

Using STEAM to Power Equality and Democracy in Vaccination Decision Making in the Face of Climate Apartheid

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Abstract

Technology and science are often promoted as the answer to the climate crisis, but changing human behavior from a user-centric position requires a humanistic and Design Thinking approach (Brown 2009). If Climate Apartheid is to be challenged to decrease the divides between social, cultural and economic groups then a participatory and democratic design approach needs to be found. One such challenge of inequality that will increasingly become more acute is the spread of viruses and disease, old and new, as the COVID pandemic has shown. Our study aims to demonstrate how Science Technology Engineering Arts Math (STEAM) education can bring together diverse groups to a common understanding and empower them to have the confidence to advocate change in human behavior from peer-to-peer rather than top down by government.

Our study focused on Human Papilloma Virus (HPV) vaccines, which are proven to save lives and eradicate associated cancers, but the uptake of the vaccine among first-year second level schoolgirls in Ireland, to whom it is offered for free, has dropped in recent years (ICS 2020). Building on the experience of a previous pilot study with Biological Science and Design students this project aimed to validate the findings of Authors (2022) with these questions: In what ways can STEAM engage and motivate students to learn about immunology and vaccination? And in what ways can STEAM help them develop the competence and confidence to communicate their understandings about immunology and vaccination? It brought together a team of academics from Education, Design, Biology, the Irish Cancer Society, and Irish post-primary students in an interdisciplinary, intersectoral and international collaboration.

Twenty 16-17 year old students, from three post-primary schools, participated in a weeklong series of on-campus STEAM workshops, facilitated by the team. These involved dialogical peer-to-peer teaching and learning (Topping 2009) amongst the participants to co-create localized,

culturally inclusive, and scientifically informed stories around HPV vaccination and immunization. Using the principles of active learning (Bransford et al 1999) the students constructed their own knowledge and understanding through drama improvisation, storytelling through scripts and storyboards in an iterative process of presentations and idea selection in a visual thinking methodology (Averinou and Pettersson 2020).

A qualitative arts-based research methodology was adopted. The impact of the workshop series was evaluated on 3 key criteria: students' knowledge of immunology, their confidence in expressing their knowledge about immunology, and their confidence in advocating for vaccination and countering misinformation. Thematic analysis of the data was employed (Clarke et al, 2015).

The project highlights key insights that have wider application to combating Climate Apartheid: a STEAM approach is successful in engaging students in active learning and changing their attitudes towards the HPV vaccine from passive to positive; the use of a STEAM approach enabled and encouraged students to become more confident in their understanding of HPV vaccine and immunization and to more confident to advocate for HPV vaccine to peers; combining creative learning and teaching approaches with scientific content can lead to meaningful changes in human behavior.

Author keywords

STEAM; immunology; drama improvisation; storytelling; advocacy

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Introduction

The global COVID-19 pandemic and recent vaccination programme roll out has prompted a lot of research into vaccine hesitancy and public messaging (De Figueiredo et al 2020; North Carolina State University 2021; ONS 2021; Murphy 2021), and has changed the priority and focus away from other diseases. The World Health Organisation (WHO) has backed up the claim of many developing countries that they have not had an equal share of COVID vaccines and have been left behind, despite pledges of generous support by the world's richest countries in the Northern hemisphere (WHO 2021). As our climate changes new diseases will occur and others will migrate to new warmer climatic conditions exposing populations to further social inequity and economic disadvantage (Roberts & Parks 2006).

The effects of climate change on public health will be substantial as there is already a disproportionate distribution of risk in our society based on socioeconomic factors, such as education level, ethnicity, and poverty level. Thus, we can anticipate that climate change will only perpetuate these disparities in health (Frumkin et al. 2008). (Sandhaus et al 2018, p. 260)

Many diseases are preventable with vaccination programs, but not everyone has access to enough information to make informed decisions, even if they have access to vaccines. Climate Apartheid exposes the most vulnerable and disadvantaged to the risk of disease through changing climate and lack of education. If only we could design a democratic way to challenge the threat of disease that is exasperated by the inequalities of Climate Apartheid.

How might we empower communities to educate and better inform themselves in order to confidently challenge the inequities in disease prevention created by Climate Apartheid?

