scaffolding to move from idea to realisation; a process that is core to art and design skills and competencies. The sprint's activities are structured using a circular design thinking model, an expansion of the standard 5-stage design thinking process, namely: Empathise, Define, Ideate, Prototype and Test. This was developed through the processes formulated in the CoDesRes project. Here sprints overtly introduced eco-psycho-social aspects and circular economic principles by including knowledge from community regeneration practices and permaculture and ecological design e.g. ROLE (McKeown, 2015).

The ROLE praxis supports learners to begin to read a system relationally, see the connections and vulnerabilities and reverse-engineer solutions that are appropriate, relevant and meaningful and importantly – limit harm. Often, when working symptomatically rather than with the whole system, the intervention created is not only a short-term solution, it can exacerbate issues in another part of the system, causing damage or initiating longer-term negative impacts.

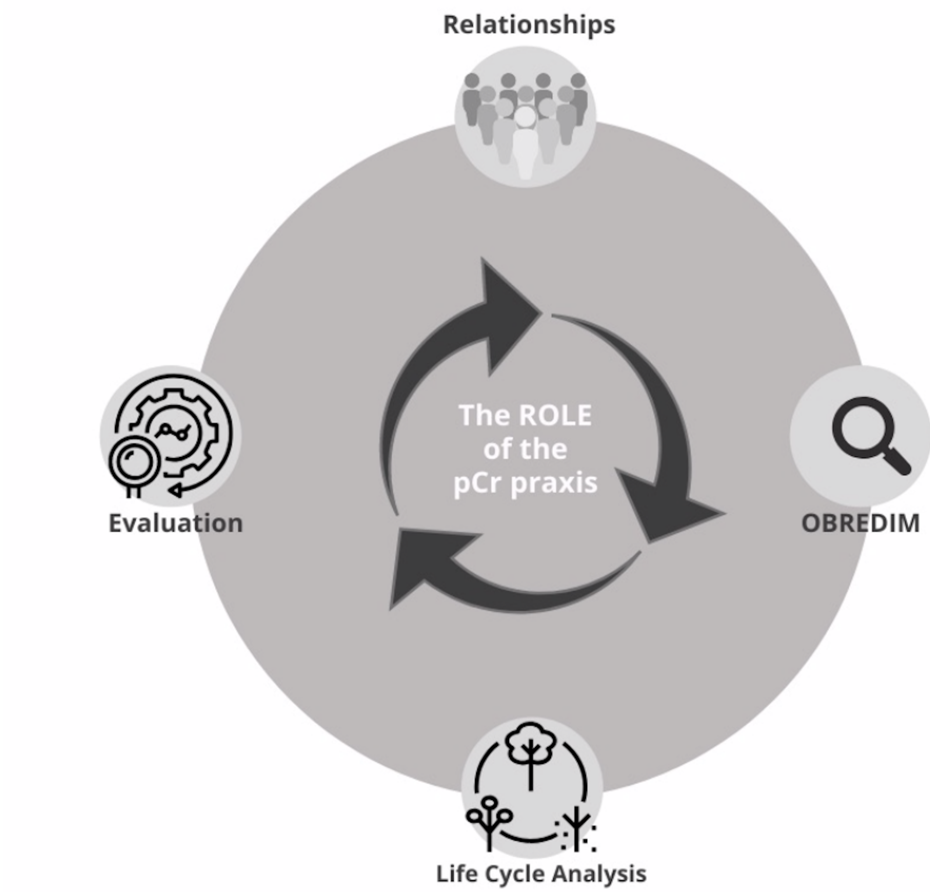

Figure 2

The ROLE of the permaCultural resilience praxis (McKeown, 2015)

The pre-existing Programme to Pitch (P2P) module which forms the core of the sprint's resources was adapted to facilitate the process of game design, with micro-lessons from the UCD team introduced in the earlier parts of the week to give the students knowledge that they could introduce into the key aspects of their game, for example: character development; storyline; world building; game objectives; and overall look and feel. In the P2P, module Lesson 2 adapted Stanford School of Design's Five Chairs Challenge[3] activity for teaching empathic design, this was further adapted for CCE with new story card profiles based on Bartles' Gamer Taxonomy (Bartle, 1996).

[3] Licence: Creative Commons attribution noncommercial sharealike 4.0 international- https://creativecommons.org/licenses/by-nc-sa/4.0/ The story cards profile content was adapted to enable participants to design for gamer types.

