Cite as: Cook, J., Ecker, U. K. H., Trecek-King, M., Schade, G., Jeffers-Tracy, K., Fessmann, J., Kim, S. C., Kinkead, D., Orr, M., Vraga, E., Roberts, K., & McDowell, J. (2022). The Cranky Uncle game—Combining humor and gamification to build student resilience against climate misinformation. *Environmental Education Research*.

The Cranky Uncle game—Combining humor and gamification to build student resilience against climate misinformation

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Abstract

Misinformation about climate change is a consequential societal issue, causing polarization and reduced support for climate action. However, the seriousness of the problem does not preclude non-serious solutions. There are numerous potential benefits to humor as a strategy to counter misinformation, such as attracting attention and engaging disengaged audiences. This paper describes a humorous serious game—"Cranky Uncle"—developed in the U.S. to inoculate players against climate misinformation. The game combines psychological research into active inoculation, critical-thinking work on misleading rhetorical techniques, communication research into cartoon debunking, and gamification. The game's cartoon humor and the creative potential of active inoculation lends it to classroom applications; educators have thus used classroom activities to complement the game in order to improve students' climate literacy and critical-thinking abilities. We present several qualitative U.S.-based case studies, in formal English-speaking tertiary classrooms and informal public education settings, to illustrate the utility of a humorous, game-based approach to building resilience against climate misinformation. The approaches adopted in our case studies are offered as a model for other educators looking to use interactive games to teach critical thinking.

Keywords: serious game; climate change; misinformation; inoculation; humor

Introduction

There is overwhelming agreement among climate scientists that humans are causing global warming (Cook et al., 2016). Climate change is the most serious public health challenge of modern times (Patz et al., 2014) and poses a substantial threat to future generations (Allan et al., 2021). However, there still remains a great deal of public confusion about the reality of climate change and the imperative to mitigate its worst impacts. One contributor to public confusion is misinformation about climate change.

Climate misinformation damages society in a number of ways. It fosters misconceptions and reduces climate literacy (Ranney & Clark, 2016), and has a polarizing effect on the public, with disproportionate impact on political conservatives (Cook et al., 2017). It reduces public support for climate policies (Ranney & Clark, 2016), which has contributed to delays in implementing mitigation policies (Lewandowsky, 2020). From a communication and education perspective, a particularly challenging aspect of climate misinformation is that it can cancel out attempts to communicate accurate information (McCright et al., 2016; van der Linden et al., 2017).

Consequently, it is imperative that scientists, communicators, and educators develop solutions to counter the negative influence of climate misinformation. Alas, a large body of research has shown that countering misinformation is not a trivial task. Misinformation can be persistent and resistant to correction (see Chan et al., 2017; Lewandowsky et al., 2012; Paynter et al., 2019), and misinformation about climate change is no exception (Cook, 2017; Lawrence & Estow, 2017; Lewandowsky, 2020; Treen et al., 2020). In part due to misinformation's resistance to reactive correction, the focus of much contemporary research has shifted to *pre-emptive* interventions in an attempt to reduce misinformation impacts (e.g., Lewandowsky & van der Linden, 2021). This work is grounded in inoculation theory, and aims to develop treatments that build resilience against future misdirection and reduce the spread of misinformation, including climate misinformation (Cook et al., 2017; van der Linden et al., 2017).

Inoculation theory

Inoculation theory applies the biological metaphor of vaccination to knowledge (Compton, 2013; Ivanov et al., 2020). This research has found that exposing people to a weakened form of misinformation can build immunity to misinformation encountered in the real world. While inoculation theory has been found to be effective across a range of topics, what is relevant in this context is that it has also been found to be effective in neutralizing climate misinformation (Cook et al., 2017; van der Linden et al., 2017).

The most common form of inoculation has been fact-based, where anticipated misinformation is demonstrated to be wrong through factual explanations (Banas & Miller, 2013). An alternative or complementary approach is logic-based inoculation, which involves explaining the rhetorical techniques or logical fallacies used to mislead (Cook et al., 2017; Tay et al., 2021; van der Linden et al., 2017). Both methods are effective in neutralizing misinformation (Vraga et al., 2020; Schmid & Betsch, 2019) but the logic-based approach carries unique benefits: The approach is generalizable in that inoculating people against a rhetorical technique used in one topic can convey resistance against the same technique used in a different topic (Cook et al., 2017; Lewandowsky & Yesilada, 2021). As a consequence, logic-based inoculation can neutralize polarizing disinformation—misinformation disseminated with the intent to deceive—because it allows recipients to be inoculated using more benign examples that do not contain culturally loaded triggers. This is particularly relevant given the state of polarization around the issue of climate change—necessitating the development and deployment of depolarizing messaging strategies that sidestep cultural triggers (Cook et al., 2017).

A popular framework for explaining the rhetorical techniques used in disinformation campaigns—and especially those that involve the denial of scientifically established factual knowledge—is the FLICC taxonomy (Cook, 2020). The acronym represents the five primary techniques of science denial: fake experts, logical fallacies, impossible expectations, cherry picking, and conspiracy theories (Hoofnagle, 2007). This framework includes a complex and diverse landscape of rhetorical techniques, logical fallacies, and traits of conspiratorial thinking (Cook, 2021a). This presents an educational challenge: how does one inoculate the public against the long “laundry list” of ways to mislead them?

One powerful pedagogical technique of critical thinking is *parallel argumentation*—replicating the flawed logic from a misleading argument in an analogous situation, often an extreme or absurd one, which carries several benefits (Cook et al., 2018). First, it allows educators to explain abstract logical concepts in concrete, relatable terms using analogous situations from everyday life (Juthe, 2009). Second, by focusing on the logical structure (or lack thereof) of an argument, it allows one to expose how an argument misleads without needing to explain complex background information. Third, parallel arguments are particularly well suited to humorous applications, and are therefore frequently employed by late-night comedians and newspaper cartoonists to debunk real-world misinformation in politics or current affairs (Cook, 2020b).