Climate justice seeks to remedy this by providing a platform for disadvantaged voices to be heard and to create community-based solutions (Cox & Pezzullo 2016). Participatory approaches to health education are supported by extensive research (Haldane et al 2019; Brear et al 2019; Schroer et al 2021) following the Ottawa Charter for Health Promotion (WHO 1986). Our study aims to demonstrate how Science Technology Engineering Arts Math (STEAM) education can bring together diverse groups to a common understanding and empower them to have the confidence to advocate change in human behavior from peer-to-peer rather than top down by government.

Our study focused on Human Papilloma Virus (HPV) vaccines, which are proven to save lives and eradicate associated cancers, but the uptake of the vaccine among first-year second level schoolgirls in Ireland, to whom it is offered for free, has dropped in recent years (ICS 2020). Building on the experience of a previous pilot study with Biological Science and Design students this project aimed to validate the findings of Macdonald et al (2022) with these questions: In what ways can STEAM engage and motivate students to learn about immunology and vaccination? And in what ways can STEAM help them develop the competence and confidence to communicate their understandings about immunology and vaccination? It brought together a team of academics from Education, Design, Biology, the Irish Cancer Society, and Irish post-primary students in an interdisciplinary, intersectoral and international collaboration.

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Context

The European Centre for Disease Prevention and Control Catalogue of interventions addressing vaccine hesitancy (2017) and European Cancer Organization's Umbrella Review of Interventions Improving HPV Vaccine Uptake in Children, Adolescents, and Young Adults (2022) explain that HPV causes about 5% of all cancers worldwide, and a significant proportion of the cancers caused by HPV in Europe are in men. HPV vaccination is probably the single most effective means of cancer prevention in the medical arsenal. Hence, Europe has set a 90% vaccination rate across all its states, in order to succeed in eliminating HPV cancers as a public health problem in the region by 2030. Amongst the richest countries in the world such a high vaccination rate has particular challenges:

- An important part of the explanation for sub-optimal vaccination rates is low vaccine confidence among parents and carers as well as young people themselves.
- This can be caused by insufficient information, a lack of trust in health authorities and vaccine manufacturers, and concerns about vaccine safety.
- But we know that vaccine confidence can be improved, and vaccine uptake increased if the right policies and programs are put in place.

(ECO 2022, p. 1)

This review identifies face-to-face as the most effective means of improving vaccine uptake, but there is no 'magic bullet' and other multimodal interventions such as videos, printed and online resources are also effective at making a difference in terms of intention to be vaccinated, and uptake rates for HPV vaccination (ECO 2022).

Imagine then the added challenge of Climate Apartheid, in developing countries where accurate data gathering and health information and education can be scarce.

Research into community participation in developing African countries in Burundi (Falisse et al 2012) and Swaziland (Brear et al 2019) conclude that 'participatory, dialogue-based methods can be effective techniques for enabling participation in learning, reflection and decision-making activities' (Brear et al 2019, p. 68) in health education. Further support for community participation in health promotion and prevention activities highlight the benefits of new insights and a broader perspective on issues shared within the group, in addition to a sense of inclusion and community building (Schroeer et al 2021).

Within the Design community Manzini (2015) argues that 'the role of design experts is feed and support these individual and collective projects – and thus the social changes they may give rise to' (2015, p. 1). Designers have had to respond to a change in their role as experts dictating a process or solution. Today everybody designs and so Designers have had to adapt to use their own initiatives to assist other 'social actors to design better' (2015, p. 2). There are also two paradigms that we operate in which are in conflict: the 'limitless world' and 'another that

recognizes these limits and experiments with ways of transforming them into opportunities'. Through collaboration with others, in multidisciplinary teams bound by shared values, Design can work in both diffuse and expert roles: working together on diverse problems facing society, and demonstrating its 'specificity...where, more than any other discipline, it can bring its most original contribution' (2015, p. 3). Sustainable and scalable local applications of an idea of well-being, and in our study health education, are possible if based on a new ecology of relationships between people.

Vignati et al (2022) argue that teaching Design in a blended and community led approach, as in a train-the-trainer methodology, in emerging countries can move away from a concrete framework of Western design, and instead provide a scaffold to create a local bespoke approach. This has the added advantage of decolonizing emerging countries from Western approaches. Diffuse design approaches leverage ground-up solutions and 'social change through increased empathy developed by the adoption of human-centered design approaches' (2022, p. 62).

