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Science Voices

# From Climate Change Ignorant to Climate Change Educator

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**What happens when you teach** someone about the effects of climate change? Dr Jennifer Rudd shares her reaction to hearing that the world could be on track for 4^<Mo>C of global heating in her lifetime and describes how she has made dramatic changes to her home life, her career and her lifestyle, and launched a new climate change education programme called *You and $CO_2$*.

From climate change ignorant to climate change educator (Rudd) @jruddchemist

Science Communication

activism
chemical education
climate change
interactive digital narrative
science communication

## Furthering Further Education

"How to educate" is a topic that has been debated for centuries and pedagogy/educational studies have evolved into research fields in their own right. As chemists, we aim to teach all students not only the theoretical aspects of our subject but give,

hopefully, equal importance to hands-on practical experiments. We ensure that students gain deeper and deeper knowledge as they travel through their chemical education until some emerge from their PhD, experts in a small sub-section of a chemical discipline. We prize depth, but in doing so we, as educators, and the students themselves, can lose the broader picture. For me this was the case. Despite a Masters degree from a top-class university with its own Green Chemistry department (2009), a PhD in next-generation solar cells (2012) and a post-doc on water-splitting devices (2015), until 2018 I couldn't have told you anything about how dramatically climate change would alter our future [for the worse].

In 2018 the world had already warmed by 1.0°C compared to pre-industrial levels,[1] there were already around 23 million climate change refugees and displaced people (from 2017),[2] greenhouse gas concentrations had reached a new high[3] and sea ice was at a record low in the Arctic.[4] In the UK we experienced "the Beast from the East"[5] (anticyclone Harmut) and then, in South-West Wales, had a record two months without rain. All around me the effects of climate change were evident, but it took participating in an outreach activity at work (Energy Safety Research Institute, ESRI, Swansea University, Wales) to make me take climate change very seriously and in doing so, my life changed.

Around this time, my colleagues (Drs. M. Taddei, R. Wakeham and M. Warwick) conceived an outreach activity called *Recycling Carbon* (https://recyclingcarbon.wordpress.com). Many of us from ESRI, myself included, were involved in honing the specific content. Recycling Carbon is a great hands-on science festival exhibit that teaches, mostly kids although some adults get involved, about carbon capture, storage and utilisation.[6] There's also an opportunity to explore carbon footprints with the participants. The outreach activity is versatile and in 2018 we developed it into an interactive presentation for *Pint of Science*. As we developed *Recycling Carbon*, I learnt about the projected climate changes for 1.5, 2 and 4°C of global warming.[7,^8] The projections for 2°C ----increasing impact of extreme rainfall, average temperature, areas subjected to drought and/or flooding----were terrifying. The projections for 4°C were even worse.[9] I remember Dr. Wakeham saying he'd be surprised if we didn't hit 4°C of global warming given the trajectory the world was on (April 2018). I was shocked and, armed with carbon footprint

knowledge from *Recycling Carbon*, Mike Berners Lee's book "*How Bad Are Bananas? The Carbon Footprint of Everything*"[10] and "*Being the Change: Live Well and Spark a Climate Revolution*" by Dr. Peter Kalmus,[11] I set about reducing my family's carbon footprint. This involved, among other things, decreased car usage, no more flying, diet change to predominantly vegan/vegetarian,[12] less central heating, more homegrown food, renewable electricity supplier, and modified political choices, going as far as activism with Extinction Rebellion.[13]

I soon realised that changing my own life wasn't enough. Obviously as scientists we weren't doing a particularly good job at communicating the vital information around climate change,[14] if even those working on climate mitigation were unaware and/or doing little to curb their own carbon footprints.[15] I thought back to the *Recycling Carbon* activity and wondered what happened in people's minds after they'd talked about the carbon footprint of various items and activities. Was there a better way to have that conversation? Could we do a longitudinal study to find out whether *Recycling Carbon* had had any impact at all? A rare example of such an endeavour is from Drs. Cordero, Centeno and Todd at San José State University, CA, USA. They investigated the long-term impact that an intensive one-year university course had on individual carbon emissions by surveying students at least five years after having taken the course. A majority of course graduates reported pro-environmental decisions (i.e., type of car to buy, food choices) that they attributed at least in part to experiences gained in the course.[16]

For me, the question arose of what can we, as highly educated and trained scientists do to influence the way our students, colleagues, peers and then the general public, view and understand climate change and its effects?