GAMER PROFILES

Lisa Simpson loves exploring and will spend hours hunting for clues. She loves mysteries and being the first to discover something. She likes to use her new-found information to make a difference, she's a vegetarian and concerned about climate change . She's not really a team player and likes to go at her own pace. She will spend hours finding out all she can about a place or a topic. For Lisa, it's the journey rather than winning, that she enjoys best.

Janey Powell is Lisa Simpson's best friend - Lisa doesn't spend a lot of time with many people except Janey. Janey is really social so she uses social media a lot to make more friends and loves to get to know people. She's always joining groups and using chat boxes or getting involved in discussion forums. Janey likes social interactive games. She cares about people and being part of a community, and wants everyone to be able to join in and will often look for ways to engage others.

Most adults struggle with Bart Simpson, who's considered a troublemaker and disruptive as he's not that interested in rules. He may not get high grades but he's smart, a quick thinker and good problem solver. He's also funny, so he's very popular and has a number of friends. He likes to do things in groups that require skill and likes both physical and video games, but they must be action orientated.

Milhouse van Outen is Bart's best friend, He has very poor eyesight and this can make him feel vulnerable. He's pretty smart and knows a lot about things that interest him. He is interested in animals and their unique abilities as well as being obsessed with science fiction / fantasy, science, and technology and systems. He notices patterns and connections and wants to understand how things work, so he can invent or create and developed new ideas particularly technical and scientific solutions for climate change.

Ralph is very conscientious in all that he does. He likes to demonstrate his skills and knowledge, particularly about climate change. He's very keen to complete tasks and activities and loves getting badges, trophies, and being recognised for his knowledge and is determined to gain high scores. He can be hard to play with as he likes to be indoors and is focused on completing a task perfectly.

Adapted from Stanford School of Design 5-chairs challenge, with the story cards profile contentadapted to enable participants to design for gamer types. Creative Commons attribution noncommercial sharealike 4.0 international - https://creativecommons.org/licenses/by-nc-sa/4.0/

Figure 3

Adapted Story Cards using Bartles' Gamer Taxonomy (McKeown, 2022)

The core sprint also adopted a place-based methodology (McKeown, 2015). Place-based learning increases learner and teacher engagement (White, 2020), and is a useful tool for connecting big ideas to the real world (i.e the Sustainable Development Goals and climate action). There is greater opportunity for spontaneous, genuine interaction and local assets can be leveraged as learning resources. By utilising people and places within a local community, partnerships are built, which ultimately serves the breaking down of barriers and stereotypes, strengthens connections and enables the transfer of knowledge and skills. Place-based learning in post-primary contexts is particularly successful in connecting these young people into the world they will soon inhabit as they leave second-level education. Within the context of the CCE sprint, participants were able to fold-in local information and knowledge into their game design, as well as embedding scaffolded third-level knowledge (via micro lessons from the UCD team) into their prototype.

In order to integrate third-level, field-specific knowledge, guidelines were provided for the development of micro lesson content. Within the sprint, activities were developed to encourage learning by doing; a practical approach to finding and applying knowledge. The main guiding focus was to develop content-based lessons in three stages; Lead in/extract knowledge, Information giving and Knowledge application. Emphasis was placed on considering what key knowledge and skills were needed, and reverse engineering the activity to lead participants there, rather than simply giving them the information at the start. Blended learning was encouraged, with differentiated strategies to cater for mixed ability.

ANALYSIS OF LEARNING AND CHANGED PERCEPTIONS

Student Perspectives

Reflective writing was employed each day in the form of 3-2-1 reflections, namely:

- *3- new things learned*
- *2- interesting things*
- *1- opinion/piece of feedback*

At the end of each day the students completed their 3-2-1 reflection. The key themes that emerged as patterns across the reflections are presented below.

Day 1

New things learned: all the students felt that participation in Day 1 of the design sprint gave them the impression that idea, even comparatively bad ones, can be turned into a good design concept, with all the participants also feeling that they had gained a better understanding of how to be more creative and how to design. Learners also felt that they had a better appreciation for how to connect creativity and design with transformational ideas.

Interesting things: Learners reflected that they found creating ideas for games very interesting, thereby suggesting that serious games may be a good means to help engage students with complex topics such as climate change.

Feedback: Most of the students felt that the activities were fun suggesting that a STEAM approach that highlights creativity and skills may serve as a useful means of engaging students.