Using Humor in Debunking and Climate Science Communication

Using humor in parallel arguments has been experimentally tested in a variety of contexts to debunk misinformation. One study testing humorous parallel-argument debunking found that it reduced HPV vaccine misconceptions, although the approach was ineffective with misinformation regarding more deeply-entrenched issues including gun control and climate change (Vraga et al., 2019). A follow-up study using eye-tracking data found that parallel arguments in cartoon form were effective in decreasing the credibility of HPV vaccine misinformation because the cartoon images attracted more attention relative to non-humorous debunkings, which further contributed to lower HPV misperceptions (Kim et al., 2020). In another experiment, cartoon debunkings using either fact-based or logic-based corrections were effective in reducing the misconception that CO_2 emissions are good because CO_2 is plant food, with logic-based corrections producing a more consistent effect as compared to fact-based corrections (Vraga et al., 2020). Additionally, humorous corrections are more likely to be remembered and discussed afterwards relative to serious messages (Compton, 2018). In short, even though humorous corrections are not always superior to non-humorous interventions, they tend to attract more attention, are more engaging, and are more likely to be shared than non-humorous corrections.

These findings are in line with more general research into the benefits of using humor in science communication. Humor, especially comedy and satire, has been recognized as an important tool to affect public knowledge, attitudes regarding social issues, and associated behaviors (Becker & Bode, 2017; Borum Chattoo & Feldman, 2017; Nabi et al., 2007). Feldman and Borum Chattoo (2019) showed that presenting the plight of Syrian refugees using comedy was significantly more effective than regular news reporting in increasing U.S. public attitudes in support for those refugees. They also showed that these attitude changes, once achieved, persisted over time. In general, research on the effects of exposure to political satire has been shown to produce modest gains in knowledge, learning, and political engagement, especially among politically inattentive groups (Baek & Wojcieszak, 2009; Cao et al., 2008; Xenos & Becker, 2009). Comedy can also be effective in the context of climate science news. For example, Brewer and McKnight (2015) found that viewing satirical news coverage/late-night comedy was able to change viewers' climate-change perceptions. So, humor may be one of the best ways to overcome audiences' reluctance to engage with climate change through regular political/news channels.

Humor in climate communication more specifically has been found to offer a range of additional benefits. Mirth in response to cartoons about climate change mediates greater support for climate action (McKasy et al., 2021). Humorous climate messages are more engaging than non-humorous messages with people who are disengaged from the climate-change issue (Brewer & McKnight, 2015). Using humor can also make the climate issue less threatening and thus more accessible (Boykoff & Osnes, 2018), although the downside of this is that people can also end up less concerned about climate change relative to non-humorous climate communication (Bore & Reid, 2014). Another benefit is that people tend to show less counterarguing in response to humorous climate messages (Nabi et al., 2007), although this benefit is moderated by people finding humorous messages less informative, even if they contain the same content as serious messages (Skurka et al., 2018).

Humor can also provide benefits when used in an environmental education context, which is important given the frequent messages of environmental catastrophe that confront children (Kelsey & Armstrong, 2012). In an outdoor education setting, humor can provide a pedagogical trigger for the

emotional engagement of students (Hoad et al., 2018). Osnes et al. (2019) found that inviting students to create good-natured comedy about climate change helped them process negative emotions and develop positive and hopeful emotions while growing climate-communication skills. Russell and Oakley (2019) argued that environmental education needs to engage with the emotional dimensions associated with climate change, invoking positive emotions in what can be an intimidating topic that elicits negative emotions. Skurka, Niederdeppe, and Nabi (2019) agreed, suggesting that the design of climate-change-related messages should capitalize on both the persuasive power of negative emotions such as fear and anger and the power of humor. While there are different styles of humor, such as wordplay and anthropomorphism (Yeo & McKasy, 2021), one particular style of humor is able to harness this duality—satire. Satire uniquely combines emotions of amusement with feelings of hostility towards the target of the humorous message, using humor to "attack ideas [and] behaviors [...] by encouraging us to laugh at them" (Bore & Reid, 2014). In other words, satire can promote both positive emotions and those negative emotions that are positively associated with desired climate-change-related outcomes (Skurka et al., 2019).

While there is a dearth of research exploring the use of humor in environmental education, environmental communications syllabi from two major US universities provide anecdotal evidence that humor-based news reporting, commentary, and late-night comedy have been effectively integrated into existing classes. A commonly used video is "Climate Change Debate: Last Week Tonight with John Oliver (HBO)" (LastWeekTonight, 2014)[1]. In the clip, host John Oliver manages to break down the critical issues of the debate regarding climate change in a short video. He addresses one of the key problems with climate news reporting: a climate-change denier is given equal airtime to a scientist, creating an inherently misleading impression of a 50/50% split of opinions. Using a visually compelling display, Oliver shows how overwhelming the scientific evidence is through a "mathematically representative climate change debate", meaning Oliver brought into his studio three climate deniers and 97 climate scientists.

Another example of humor employed in class assignments was found in a syllabus from an Environmental Journalism class at the University of Florida. Students were asked to discuss the following The Onion (2015) article "Atlantic Ocean Excited To Move Into Beautiful Beachfront Mansion Soon":

> WEST PALM BEACH, FL—Admitting it has had its eye on the property for quite some time, the Atlantic Ocean confirmed Monday that it was looking forward to moving into a beautiful beachfront mansion in the near future. "For the longest time it seemed like this place was completely out of reach for me, but I've come a long way in the past few years, and now it's looking more and more like a real possibility," said the body of water, which confided that, after having admired the building's impressive exterior and grounds for so long, it was thrilled at the prospect of finally going inside and exploring all eight bedrooms and 7,500 square feet of living area. "I'm not quite ready yet, but in a couple years or so, I can definitely see myself in there, making the place completely my own. And the little beachside community that the house is located in is just so cute, too—I can't wait to go through and visit all the shops and restaurants." The ocean noted, however, that it might make a few cosmetic changes to the mansion once it moves in, including gutting the lower floor and taking out a few walls.

Using language typical of real estate brochures, the article switches perspective in a humorous way by anthropomorphizing the Atlantic Ocean as a potential real estate buyer of properties impacted by global sea-level rise. The article avoids direct political association, which broadens its applicability from an educational and activist perspective. The key assumption on which the humor of the article rests—sea level rise—is left unstated but is the more effective for it.