STEAM

Art-based intervention has been part of bringing climate change to public awareness for some time (Lippard 2007; Volpe 2018; Baztan et al 2020). Baztan et al (2020) argue that community art-based action groups not only stimulate awareness of climate issues, but they generate capacity to mobilize public opinion that help realize empowerment and greater social justice. The benefits of art and science integration are 'helping to engage multiple senses and emphasizing social interaction within research practices...rearticulating politics and knowledge (Latour 2017); offering more effective approaches to multiple publics in climate-compatible behavior change...' (2020, p. 3).

Combining arts-based approaches to STEM (Science Technology Engineering Math) to STEAM education is argued by many in education as an essential pedagogical development (Verran 2019). 'Indeed, as technology and the human species continue to symbiotically evolve, STEAM approaches will be crucial to facilitating acute and long-term insights into possible social and environmental interactions, impacts, benefits and consequences for our human condition' (De la Garza and Travis 2019, p. 2).

Our incapacity to address wicked problems has been traced to the compartmentalization of scientific and professional knowledge, to the sector-based division of responsibility in contemporary society and to the increasingly diverse nature of the social contexts in which people now live (Lawrence 2011). Transdisciplinary research and practices offer an avenue for the STEM disciplines, the arts, humanities and social sciences (STEAM) to overcome these obstacles and tackle these truly vital issues. It also introduces a model of accountability to society and promotes innovation as previously separate fields are brought into contact with one another. Transdisciplinary models of knowledge production are a necessary response to demands that academic life becomes more integrated with society and the economy.

(De la Garza 2019, p. 144)

Further, communicating scientific principles, in our study it was immunology, through visual arts, such as drama, storytelling and video, opens dialogue and encourages unorthodox and innovative creative communication.

...the arts can also disseminate STEM knowledge in a more accessible manner by 'making connections between diverse ideas and provok[ing] unexpected

conversations (Wellcome Trust 2017, para 3)...In STEAM education, learning occurs at the intersection of the five fields, transforming how we know and investigate the world. As a pedagogical innovation, the STEAM agenda offers an approach to teaching and learning 'that encourages and facilitates unorthodox methods and strategies' (Rose and Smith 2011, p. 8).

(McKeown 2019, p. 108)

Following recent studies that have sought to establish best practice for integrating 'interdisciplinarity' into higher education and research methodologies (Power and Handley 2019; Tobi and Kampen 2018; De Greef et al 2017) this study explored new methods of communicating and learning the principles of immunology, at a time when the concept of a pandemic was real and present. We will argue that interdisciplinary co-design workshops (Steen 2013; Steen, Manschot and De Koning 2011; Kleinsmann and Valkenburg 2008) are an effective means of mitigating Climate Apartheid by creating opportunities to develop a pathway of communication through empathy and reflective practice (Schön 1992).

Methodology

We established two research questions:

- In what ways can STEAM engage and motivate students to learn about immunology and vaccination?
- And in what ways can STEAM help them develop the competence and confidence to communicate their understandings about immunology and vaccination?

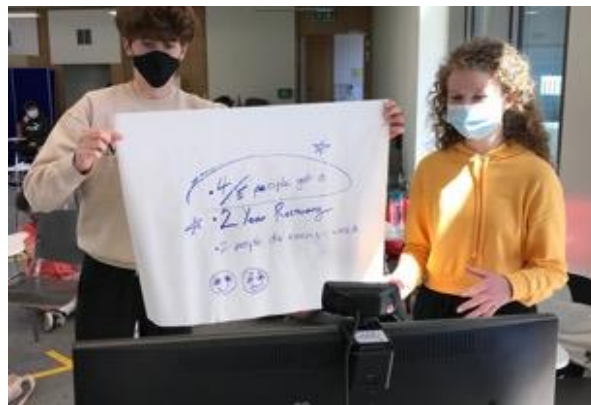
Our study was intersectoral, involving Maynooth University, Edinburgh Napier University, the Irish Cancer Society and 3 post-primary schools. It was interdisciplinary involving academics from Education, Design Innovation, Product Design, and Immunology. Involving collaboration between colleagues in Ireland and Scotland, it was also international.

Having achieved ethical clearance and Police vetting, we invited post-primary schools from the Maynooth area, 20km west of Dublin, to participate. Twenty 16-17 year old students, from three post-primary schools, participated in a weeklong series of on-campus STEAM workshops, facilitated by the team. These involved dialogical peer-to-peer teaching and learning (Topping 2009) amongst the participants to co-create localized, culturally inclusive, and scientifically informed stories around HPV vaccination and immunization. Using the principles of active learning (Bransford et al 1999) the students constructed their own knowledge and understanding through drama improvisation, storytelling through scripts and storyboards in an iterative process of presentations and idea selection in a visual thinking methodology (Averinou and Pettersson 2020).