Day 2

New things learned: Three quarters of participants felt they acquired new knowledge about climate change, fossil fuels and carbon sinks. Half of the students also felt that they learnt new aspects about core game components

Interesting things: Participants felt activities were interesting with a mix of climate change related knowledge and game creation elements, i.e. creating a game backstory, characters and game world. Day 2 structured learning so participants would learn the necessity of using scientific knowledge about climate change as the basis for the creation of their game's backstory and world. Empathic design activities initiated reflection on how best to communicate this new scientific knowledge to their peers, many of whom have different interests and learning styles. This suggests that the interweaving of science and art in the STEAM approach can prove fruitful in sparking learners' interest in new knowledge and helping them to reflect deeply on it by using it in acts of peer orientated creation and communication.

Feedback: The majority of participants felt that the day was both interesting and fun, with over a third of respondents noting how they enjoyed the opportunity to be creative. This again speaks to the strengths of a STEAM approach as it engages students in knowledge acquisition through the process of creative mediation in the use and communication of such knowledge.

Day 3

New things learned: A surprising 80% of students indicated that they learnt new things about games, and how they work, such as character details, goals, themes and audience. A majority of students also felt that they learnt new information about the different functions games can serve, namely, interventional, educational, research and entertainment.

Interesting things: Much of Day 3 was focused on researching game components and structures as a means to construct an artist platform as a medium for interweaved new knowledge in a fun and memorable way. Hence, it is unsurprising that students expressed their interest in the structural components of game design.

Feedback: The primary pattern emerging from a review of the feedback on the third day of the sprint was that students found the learning activities interesting and enjoyed the opportunity to be creative.

Day 4

New things learned: A majority of students indicated that they learnt new skills concerning vision boarding and prototyping. These skills involved the search, identification, reflection on, and use of scientific knowledge in the creative act of brainstorming new game related ideas for specific peer cohorts. Thus, successfully learning these new skills signals the constructive role of creative thinking and design in both the acquisition of new knowledge and channelling this into novel solutions to the challenge of how to communicate climate change issues effectively, in a way that empowers rather than deflates one's sense of agency.

Interesting things: Reflecting the new things learned, most students found the prototyping and vision boarding stimulating activities, thereby attesting to the power of a STEAM approach to engage students in learning.

Feedback: In general the students noted that they found the activities fun. A further trend emerging from the feedback was that about half of the students indicated that they enjoyed the act of making and building, which was central to the prototyping process. This suggests that the very materiality of the art-informed approach to prototyping provided an engaging and enjoyable experience for many students, where they mobilised the new creative-brainstorming mediated new scientific knowledge in the construction of something tangible. Indeed, there was considerable energy in the room during the prototyping process as students debated how best to translate their new knowledge and brainstormed ideas into three dimensional physical representations of their game design concepts.

Day 5

New things learned: Almost half of the students indicated that they learned new presentation skills on Day 5. This may be attributable to how the STEAM approach adopted involved the students providing a *pecha kucha* 'elevator pitch' of their game prototype. This entailed distilling the key scientific concepts and game ideas, and communicating these to their peers using visuals and a practised narrative.

Interesting things: Students indicated that they found learning about others' ideas interesting. This reflects the interest students displayed over the five days in how different student groups adopted very different ways of communicating the climate change concepts they were learning and how different groups shaped their game ideas in response to different audiences.

Feedback: Overall a majority of the students indicated that they found the design sprint an enjoyable experience. When asked to elaborate on this, most students indicated that they thought it was both fun and interesting, while a third of the students indicated that they liked the experience because they had an opportunity to be creative.

Negative feelings

Over the course of the week, there were 10 instances of negative responses. These included boredom, difficulty in remembering content and a lack of interest in researching and writing. Although research and writing were minor dimensions of the activities, it is interesting to note that the negative sentiments were largely associated with the more conventional pedagogical methods rather than with the STEAM-informed initiatives. For example, students were asked to keep a reflective log throughout the week. There were 6 instances of not liking the reflective log as it was too long, hard to remember and they did not see learning from it. However, there are instances that show they understood the importance of research. Additionally, there were 3 instances of not liking presentations due to being nervous and finding it stressful, and not liking having to present in front of their peers. This suggests some room for improvement, particularly with respect to integration of rolling micro presentations throughout the week so that students gain confidence in speaking to their peers. However, overall there was very little negative feedback.

Before & After

Focus group discussions were undertaken on Day 1 and Day 5 to determine if the design sprint had changed knowledge and perceptions about climate change. As detailed below, these focus groups were structured around 6 thematic questions:

1. *How does climate change make you feel?*

   On Day 1, groups were overall negative and worried about climate change, and felt that the issue doesn't directly affect them, and if it does, then they can't do anything about it. However, on Day 5, groups were more positive and felt like they could make a difference.

2. *What are the predicted impacts of climate change for Ireland and our area?*

   There was no awareness of the possible impacts of climate change locally and nationally on Day 1 of the sprint. Knowledge of these impacts were given on Day 5, demonstrating an expanded understanding.