Another article found in a review of university syllabi is the 2013 Rolling Stone article "Goodbye, Miami" (Goodwell, 2013), later republished under the title "Miami: How Rising Sea Levels Endanger South Florida," of which some excerpts are presented here (emphasis in the original):

> **When the water receded** after Hurricane Milo of 2030, there was a foot of sand covering the famous bow-tie floor in the lobby of the Fontainebleau Hotel in Miami Beach. A dead manatee floated in the pool where Elvis had once swum. Most of the damage occurred not from the hurricane's 175-mph winds, but from the 24-foot storm surge that overwhelmed the low-lying city… Tampons and condoms littered the beaches, and the stench of human excrement stoked fears of cholera. More than 800 people died, many of them swept away by the surging waters that submerged much of Miami Beach and Fort Lauderdale; 13 people were killed in traffic accidents as they scrambled to escape the city after the news spread – falsely, it turned out – that one of the nuclear reactors at Turkey Point, an aging power plant 24 miles south of Miami, had been destroyed by the surge and sent a radioactive cloud over the city. The president, of course, said Miami would be back, that the hurricane did not kill the city, and that Americans did not give up. But it was clear to those not fooling themselves that this storm was the beginning of the end. With sea levels more

> than a foot higher than they'd been at the dawn of the century, South Florida was wet, vulnerable and bankrupt.

By changing the setting to a dystopian future of 2030, the article used biting satire to address the likely impact of climate change in South Florida. The article provokes discussion, including both praise and backlash. This makes the article pedagogically useful if a teacher wants to push a lively debate on the topic. However, the article's clear political positioning and polemic nature may not be effective in convincing conservatives about the danger of global warming. On the other hand, it is interesting that the article appeared in Rolling Stone magazine, which is not typically very political. As a result, the article may have reached politically inattentive groups not normally exposed to the climate-change debate. As such, future experimental studies on the impact of such pieces on readers' climate-change perceptions would seem timely.

Unfortunately, scholarly work examining the use of humor in environmental education is still understudied. This paper seeks to address this gap by exploring three case studies that used computer-game-based satirical humor to educate students and the general public about the techniques used in climate change disinformation.

Non-serious Serious Games as an Active Inoculation Tool

Games that are fun and engaging while also being educational are known as serious games (Girard et al., 2013). Digital serious games are being increasingly recognised as a useful tool in countering misinformation, specifically as they build player resilience against misinformation using an approach known as active inoculation (Roozenbeek & van der Linden, 2018). Unlike passive inoculation, where recipients receive an inoculating message, active inoculation is a two-way process through which participants engage interactively. Serious games promoting media literacy and increased skills in identifying misleading sources of information have targeted general fake news (Roozenbeek & van der Linden, 2019), campaigns that undermine democracy (Roozenbeek & van der Linden, 2020), and misinformation about COVID-19 (van der Linden, 2021).

This paper is focused on the digital game *Cranky Uncle*, which combines logic-based, active inoculation and cartoon humor to build resilience against climate disinformation. The cartoons used throughout the game are adapted from the cartoon book *Cranky Uncle vs. Climate Change* (Cook, 2020a). This book uses a number of parallel arguments in cartoon form, featuring an archetypal cranky uncle character, to illustrate the common rhetorical techniques found in climate science denial. While the *Cranky Uncle vs. Climate Change* book is an example of passive inoculation, the *Cranky Uncle* game takes an active inoculation approach. The Cranky Uncle character explains to players how to apply the techniques of science denial, and in so doing, aspire to become a Cranky Uncle themselves. The game relies heavily on humor, which is an important element to helping serious games be entertaining (Dormann & Biddle, 2009), as well as incentivizing players to play a game repeatedly (Imbellone et al., 2015). Characters are a strong source of humor in games (Dormann & Boutet, 2013); in this case, Cranky Uncle delivers deadpan explanations of how he is able to deny overwhelming scientific evidence using obviously fallacious reasoning. As players progress through the game, they collect "cranky points" and periodically level up, graduating to a crankier mood (e.g., from "agreeable" to "peevish" to "huffy"). The further the player gets into the game, the broader and deeper their understanding of science denial techniques, with the intended end result being greater resilience against climate disinformation.

The game development was led by George Mason University in collaboration with a U.S.-based creative agency, Autonomy Co-op, using the Quasar Framework and released as native iPhone and Android apps as well as an in-browser game. Academics from other U.S. and Australian universities provided input on the game's content design. The game is heavily content-management system driven, using the Strapi platform to add content such as cartoons, quiz questions, and explanations of denial techniques. Players' scores and progress are saved to the cloud and behavior monitored via analytics. The game's use of web technologies makes it easy to maintain and to support different types of devices.

One of the purposes of the game is to address the educational challenge of inoculating players against misinformation—there are many different rhetorical techniques and fallacies used to mislead, and developing the critical-thinking ability to detect these techniques in real-world settings is cognitively

challenging. Games offer a powerful solution to this problem, because gameplay elements such as points collection and leveling up incentivize players to practice learning tasks (Blair et al. 2016). A key element of the *Cranky Uncle* game are quizzes, where players are tasked to identify reasoning fallacies in misinformation examples (which are presented in text or cartoon form). By repeatedly practising the spotting of fallacies and denial techniques, players become faster and more proficient over time.

Given the launch of the game was only available in English and launched in the U.S., the initial primary audience for the game was U.S. users, particularly within a classroom context. Nevertheless, the *Cranky Uncle* game can be played by English-speaking members of the public anywhere in the world with a smartphone or access to a web browser. To facilitate the use of the game as a classroom activity, a *Teachers' Guide to Cranky Uncle* was published, offering a number of suggested activities to complement and reinforce the game (Cook, 2021b). The game was quickly adopted by many educators in 17 countries, including primary, secondary, and tertiary classes across 37 U.S. states. As well as laying the theoretical framework informing the *Cranky Uncle* game, this paper presents a number of case studies where the *Cranky Uncle* game was combined with classroom activities to reinforce the content of the game.