After receiving an information briefing to entire year groups 10 boys and 10 girls were self-selecting and volunteered. Information sheets, letters of consent and assent were signed. They attended approximately 18 hours workshops on campus over 4 days. Two of the team facilitated the on-campus workshops with some extra input from a postgraduate student teacher. Our colleagues from Edinburgh Napier University and the Irish Cancer Society participated in the workshops remotely online due to COVID travel restrictions at the time.

As the students were from different schools and didn't know one another, the emphasis on the first day was on establishing a collaborative environment. These activities were mainly drama in education based and as well as building a sense of community they focused on facilitating learners to reflect on what they already knew about immunology, vaccines and in particular the

HPV vaccine. We used a mix of self-reflection and group reflection with thoughts and opinions being shared in small groups initially and then collaboratively to the larger groups. We encouraged learners to incorporate a multi-media approach to presenting their thoughts and opinions and so they used storyboarding, posters, improvisation and role play, pictures, diagrams, movement and sound, among others (see figures 1 & 2).



Figures 1 & 2. Students present in front of camera for online facilitators and in-person peers and facilitators.

Planning and Reflection

We had planned the sessions in advance and collaboratively honed them each evening based on our reflections on the day's events. As researchers we also engaged in reflection in action and altered our planned activities and tasks and sequencing of these according to perceived levels of student engagement and interest. Observation grids were used to record and identify what engaged learners, what motivated them to learn, what helped to their competence and what helped to develop their confidence to communicate their knowledge and understandings. These were reinforced by ongoing requested feedback from the learners about what worked for them, what they found most helpful, what they found most enjoyable. At the end of each session we held focus groups with the learners for further feedback and discussion. Research team members also recorded daily entries in reflective journals.

Activities and Tasks

Following a Design Thinking (Brown 2009) approach, journey and empathy mapping exercises encouraged learners to reflect on and discuss their personal experiences of vaccination, other's

experiences, what they've heard and read about vaccination. They helped them to collectively identify gaps and ambiguities in their knowledge and understanding and to prepare questions for the immunologist. Drama in education activities such as 'line of life' enabled the team and the learners to reflect on their knowledge and understandings and to articulate them and as time went on, to see their progress. Activities such as 'Angels and Devils' enabled them to express both sides of the argument for and against vaccines, particularly the HPV vaccine. It enabled them to express disinformation that they had heard or found on the internet and to counter this with so that they expressed a rounded understanding of issues. Design activities such as storyboarding allowed them to express understandings visually and to scaffold the planning of their videos.

They used the storyboards to present their plans to the whole group including the facilitators. Peers asked questions when the narrative was unclear. Each subject discipline experts were available for drop-in sense checking and advice, whether it was for creative and technical suggestions for improving the plans, challenging incorrect scientific information and giving feedback on how this could be corrected, advice on videoing and scenes and props, and input on improvising the storyboard content (see figure 3). The planning and presenting of their plans enabled them to express and improve their scientific understandings and to collaboratively engage in artistic creation, collaboration and communication (see figure 4).



Figure 3. Online tutorial with facilitators



Figure 4. Student participants shoot their video

Baseline

One of the first activities on day one was to establish how confident the learners were in their knowledge and understanding of vaccines using a line of life drama in education activity. This showed that learners had very little knowledge and understanding. Typical responses were:

What do you know about vaccines? (I know all I need to know about vaccines)

3.M.a 'I know about them but not the ins and outs.'

1.F.f. 'I've heard of immunization so I'd probably know but can't quite remember.'

Asked about their understandings of how immunization works, most indicated that they had a no understanding, or a basic or vague understanding. Just one indicated that they had a good idea of how it works. Asked how confident they would be to talk to peers about the HPV vaccine, typical responses indicated that they wouldn't feel confident as they didn't have the facts and didn't have confidence in their knowledge.