3. *What actions can you take to reduce climate change in Ireland and our area?*

   There was a lot of silence on Day 1, with some probing by the facilitators necessary to elicit even laconic responses. On Day 5, there was a clearer articulation of the actions needed to reduce climate change locally and nationally. However, there was a feeling that groups know what climate change is about and some of the actions that can mitigate it, but don't know how to adapt to it. This indicates less of an awareness around adaptation as opposed to mitigation. For example, one group discussed their lack of knowledge of how to adapt to climate change locally.

4. *Where could you find information about climate change?*

   On Day 1, groups were generally critical of the source material they are usually presented with on climate change. They specified a need for more diverse learning methods, with better source material. On Day 5, they were able to better articulate their own learning needs and were more critically-analysing what is required of source material. For example, a need for more modern/contemporary information and less general knowledge was identified as something desirable. They recognised the benefits and limitations of social media in disseminating information, and would like to see more trustworthy content on platforms such as Tik Tok.

5. *How do your daily activities impact climate change?*

   While it was clear that the participants had a broad appreciation for the types of activities that impact climate change, there was some uncertainty in discussing them and the link to their own lives. On Days 1 and 5, it took time and prompting to discuss answers, which varied between groups. This suggests scope for enhancing the association between the game concepts and the daily lives of participants in future iterations of the design sprint method.

6. *What can you do to reduce your contribution to climate change?*

   There was uncertainty around this on Day 1. Prompting was needed to expand on ideas. However, on Day 5 the answers were more nuanced, with distinctions being made and a discussion around consuming less (e.g. taking short showers rather than baths). Actions were also more grounded and locally-based (e.g. buying locally sourced seasonal products).

Project Team Perspectives

The project team were also asked to reflect on their experiences of employing this STEAM-informed design sprint method with post-primary students regarding climate change education. A review of these reflections indicates that there was learning ‘in’ the sprint, learning ‘from’ the sprint and learning ‘for’ the sprint. An outline of these is provided below.

Learning ‘in’ the Sprint

For the UCD team members, this style and context of learning was different to what they were used to in third-level instruction. The sprint was noisier, with learners working more freely and independently to manage their time. It was dynamic and a much more flexible learning environment, which the UCD team believed led to accelerated learning, enhanced engagement and student-directed learning. The UCD team held that information was broken into more digestible chunks for learning, and inspired and adapted to the learners own content.

By facilitating space and autonomy, the broader research team considered that there is an increase in creativity, collaboration, learner agency and accountability, which it was deemed important for motivation. Over the week, the team noticed how the relationship between learners and facilitators changed, as the former became more confident and competent in the process.

The research team expressed the view that there was a natural development of roles within student teams, with no behaviour management needed. Initially some struggles were observed with the process of self-organisation and management. It was noted that teams who did not invest a lot of effort at the beginning of the week increased their output simply by watching other teams progress. It was felt that this struggle may have been mitigated if time was spent developing a working contract, that is usually part of the sprint, but that this was compromised due to the addition of extra micro-content lessons.

It was perceived that much scaffolding was needed for the development of the micro-lessons from third-level educators. This was attributed to their experience in working with adults, having more time to spend on content, and a more passive learning methodology, where lecture-style lessons often operate on an expectation of prior knowledge. The value of the sprint both for learners and the potential for external 3rd-level expertise or those who do not commonly deliver education using experiential learning or more active methods was affirmed by all.

Learning 'from' the Sprint

The sprint operated as a lens for third level educators to review their own teaching and how best to communicate their expertise to young people. Using the sprint approach rather than didactic alternatives in third level was considered an effective way to engage learners and provide them with the space to process big picture concepts and integrate the content into skills application. Participation in the sprint helped illustrate for the UCD team members that teaching is not only about content, but about those around you (building interdisciplinary teams) and building community.

All UCD team members were educators. Each experienced a deeper understanding of the design-thinking process, and in some instances, the sprint was an introduction to the process itself. Once becoming aware of the stages of design thinking, it was considered easier to move in and out of them seamlessly and build upon them. These members reflected that participation in the CCE project has encouraged them to incorporate elements of the process into their own university level classes, and indicate that seeing it being applied was inspiring. For team members using the sprint method since 2018 within post-primary contexts, the process identified more effective ways to work with educators who don't have post-primary, arts and design or STEAM education experience.