Methodology

This exploratory study combines (a) conceptual work on humor-based active inoculation using a serious game with (b) case study research that looked at application of humor-based activities in classroom settings. Our study is exploratory in the sense that we try to understand better a specific aspect of inoculation theory that has not been thoroughly investigated in the past but at this early point we do not yet expect to find conclusive results.

In our study we investigated the following research questions: *How can humor-based active inoculation be used in serious games? What type of classroom activities have been used to complement such games in order to improve students' climate literacy and critical-thinking abilities? What insights did the assignments provide about the creative potential of active inoculation using humor?*

To answer the first question, the 'Cranky Uncle' game has been introduced and conceptually discussed. To answer the other two questions, the lead author invited three educators to provide observations of class activities to generate case studies. The lead author chose those three contributors through purposive sampling—these educators were known to have had used the Cranky Uncle game in their teaching or public engagement and had shown an active interest in the topic. Following Baxter and Jack's (2002) advice on choosing a case study approach, we focused on understanding the contextual conditions and dynamics that are relevant to instances of the phenomenon under study, that is, we looked at cases that used other humor-based techniques in conjunction with the Cranky Uncle app. To strengthen the conceptual argument as well as the explanatory power of the case studies, a review of syllabi of 'Environmental Journalism' classes at University of Florida and honors literature classes on 'People vs. the Planet: An. Interdisciplinary Approach to Climate Change' at West Virginia University, as well as personal communications with the instructors were used to identify additional effective humor-based class readings/assignments. Three such identified readings/assignments – John Oliver's Last Week Tonight's TV segment on the 'Climate Change Debate', a 2013 Rolling Stone, and a 2015 The Onion article – were presented as examples of effective use of humor to educate about climate change. For reasons of parsimony and in order to allow the original two short articles to stand on their own merits, the articles and tv clip are presented without a discussion of their observed efficacy in the classroom as three mini-cases in the conceptual section.

We followed Eisenhart's (2002) advice on using a case study methodology to build theory from cases, testing and elaborating the value of our key construct—active inoculation—when it is used to investigate the phenomenon of humor-based pedagogy. The aims of our study were moderate: We wanted to show that humor-based active inoculation approaches are being used in the classroom and to introduce to the literature humor-based serious games that have been successfully implemented. In this limited context, our case study has reached closure: We provided three full and three mini case studies as well a description of a humor-based serious game that has been implemented by the lead author and a team. As an exploratory study, we did not achieve—nor did we expect to achieve in an article of this length—

saturation (that is repetition of the same types of techniques used) on the types of approaches that use humor-based active inoculation to build up resilience against disinformation in classroom settings. We hope that future studies, especially using more cases, will remedy this deficiency. However, we do believe that the cases from educational settings discussed in conjuncture with our conceptual work provide a starting point towards theory development in humor-based active inoculation and climate education.

Case Studies

Case Study 1: Please Don't Fail Me

The first case study is from a non-majors biology undergraduate course at Massasoit Community College in Massachusetts. The class, Science for Life, focuses less on the findings of science and more on science literacy and critical thinking, giving students the tools they need to make better decisions in their own lives. Students learn to evaluate the evidence for claims and to recognize the characteristics of good science by evaluating bad science, pseudoscience, and science denial. Over the 2020-2021 academic year, six classes of approximately 20 students each with an average age of 22 and predominantly non-white students, played the *Cranky Uncle* game after covering the basics of argumentation in the lecture. Students appreciated the combination of humor and real-world examples, with one commenting, "Humor made it enjoyable to learn." Another student said that *Cranky Uncle* "teaches you to outsmart Boomers." Students were then instructed to engage in a thought experiment and compose an email to the instructor arguing why they should not fail the course (despite hypothetically deserving to fail), using at least four fallacies learned in class—an example of active inoculation that required the students to actively engage with the learned fallacies and produce their own arguments. Specific task instructions were as follows:

1. *Imagine that it's the end of the semester and you're failing this course because you didn't do the vast majority of the work, such as watching lectures or completing assignments. Write the professor an email arguing why you should pass the course, using at least four of the following fallacies: Hasty generalization, cherry picking, single cause, false choice, appeal to (false) authority, appeal*

to emotion, ad hominem, red herring, slippery slope, appeal to the masses, false analogy, and/or false choice.

2. *After you make your initial post, please read your classmates' posts carefully and reply to at least two of your fellow classmates. Identify and name the fallacies the other student used in their argument, and explain why they're fallacious.*

Students were encouraged to have fun with the activity. As a consequence, the students employed not just critical thinking but self-generated humor in their fallacious arguments, as the following excerpt illustrates:

> *So, I couldn't help but notice you gave me a 34% for the year, and see, I'm gonna need you to bring that grade up a little bit. The reason my grades have been slipping lately is actually because my uncle's friend's kid's dog just had babies, and one of them got hit by a car. My car. I accidentally killed my uncle's friend's kid's dog's kid and now my uncle's friend's kid's dog is depressed, which honestly has been weighing on my heart lately. Also, other than that, if you fail me in this class then I'm not gonna get into the graduate school I wanted to get into, and I'll never be able to get my doctorate and then even more people will die. If you fail me in this class people WILL die and it will be your fault. The way I look at it is like this, why would you give me a failing grade? Yeah, I didn't do any of my homework but there are homeless people. Literally homeless people. Everywhere. You should put more of your focus and energy on that if you really care so much. I even asked my mom and dad if they think my final grade is fair, and they agree with me. It's not fair. So, anyways PLEASE update my grade and I would appreciate it sooooo much. Thank You.*

In their responses, students correctly identified the fallacies committed (in the above example: slippery slope, red herring, appeal to emotions, and appeal to false authority). Other popular fallacies employed in student submissions were appeal to the masses and ad hominem, with some entertaining attacks on the professor's character.

The *Cranky Uncle* game's combination of humor and real-world examples increased student engagement and helped students identify misleading arguments, with one student commenting that it's "helpful to know when you're being lied to." The follow-up "Please don't fail me" assignment allowed students to channel their own inner *Cranky Uncle*, creating their own misinformation using humor to argue for a topic they could relate to. In the assignment debrief, the professor lauded their efforts at creating fallacious arguments and thanked them for making her laugh. She also reminded them to use their new *Cranky Uncle*"powers" for good, and not to persuade other professors to raise their grades.