Science Input

Having heightened their awareness of what they knew and didn't know about immunology, vaccines and the HPV vaccine, we had inputs from team member Dr Eva Malone, an immunologist, on how vaccines work. The presentation was live streamed and included colorful visuals and a short video. As with the workshops, a collaborative team based approach was used in the preparation of the science input. Working on advice from colleagues in the Education Department, Eva created a presentation which was broken into short segments and included opportunities for learners to discuss their understandings and list questions which were then brought back to Eva. In order to ensure that the language and terminology used was suited to the learners, Eva collaborated with two of her university students who advised her on language, terminology and slide content. The science input was followed by interactive activities where students shared their understandings and established further questions they had. Eva and her students stayed online and learners approached the laptop to pose questions and seek clarifications.

Students engaged with the new science learnings and incorporated them into drawings and improvisations. They were given input on storyboarding and design using a blended approach with Dr Iain Macdonald onsite and Dr Richard Firth online.

Further science input on the HPV vaccine was given by Dr Robert O'Connor from the Irish Cancer Research Society. Learners used the information gathered as a basis for discussion in small groups, for further self-directed online research. In small groups they discussed and planned freeze-frame tableaux and improvisations for showing communicating their understandings to peers. Having shown them to the full group they continued to adapt them and to make TikTok type short videos. With feedback on these and input on technical issues around making videos, the groups scripted, storyboarded, rehearsed and short videos for presentation to 12-13 year old students (pre-vaccination target audience) telling stories carrying facts about the HPV vaccination process. Each group presented their story with their 'storyboard' prior to having it screened on the big screen for all to see (see figure 5).



Figure 5. Stills and end caption from student video.

Findings

Data Analysis

A qualitative arts-based research methodology was adopted. The impact of the workshop series was evaluated on 3 key criteria: students' knowledge of immunology, their confidence in expressing their knowledge about immunology, and their confidence in advocating for vaccination and countering misinformation. Thematic analysis of the data was employed (Clarke et al, 2015) and an interpretive description of meaning was used (Thorne 2016).

Analysis of our participant observation grids highlighted that learners showed signs of being most engaged and motivated when involved in tasks in which the outcome was clear, where they had agency over how they engaged with the task and how they demonstrated their understanding or knowledge, where they were able to collaborate. This was particularly evident in their planning, developing and creation of videos around HPV vaccination. These encouraged them to bring all their learning and interests to the process, a holistic approach which encouraged and supported learner autonomy.

The STEAM approach successfully enabled learners to develop their knowledge and understandings of immunology, and especially of HPV vaccination, and to develop their competence and confidence to communicate this to peers and to counter misinformation through creative output.

Feedback from the students from focus groups and last day line of life activities showed that they had internalised the scientific facts and information and felt confident about communicating these to others. They were more confident because they believed they were better informed. Typical statements were:

- 1.F.f. I'm definitely more informed about how vaccines work, and how to promote it to other people.
- 3.M.d. and it spread awareness about the virus we didn't know beforehand
- 1.F.f. and we were able to talk to experts, work with immunologists, like it just really reassures you, about most of the doubts surrounding the vaccine are usually just caused by like, conspiracy theorists, that's not very grounded in the reality, like actual science of vaccines.

The STEAM approach enabled them to develop their science knowledge, but also to develop other transferable skills such as working collaboratively, public speaking, being creative. Indicative comments:

3.M.a. also we learned a lot of skills like public speaking and working in groups together, which was very useful.

3.M.e. teach you how to work in groups as well, learning social skills.

3.M.a. get to show our creative side.

Learners enjoyed the holistic approach which encouraged them to be actively involved in their learning. Indicative comments:

3.M.g. it was a good fun way to learn about a serious topic, so it was easy to participate, taking the information and making something cool.

2.F.b. I really liked the call with the professor, I thought that was really fun and it was interesting, and that a lot of the activities were very much like umm...they were more practical, you were doing that and not just writing stuff down.

2.M.e. yeah it was fun how it wasn't just like, we learning about vaccines, but it incorporated other things like, they had an expert in design there, and it incorporated that into it. So it wasn't just about vaccines, it was a lot fun.

Learners regard communication of HPV vaccine information to be important. Indicative comments:

2.M.e. get the HPV vaccine...because before I didn't really know anything about it, I never...they talked about vaccines in general at school, but nothing specific about the HPV vaccine, so I feel it was important to learn about something that is that important.

1.F.b. you only get to hear of it, like 2 weeks before you get it in first year, and that's it, and then it's gone again.

4.F.b. I don't think they do enough to stop the rumors, they just don't address it, and that makes people think that they are true.