Learning 'for' the Sprint

There were a number of suggestions for future iterations of the CCE sprint. While it is acknowledged that some of these may be difficult to integrate into a sprint due to time constraints, it is believed that highlighting these may stimulate creativity in generating opportunities for formal education to address. These included:

a) *Interaction with experts*

- Consider the balance of skills and knowledge required to integrate greater opportunity to interact more with game designers and climate change researchers

b) *Engagement*

- Incorporate more video resources within the micro-lessons' content earlier in the sprint to support increased tangibility and understanding of the issues.
- Name various processes during the week (team meeting, standup, etc.) and connect them to real life scenarios.

c) *Learner autonomy and confidence*

- Engage learners daily with the overview/timetable of the week to create more ownership/accountability.
- Dedicate more time on Day 1 to facilitate students to set-up their own 'rules' about scheduling, physical space and contribution expectations. Although present within previous sprints, the lack of this in Day 1 was evidenced, leading to delays in explaining basic housekeeping rules and the transition to autonomy.
- Balance the explanation of tasks adequately with allocating more responsibility to learners.

d) *Content micro-lessons*

- Include more structure around micro lessons. Upon reflection, the team considered that these need more grounding and scaffolding to achieve greater impact. This was evident in how a minority of students still struggled with questions raised in the focus groups on Day 5.
- Depending on the focus of the sprint and foundational input required, the team considered that it would be interesting to trial a situation where prerequisite, subject-specific learning happened in advance or was more commonplace within existing formal education

CONCLUSION

Complex societal challenges like climate change require synergies between knowledge from the natural sciences, social science and humanities to address pressing issues. However, identifying effective means to achieve this in educational practice can be challenging. A STEAM-informed pedagogical approach offers significant potential in meeting this challenge by meditating knowledge through creative media that encourage students to explore novel connections between a wide spectrum of academic and non-academic pursuits. Yet learning design skills and competencies, intersectional systemic approaches, as well as field-specific knowledge can be daunting. The CCE sprint helped mitigate this by furnishing a fruitful approach to climate change education with learners who had minimal foundational science, social science or arts skills and competencies. Indeed, the learners participating in the CCE sprint had negligible experience of autonomous, project-based learning or specific climate change education, most noticeably concerning climate change adaptation. While the learners had some knowledge around mitigation, their access to reliable information was not delivered in ways that they found easily accessible to them. Similarly, there was little evidence of an acknowledgement of how they like to learn, particularly with respect to the communication and information platforms that are embedded in their way of life. This presents both barriers and opportunities for educators and researchers.

Against this backdrop, the CCE project sought to reflect their interests, ways of worldly engagement and forms of peer communication by harnessing their gaming experience and knowledge as a vehicle for thinking about climate change information, engagement and communication. The success of this strategy was evidenced by the ease with which they identified relevant target audiences, developed solutions and formulated communication strategies that an adult educator or game designer may not consider or utilise. The opportunity for them to engage with empathic design skills, user experience and focused consideration also enabled them to mobilise their own knowledge, ways of viewing the world and interacting with peers. Further, the opportunity to understand more about game 'production' – and not just 'consumption' – stimulated motivation and increased learner autonomy.

Nonetheless, there are challenges to this pedagogical approach. For example, the project as initially envisaged involved working for a few hours with a school one day per week over a number of weeks. However, this was difficult to timetable and subsequently rendered impossible by the Covid-19 pandemic. Once public health restrictions allowed, the project was adapted to the 5-day immersive sprint. The added benefit of this approach was having young people immersed in the process over a protracted period. Being outside the normal school routine supported dynamic interaction between peers, enhanced the opportunity and scope for learners to self-reflect and offered avenues for success not based around academic performance.

An additional challenge was locating suitable content knowledge for this age cohort. As a result, the time scheduled for micro lessons needed to be lengthened to effectively redress knowledge gaps and allow more time to strengthen the learners' core understanding in order to effectively apply it to the development of their games.

Furthermore, the methodology of the sprint was new to learners as the Irish national school curriculum meant that they had limited experience of project-based learning since primary (elementary) school. The 'hands-off' approach from facilitators was entirely novel to them. It was thus necessary to allow extra time for the learners to fall into a natural rhythm of working, where they had most of the control over their day.

However, such issues concerning content, time and format have been addressed through the development of the full 12-week TY unit, which allows more time for knowledge acquisition and application between activities. Each lesson includes opportunities for more input from climate change and game design experts, with links and blended learning resources to support post-primary educators. This will be evaluated within the ongoing Muinín Catalyst Sustainable STEAM project, through which the full TY unit is being rolled out [4].

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[4] The Climate Change Engage full TY Unit is available here https://www.codesres.ie/curriculum-resources under Creative Commons licence.

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