Case Study 2: Denialist for the Day

The second case study involved use of the *Cranky Uncle* game in a climate-science class at Texas A&M University. The upper level course called *The Science and Politics of Climate Change* is typically attended by 50-60 students from Texas, of average age 21 and dominantly white ethnicity, most with majors in Environmental Geoscience or Environmental Studies. The course covers a review of pertinent climate-change science and discusses the societal responses of mitigation, adaptation, and geoengineering. Among its learning outcomes is not only the ability to "explain how science works, how policy debates work, and how these domains interact", but also to have students "describe how science denialism works and how it undermines science and society". A significant section of the class is devoted to examples of science denialism in the context of policy debate, such as the denial that smoking causes cancer or the denial of CFCs causing stratospheric ozone depletion. Explicitly discussed in class are the common denominators of science denialism, abbreviated with the acronym FLICC (Cook, 2021a).

In the 2021 spring run of the class, students were assigned to play the *Cranky Uncle* game on their smartphones during two weeks leading up to two consecutive writing assignments. For the first assignment, students were asked to be a "Denialist for the day" by writing a 200-400-word denial argument using logical fallacies that they had learnt from the game. Their choices were:

1. *Argue that wind and solar power were to blame for the recent massive power outages in Texas (Domonoske, 2021).*
2. *Argue that you deserve an A in the class no matter what.*
3. *Argue that urban industrial emissions cannot be blamed for high pollutant abundances in a suburb.*
4. *Argue that you should be allowed to continue smoking in your favorite bar whenever you want.*

Students overwhelmingly (49 out of 60) chose one of the first two options, and almost all were able to include three or more fallacies with ease. The assignment included peer review using the

Peerceptiv platform, meaning students also had to be able to correctly identify the chosen fallacies in several of their peers' submissions. Students' creativity and humor in writing denialist arguments were especially prominent in responses to choice topic #2, and many wrote similar pieces to the example given in case study #1. The other choices required more topical knowledge, some of which was provided in class, and thus arguably left less room for creativity and humor.

To deepen fallacy identification and analysis, a follow-up second assignment was created involving a related list of examples, but specific to climate-change misinformation (details in the Supplementary Material). Partially based on a poll of what climate-change-related arguments students had heard in their own social environments, they were given a list of six common claims:

1. *There is no consensus among scientists on climate change.*
2. *Atmospheric CO_2 lagged the warming during the deglaciations; therefore, CO_2 cannot cause current warming.*
3. *The cold spell we just had clearly disproves the notion of global warming.*
4. *CO_2 is plant food, its increase will lead to a greening of Earth.*
5. *Warming is natural. The globe has warmed (and cooled) before.*
6. *It's a liberal hoax, led by Al Gore!*

Students selected one example (claims 3-5 were most commonly chosen), then deconstructed the associated arguments according to the step-by-step methodology outlined in Cook et al. (2018), which had been briefly discussed in class before-hand, and reinforced via an associated reading assignment. The deconstruction exercise can be considered an active inoculation process, as students needed to "get into the head" of the misinformer in order to outline the premises and reasoning fallacies in the misinforming argument.

More than 80 % of the class completed the assignment with a grade B or higher, which can arguably be credited at least in part to the *Cranky Uncle* game, considering that several of the provided arguments are directly tackled by the game. Several students expressed their creativity in part via artful fonts and drawings to reinforce their deconstructions (examples in the Supplementary Material), while

many used the opportunity to summarize aspects of the climate science covered in class. Class feedback solicited at the end of the course suggested that these assignments were well received and successful in prompting students' critical thinking to identify misinformation in the public sphere.

Case Study 3: The Cranky Contest

Case study 3 involved an informal learning context outside of the classroom. Specifically, the Fairborn Sustainability Committee (FSC) of Fairborn, Ohio, challenged four nearby towns to a "Cranky Contest," with each town striving to accumulate the most cumulative points in the *Cranky Uncle* game. The challenge was developed by public librarian and climate-change educator Karen Jeffers-Tracy, who proposed the idea of a critical-thinking contest between local communities to *Cranky Uncle*creator John Cook. In response, Cook consulted with the game developer Autonomy Co-op, who developed a Cranky Contest leaderboard webpage[2]. In order to provide a non-digital component for people without smartphones, the contest was accompanied by a "walk in the park" public engagement program, where people identified fallacies in parallel-argument cartoons in a public space. The outdoor interaction with nature was also considered appropriate when learning about climate change.

The contest commenced one month before Earth Day, with the goal of culminating with a "Masters of Critical Thinking Award" presented to the winning city along with a hard copy of the *Cranky Uncle vs. Climate Change* book presented to their own local public library, at an FSC event on Earth Day, Thursday April 22, 2021. The library agreed to host an art exhibit of the *Cranky Uncle* cartoon poster featuring 97 climate scientists endorsing the scientific consensus on human-caused global warming.[3] To accomplish this, the FSC collaborated with the city parks department, the schools, and library, all of which were supportive and enthusiastic. To promote the contest, members of FSC, including a Fairborn school principal, a high school science teacher, and two city council persons, participated in a promotional video, which challenged the neighboring cities in a humorous way[4]. The video featured

slapstick physical humor, physical metaphors (such as slaying fallacies), and wordplay ("pumping up" for the *Cranky Contest* by working out in a playground).

The park next to the school hosted the walk with laminated cartoons, adapted from the *Cranky Uncle vs. Climate Change*book, attached to trees and fences along the one-mile walking path. A game sheet and pencils were housed in a "little library" structure near the start of the walking path. The game challenged players to remember the definition of a logical fallacy, retain the information for the time it took to walk 400-500 feet, then use that knowledge at the next cartoon to "answer the Cranky Uncle." For example, for the "it's the sun" argument, an appropriate response would be "Hey Cranky Uncle! That's slothful induction!" Similarly, for the argument "birds fly, therefore gravity isn't real," the response would be "Hey Cranky Uncle! You're jumping to conclusions!" Participants were encouraged to film themselves "talking back to Cranky Uncle" and to submit the videos to FSC's Facebook page. Since some fallacious arguments contained more than one fallacy, the player only had to use the one described 400 feet before the cartoon. If they forgot, they had to jog back to the previous poster to refresh their memory, with the repeated exposure aiding long-term retention. Participants who completed the park walk provided positive feedback, such as "I learned a lot, thank you, it was fun!" and "I feel smarter now!"