## STEAMing on Ahead: Developing Targeted Outreach Programmes and Making Learning Interactive/Accessible

Thankfully, it was at this time that I joined the Welsh Crucible programme (www.welshcrucible.org.uk), a 3×two-day residential course that brings together researchers at Welsh universities across a variety of disciplines.[17] I went armed with the question "Can we teach climate change in a way that *effects* behavioural change". During a research "speed-

dating" event I posed that question to a cognitive psychologist (Dr. R. Horry, Swansea University) and a pedagogist (Dr. D. Aldous, Cardiff Metropolitan University), who were very enthusiastic about working on such a project. Later that day, it was a walk with a creative writer (Dr. L. Skains, then Bangor University, now Bournemouth University) that birthed *You and $CO_2$* (www.youandco2.org). Afterwards, a chemist, a psychologist, a pedagogist and a creative writer sat in a bar. We all felt strongly about climate change communication and, combining our areas of expertise it was decided that we would write climate change education curricula for school students in Key Stage 3 (13--14 year olds). The decision on the target audience had two factors; first it was due to the expertise of the team (Dr. Aldous was a secondary school education expert, Dr Skains had worked previously with teenagers and I had experience in secondary school STEM outreach). Secondly, there was a dearth of explicit climate change education material in secondary schools, something highlighted by a number of organisations including Friends of the Earth and Teach the Future.[18]

We decided that the climate change education curricula we wrote would be supported with a quantitative psychology-based measure of attitude change. The curricula would also incorporate an interactive digital narrative,[19] to convey climate change in a novel manner. Emboldened by my time at Welsh Crucible, and so that I would have time to work on the climate change education, I asked my employer to change my contract to incorporate science communication, thereby shifting my focus from 100^% lab-based research to 50:50 lab-based : science communication-based research.

It was now July 2018, one month before Swedish teenager Greta Thunberg would walk out of school and set off a chain of school strikes around the world[20] and four months before I would sit on Waterloo Bridge as part of Extinction Rebellion's (XR's) first mass act of civil disobedience to bring the message from the public to governing offices that climate change needs to be addressed sooner rather than later. I didn't know then that within a year I would be teaching climate science from a "Scientists for XR" tent (scientistsforxr.earth) in Trafalgar Square. I didn't know that I had changed my career path to one that would move me away from the lab and into science communication.

At this point in time the New Curriculum for Wales[21] was being written and trials of it were being conducted in selected schools. The idea behind the New Curriculum is that it is less siloed, grouping disciplines into six areas ("The Six Areas bring together familiar disciplines and encourage strong and meaningful links across different disciplines"[21]). The curriculum sets out Four Purposes, one of which is to create "ethical, informed citizens" who "show their commitment to the sustainability of the planet". In addition, it calls on students thus "As ethically informed citizens we need to consider the impact of our actions and technological developments on Wales and the wider world, asking "Just because we can, does that mean we should?". Therefore, the New Curriculum points towards the incorporation of climate change education into school curricula despite it not saying so explicitly.

Additionally, a new area of educational research, STEAM (science, technology, engineering, arts, mathematics), was and is still emerging and has been summarised in a report from the British Educational Research Association.[22] Briefly, STEAM is a multidisciplinary approach that enables students to link science to that which is relevant to them. It bridges the gap between the classroom and the wider world and topics aren't just concerns of curricula but tend to be more societally engaged.

The New Curriculum for Wales significantly framed the development of *You and $CO_2$* and the STEAM aspect happened serendipitously as it reflected the backgrounds of the researchers involved in the project. We applied for, and were awarded, some seedcorn funding to run *You and $CO_2$* as three workshops (2019).