The learners showed the essence of their learning around science, communication, collaboration, creativity in their final outputs, their videos. The learners brought their understandings of life and culture into the making of these videos. They brought their knowledge of science, of storyboarding, of improvisation, of music, of videoing, of dramatic effect, of advertising: a cross-curricular approach to showing their understanding and communicating their message.

Discussion

Insights from our data analysis reaffirmed that STEAM education provides a holistic learning experience, but moreover it can enable participants to communicate their understandings about vaccines, and in our case HPV, with peers and others, particularly those who will be offered the opportunity to be vaccinated, and their parents. It is a powerful way to engage dialogue, build empathy, and deliver science in a manner that is in the culture and lived experience of its audience, whatever their age, or wherever they live. Could this approach be transferrable to other scientific principles and concepts, such as climate change? In highly-industrialized nations

people protect themselves from their culpability in furthering global climate change, often leading to an everyday denial of climate change (Norgaard 2011). Stapleton (2019) argues that a collaborative participatory design approach can build empathy amongst the privileged through personal connection with those that are impacted directly by climate change.

Perhaps this is the way out of the problem Norgaard (2011) poses where emotions can be a roadblock to engaging in climate change, leading people to denial. Here. Emotions are used for connection; through connection to real people affected by climate change, youth become tangibly linked to what can otherwise seem a complex, amorphous, abstract problem.

(Stapleton 2019, p. 745)

In our study, as facilitators we also learnt from each other's disciplines and STEAM enabled collaborative, inquisitiveness through the participants playful learning. Future workshops may bring to light facilitators with sceptical or even opposing views, and yet as an interdisciplinary and collaborative process it could be a viable democratic methodology for discussing Climate Apartheid through empathy building.

Our study showed how readily teens wanted to interpret scientific concepts and personal stories around immunisation into visual form, and more often if drawing was not their first choice it was through their phone cameras to capture performance and enact scenarios. Stories that are visual and are about solutions rather than warnings appeal to underrepresented communities (Wenzel et al 2016). Dahmen et al (2019) found that 'solutions-orientated photos also led to greater levels of narrative engagement with the story, which then facilitated significantly positive outcomes for interest, self-efficacy, and behaviour intentions' (2019, p. 284).

As Climate Apartheid exasperates the disparities between the hemispheres, it is local solutions that will have most impact. The 2021 United Nations Conference on Trade and Development reports that least developed countries suffer a digital divide in mobile connectivity: not only is network coverage much lower, but their data usage is significantly more expensive. 'This situation perpetuates existing inequalities – rural vs urban, poor vs rich – that intersect with micro-level disparities across gender and ethnicities' (UNCTAD 2021). Global charity networks know the importance of nurturing relationships on the ground, and to be sustainable any healthcare intervention needs to involve training and resourcing local stakeholders. Haldane et al (2019) affirm that community involvement is key to driving improvement in healthcare as it provides a contextualising learning phase and allows organisational relationships to build trust with stakeholders and communities. 'Health improvements do not happen in a linear progression, but rather consist of complex processes influenced by an array of contextual factors' (2019, p. 21). As the ECO (2022) umbrella study of HPV interventions reports there is no one single 'magic bullet'.

Conclusion

Our study provided space for dialogue that challenged misinformation, and it offers a scalable template of peer-to-peer communication to positively impact the health trajectory of others across inter-generations within schools, families and as future parents. As part of a multimodal strategy, this could educate and protect many that participate in such workshops, not just from the cancers prevented by HPV vaccination in our case study, but in any health context across the globe. This is an example of how to also help insulate these communities from the growing tide of health misinformation.

The project highlights key insights that have wider application to combating Climate Apartheid using STEAM to power equality and democracy: a STEAM approach is successful in engaging learners in active learning and changing their attitudes towards the HPV vaccine from passive to positive; the use of a STEAM approach enabled and encouraged students to become more confident in their understanding of HPV vaccine and immunization and to be more confident to advocate for HPV vaccine to peers; combining creative learning and teaching approaches with scientific content can lead to meaningful changes in human behavior. While our case study focused on HPV vaccines, we argue that this is an multidisciplinary template that could be used for other vaccination programs to power equality and democracy.

In order to challenge Climate Apartheid, to mitigate against the forces that divide people economically, culturally and socially, such as access to vaccines to combat the spread of viruses and disease, then a participatory and democratic design approach is required. STEAM education can bring together diverse groups to a common understanding, using empathy, creativity to communicate science that empowers them to have the confidence to advocate a positive change in human behavior peer-to-peer.

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