The *Cranky Contest* leaderboard was also popular, inspiring high school students to outplay neighboring schools, which were traditional sports rivals. In Fairburn, the tally quickly rose to 39,222 points (approximately 32 hours of gameplay); once the leaderboard was up, activity also began to show in the neighboring towns, with tallies of 1,060 (Dayton), 661 (Xenia), 95 (Beavercreek), and 20 (Yellow Springs). However, 10 days into the contest, parents of participating school students began filing complaints against a science teacher encouraging her class to participate in the contest. Initially, the School Superintendent defended the teacher and took a stance for science; the City Council and the City Manager also made science-defending stands. However, as complaints continued and it became clear that the complaints were about political rather than scientific issues, support faltered. The game was perceived to include "digs" at conservative politics, pointing out fallacial arguments in topics such as abortion and

gun control. Politically conservative parents objected to cartoons on the *Cranky Uncle* website which satirized then-President Donald Trump.

Interestingly, some reactance was also shown among political progressives playing the *Cranky Uncle* game, who did not complain publicly, but privately told the organizer that their enthusiasm for playing the game waned after seeing quiz questions debunking misinformation about homeopathy. After sustained criticism, the Fairborn Sustainability Committee, the Schools, and the City decided to no longer promote or sponsor the event, and some students were actively discouraged or prohibited by parents from participating. Consequently, the park walk, which was supposed to last two weeks, was suspended after five days. As the contest was canceled, instead of awarding a single 97% consensus poster to a single winning city's library, ten posters were distributed to branch libraries across the Fairborn county and two adjacent counties, as a separate event highlighting library programs about COP26. Each library will receive a hard copy of the book, with the formal presentation and art display to be covered by a local newspaper. The book is also planned to be a requirement towards a "Citizen Science Climate Change Literacy Certificate" program.

This experience illustrates that the inoculation metaphor applied to this form of pre-emptive intervention not only describes the immunity developed from the intervention, but also captures the potential adverse reactions that can stem from an inoculating message. The incident raised reasonable questions about how public interventions addressing misinformation should be designed. Some players recommended that the scope of the game be restricted to climate-change science, finding that examples from other controversial topics were distracting and confusing. From an organizer's point of view, another requested feature was more detailed analytics such as how many people participated in the game, and how far into the game participants progressed, which could potentially provide insights into which climate science concepts were hardest for players to understand. Given that there were adverse reactions from members on both sides of the political spectrum, this indicates that any intervention that addresses real-world misinformation will offend someone. We advise that practitioners implementing similar interventions should consider this issue and strategically prepare for potential push-back.

Discussion

This paper examines the application of humor in environmental education through the use of a digital game and critical-thinking classroom activities. While there exists little research into the use of humor to teach climate change in the classroom, a broader body of research has examined using humor in climate communication more generally, as well as humor-based responses to misinformation. The example of three case studies applying these approaches in a variety of contexts demonstrates the versatility and benefits of humor in education.

On a basic level, humor-based pedagogy can help with information transmission, by making dry statistics and complex scientific data more exciting and thus easier to learn. However, it can and should do more than that: it can teach students effective communication techniques to help them become active in a meaningful way. Students choose to study environmental issues not just because it is exciting or inspiring; they enroll to learn how to have an impact on efforts to mitigate the threat of climate change. We argue that one of the most important aspects of a humor-based approach as implemented in the *Cranky Uncle* game is its ability to demonstrate to students how strategic communications skills can be leveraged to achieve social change. This process is sometimes called public interest communications (PIC; Fessmann, 2016, 2017). Specifically, we argue that humor-based communication is both a great tool for environmental educators to engage their students and a key strategic tool that students can learn to use to impact the broader discourse.

Interestingly, independent lines of research have explored humor as an effective strategy in response to misinformation, with a particular focus on climate-change misinformation. These lines of research converge when considering solutions that counter misinformation about climate change. The benefits of humor in both climate communication and countering misinformation are multi-faceted, with further nuances when applied in a gaming context. As a correction to misinformation, humorous (cartoon) interventions utilizing parallel arguments can attract attention, provoke information seeking, stick in memory longer, and explain logical fallacies in a concrete, accessible form (Compton, 2018; Cook et al., 2018; Kim et al., 2020). When employed in serious games, humor makes educational content more

entertaining, creates a positive atmosphere conducive to learning, and motivates players to return to the game (Dormann & Biddle, 2009; Imbellone et al., 2015).

In the *Cranky Uncle* game, which is designed to counter disinformation about climate change, these diverse benefits combine and interact to provide a rich, engaging experience. The active inoculation that is administered through parallel arguments involving the *Cranky Uncle* character can trigger a "cognitive immune response", viz. a boost to critical thinking; this can subsequently facilitate the creative and confident engagement with complex, inter-related issues (Kelsey & Armstrong, 2012) and provide protection against future encounters with noxious information across different topic domains (Cook et al., 2017; Lewandowsky & van der Linden, 2021; Lewandowsky & Yesilada, 2021). While inoculation approaches are not always more effective than more reactive debunking approaches (e.g., Tay et al., 2021), they have the clear benefit of acting preemptively. As such, science communicators, policy makers, and other practitioners dealing with misinformation should incorporate "prebunking" tools in their arsenal, and apply these strategically where significant levels of misinformation dissemination and impact can be anticipated (Lewandowsky et al., 2020).

While the active inoculation approach has been successfully applied in digital serious games, the approach is also conducive to more traditional (pen-and-paper, face-to-face) activities, both inside and outside the classroom (e.g., informal community settings), and carries strong pedagogical value in this context. Prompting students to generate their own content unlocks their potential for creativity and encourages them to experiment with humor as they apply newly acquired critical-thinking skills. The case studies presented here showcase examples of the complementary implementation of the serious game and related (classroom) activities, which allowed participants to exercise both their critical-thinking skills and their creative ability, for example by writing assignments employing the rhetorical techniques and logical fallacies introduced in the *Cranky Uncle* game.