**You and $CO_2$ in Practice: What Worked and What Didn't Work?**

You and $CO_2$ comprised three workshops:

*Workshop 1* was based heavily on the *Recycling Carbon* outreach activity----students would be introduced to the concept of a carbon footprint, create $CO_2$ from methane using chemistry modelling kits and then discuss the carbon footprints of various food items.

*Workshop 2* was centred around reading an interactive digital narrative (IDN),[19] No World 4 Tomorrow,[23] written by my colleague Dr. Lyle Skains. This addressed both individual behaviours and political-economic systemic changes.

*Workshop 3* saw the students write their own interactive digital narratives on climate change, combining creative writing and computer coding.

I had to re-write workshop 1 after feedback from a class teacher who said that it was very boring and I'd lost the students' interest. I also discovered during that workshop that lecturing and teaching are two very different things and that I wasn't cut out for classroom delivery! The re-written workshop retained the discussion around carbon footprints and the chemical modelling. I then added an activity for students asking them to calculate their carbon footprint for the first two hours of their day before getting into groups and reducing the groups' footprint by one third. When we ran this version in a second school it was a success and much more applicable to the students' lives.

Dr. Skains wrote the IDN for workshop 2 after carrying out a literature survey to determine what would appeal to the target audience (13 and 14 year olds). Interactive Digital Narratives are web-based stories with multiple endings depending on the decisions made by the reader during the narrative. I was expecting an IDN that explicitly spoke about carbon footprints, our effect on the planet and specific actions that we would be encouraging our students to take. The IDN she wrote, "*No World 4 Tomorrow*" at first glance is nothing like that! However, all of our day-to-day decisions are reflected beautifully in the narrative. Students must choose how they get to school and what they eat, they need to use resources wisely and ultimately when their character discovers a life-altering truth what do they do? Do they ignore it, shout about it, get political, become an activist? At the end of the narrative, the students get feedback on the choices that they made and we carry out an exercise with them in class where we ask them to reflect on how the themes in the narrative relate to their lives.

The final workshop teaches students to code using a language called Twine (twinery.org) so that they can write their own interactive digital narrative about climate change. We ask the students to write about what is interesting to them and then expect them to carry out a bit of research to fill their content. For instance, one student was really interested in footballs (soccer balls) and spent time researching where they came from and what they were made of, effectively thinking about life-cycle analysis. Some students, disinterested at the back of the class and all copying each other writing about holidays, suddenly realised that

political decisions around travel may change their lives whether they'd like it or not. "Err does this mean we can't, like, fly or something?" from one of the students prompted a discussion with me about why I no longer fly and Greta Thunberg's train journey from Sweden to Rome. Some students thought about climate change and social justice. We have two excellent examples on our project website (www.youandco2.org), one where students wrote about mining for make-up components ("Destroying Makeup") and another where a student wrote about visiting Malawi and seeing the climate change effects upon a village and its population ("Linda and Akachi's Story"). We believe that these are good indications that participation in You and $CO_2$ enables students to think more critically about the world they live in and the mechanisms that rule our lives. In the future, I would like to collaborate further with experts in the field of law and governance and incorporate a further workshop in describing the broader social structures that shape our lives.

Led by our psychologist, Dr. Horry, before, during and after the workshops we asked participating students to complete a short questionnaire to assess their attitudes to climate change. The change in response could be measured quantitatively and "Our data suggest that participating in the *You and $CO_2$* program was associated with some small, positive changes in attitudes toward carbon footprint reduction."[24] However, the results can only be viewed as indicative. We had no control group and the workshops delivered in School 1 were spread over three months, during which the school strikes gained traction[25] and Extinction Rebellion held their second mass civil disobedience action in London.[26] It's possible that students from School 1 were affected, consciously or unconsciously, by external influences. This was probably not the case in School 2, however, where the programme was delivered over three days as part of a STEM week.