There is much potential to further explore the use of humor and gaming to inoculate students against misinformation. Version 1 of the *Cranky Uncle* game was an English-only individual game where players privately learn about misinformation techniques. At the time of writing, version 2 of the game was

being launched, offering the game in Dutch and German. While this new development is too recent to have collected sufficient research data, expansion into other countries is already underway with translations into 14 other languages. There are also plans to introduce a more racially-diverse pool of cartoon characters, given the first version's almost exclusive use of white characters.

Another exciting area for future expansion is incorporating player vs. player contests within the game, where students can challenge fellow students to one-on-one contests and participate in critical-thinking tournaments. A preliminary version of such a contest was foreshadowed in the Cranky Contest described in Case Study 3. A more structured contest environment could incorporate social elements, which are important for student engagement through friendly competition, social bonding, and shared fun (Lazzaro, 2004). Social game-play can potentially foster user-generated or emergent humor, which is a powerful element to humor in games (Dormann, 2014). Player contests would necessitate adding a crowd-sourced feature where players could contribute quiz questions, incorporating another degree of active inoculation into the game. Research into these new elements would explore whether player vs. player contests successfully motivate players to practise quizzes more, and whether contests and participation in active-inoculation-based content creation predicts greater improvement in critical-thinking performance.

Given that the scientific consensus has identified climate change as an existential threat to human existence as we know it, we argue that environmental education needs to do more than teach the theory. It needs to help activists become more effective in countering well-funded organizations of vested interests that only need to maintain the status quo to achieve their goals (Fessmann, 2019). A core issue of environmental education is that it tends to be dominated by information-deficit approaches (Suldovsky, 2017), which falsely posit that providing enough information about the scientific clarity of climate change will be sufficient to persuade students and broader audiences. The *Cranky Uncle* game that we have introduced in this article aims to go beyond this approach by focusing on two audiences with separate goals for each. The first audience is the segment of the population that is undecided or disengaged about climate change, with the goal of not only providing accurate scientific information, but also inoculating players against future misdirection, and engaging them deeply through the use of humor. The second

audience comprises those who are concerned and alarmed about climate change but who self-censor and neglect to discuss climate change with friends and family. A primary contributing factor to this self-censoring is fear of pushback and being made to look foolish (Geiger and Swim, 2016). For this group, inoculation provides confidence to discuss the climate change issue despite potential dismissive counter-arguments. In this situation, inoculation is not about preaching to the choir—rather, it is about teaching the choir to sing (Swim, Fraser, & Geiger, 2014).

Educators typically face classrooms with a diverse spectrum of beliefs and backgrounds, which can present a challenge when teaching content that some may find culturally threatening. However, there are strategies that teachers can employ to help them negotiate these kinds of challenges. For example, one educator found that a productive approach for addressing climate misinformation with conservative students in Utah was first addressing misinformation techniques from the political left before transitioning to climate misinformation originating from the political right (Cook, Bedford, & Mandia, 2014).

The approach of combining creative humor and scientific content about climate change speaks to the broader principle of adopting interdisciplinarity to address complex societal issues. Climate change is a culturally polarized issue, which means public-engagement efforts need to take into account attitude roots that are the source of resistance to climate messages (Hornsey and Fielding, 2017). Misinformation is ubiquitous, amplified by social-media platforms, and implacable due to cultural polarization and the interconnected nature of contemporary communication channels. Adequate solutions to this problem need to be multi-pronged, holistic, and interdisciplinary (Ecker, 2017; Ecker et al., 2022; Lazer et al., 2018; Lewandowsky et al., 2017). Digital games incorporating inoculation, gamification, and cartoon humor in response to misinformation exemplify this approach by combining science, technology, psychology, education, and the arts.

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Supplementary Material

S1. Texas A&M Assignment

Analyzing Misinformation in Detail

Make sure you accessed the associated Reading Assignment: https://crankyuncle.com/using-critical-thinking-to-analyze-misinformation/
Critically, and systematically, evaluate a climate science myth/argument (frequently) made in the public realm. Summarize onto ONE PAGE.
Your choices appear below, pick only one!
Follow the outline (workflow, organization) given in the reading assignment. Create a graphic with the myth (argument) on top, and any associated premises on the left, analyzed for FLICC characteristics on the right. Give the (almost always wrong) conclusion the argumenter arrived at (or implies) on the bottom left. Don't worry about your color scheme or font. Focus on clarity of the graphic.

Below your graphic (2nd half of the page), summarize your thoughts by

- providing some context for the myth/argument,
- identifying what FLICC characteristics the argumenter used in the myth and/or its premises, and
- explaining what the scientific consensus on the topic actually is.

This way, you created a concise debunking of the myth that includes an explanation of its fallacies AND replaces the (shoddy thinking related) myth with the actual science on the issue.
Choices:

1. There is no consensus among scientists on climate change. Richard Lindzen makes that much clear.
2. Atmospheric CO_2 lagged the warming during the deglaciations, Therefore, CO_2 cannot cause current warming.
3. The cold wave we just had (example "snowmageddon") clearly disproves the notion of global warming.
4. CO_2 is plant food, its increase will lead to a greening of Earth.
5. Warming is natural. The globe has warmed (and cooled) before.
6. It's a liberal hoax, led by Al Gore!