**Back to the Future: Know Thyself**

It's now 2020.[27] Climate change is apparent every day and our planet has reached 1.16°C of global warming.[28] Professor Michael Mann, Director of the Earth System Science Center at Pennsylvania State University says "We are seeing increases in extreme weather events that go well beyond what has been predicted or projected in the past. We're learning that there are factors we were not previously aware of that may be magnifying the impacts of

human-caused climate change. Increasingly, the science suggests that many of the impacts are occurring earlier and with greater amplitude than was predicted"[29]

2020 started with Australia burning; approximately 20^% of Australia's forest cover was lost and over 1 billion animals were killed.[30] The UN Environment Programme "reported 400 megatonnes of $CO_2$ emissions, equivalent to Australia's typical annual emissions in just three months."[31]

A previously unknown virus, SARS-CoV-2, locked down most of the Northern Hemisphere, decreasing some of 2020's greenhouse gas emissions compared to preceding years.[32] However, because $CO_2$ accumulates in the atmosphere $CO_2$ levels still reached a record high this year.[33]

As I type, California, Oregon and Washington States are on fire and hundreds of thousands of people have fled their homes.[34] 2.7 million hectares of land have burnt so far leading to the worst air quality on record and the "plumes of smoke...have reached the skies of Europe".[35]

Half a million people in Ethiopia have been made homeless and 100 people have died "in the worst flooding in at least a century" from the Blue Nile and other Sudanese rivers.[36]

In the Arctic, Greenland's Spalte Glacier has disintegrated, which is predicted to affect sea level rise.[37,^38]

In the UK flour shortages are expected as erratic weather conditions have resulted in a very poor wheat harvest.[39] This list doesn't even cover a fraction of the extreme events caused or exacerbated by climate change in 2020. To be honest, I can't mentally catalogue further events.

I feel more than ever that we, as humans living on this planet, *must do more*. I'm well aware that my personal circumstances afford me certain privileges that many around the world do not have (money, autonomy, my own home) and that those privileges come with a responsibility.[13d] I have, therefore, striven to use those privileges for the good of the planet----to the best of my knowledge and understanding of what effective climate mitigation is. At home, this has meant investing in an air source heat pump to decrease our heating emissions,

as well as expanding my vegetable garden and taking good care of my soil. I've also changed my job, moving to the School of Management to develop circular economy innovation communities (CEIC) and effect real change on the operations of public and third sector businesses in South Wales, on short timescales through ten month programmes. Through project managing CEIC I believe that I can have a significant impact on the carbon footprint of operations of public service organisations around South Wales.

*You and $CO_2$* is being honed; our new pedagogy expert, Dr. Helen Ross, (www.helensplace.co.uk) has enabled us to make the programme more accessible for students with special educational needs and a volunteer teacher, Mr. Martyn Steiner, has helped us differentiate the material so that more able and less able students can fully access the content. We've also spent a considerable amount of time adapting the programme for fully online or blended learning. To bring us closer to answering the question "Can we teach climate change in a way the effects behavioural change?" we have re-designed our student survey to make it more robust and will trial it with the next schools. We also aim to use control groups and expand the programme across the UK to increase our sample size. SARS-CoV-2 has dramatically affected our ability to run the programme in schools, but we're hoping to resume conversations and delivery across the UK in 2021.

Writing this article has been a sobering experience. It's not often that I delve into the dramatic effects of climate change, I find it emotionally challenging. Instead I prefer to focus on what I can do to mitigate the worst. When my young son grows up, he will ask me what I did for the planet. I want to be able to look him in the eye and tell him I did *everything* I could.

So that is my rallying cry to you who have read this article: "Are you doing everything you can to mitigate climate change?"

There are changes to be made in your personal life, but more importantly you can use the autonomy you have as an academic to interrogate the systems we live and work in. Challenge your university to decrease its carbon footprint, question your political representatives as to whether they represent the climate, change the way you communicate

your research to make it more accessible to the general public, use social media to open dialogues around climate change mitigation, get radical and take to the streets.

“Stop climate change, make me happy”

(Author’s son, aged 4)

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**Conflict of interest**

The authors declare no conflict of interest.

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