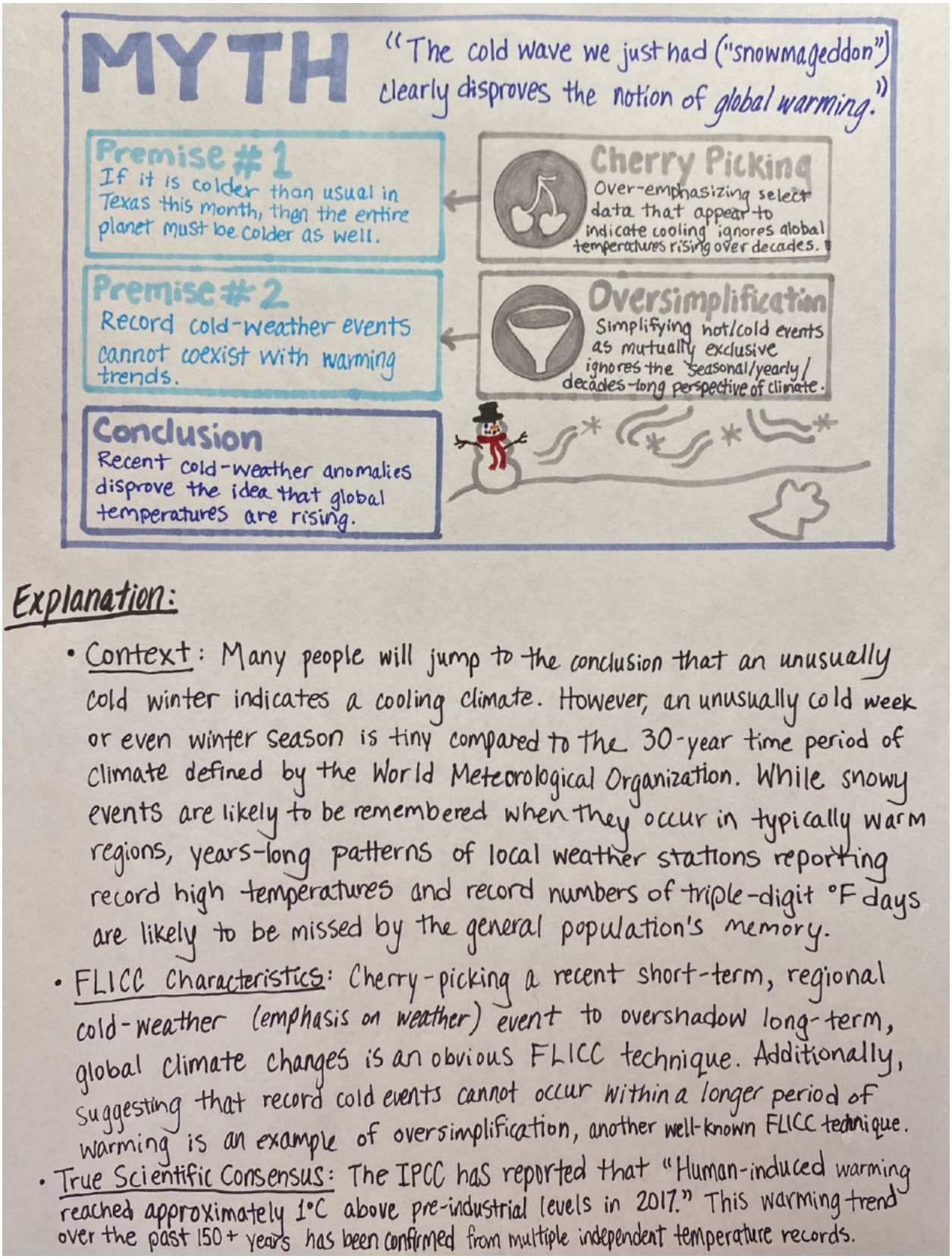
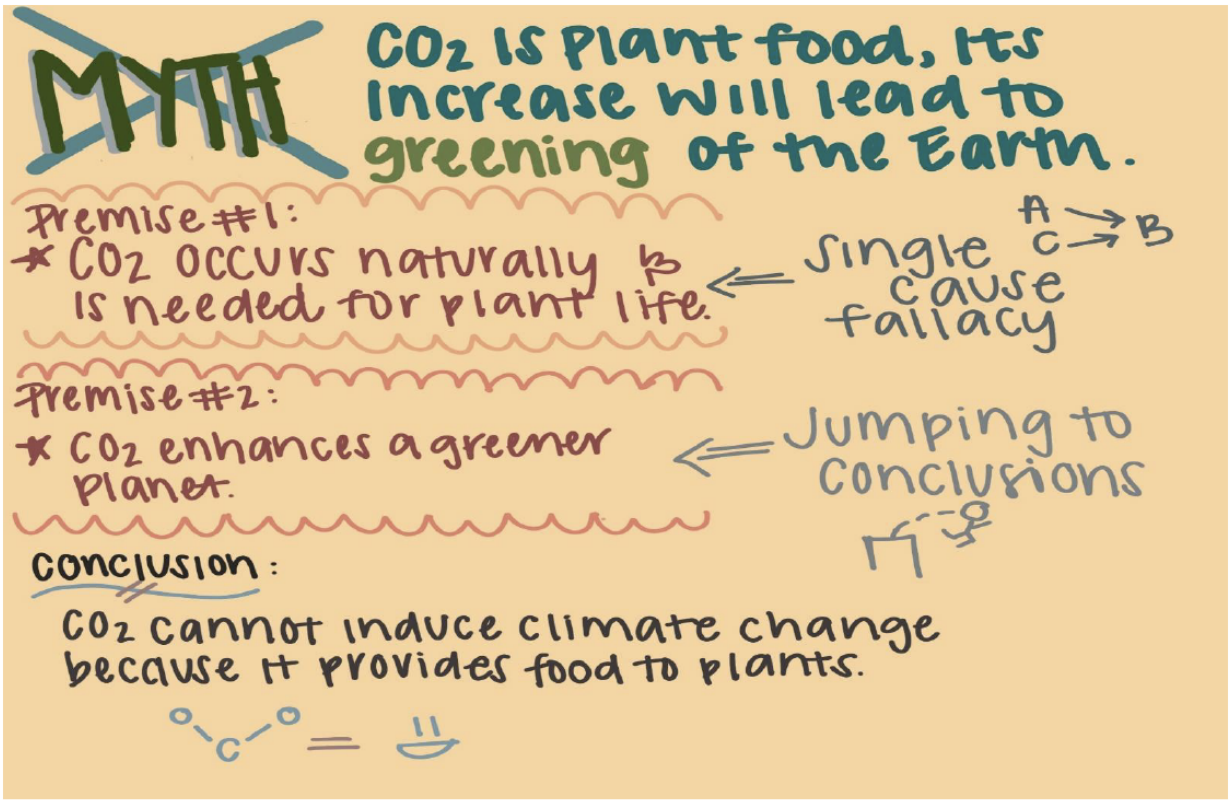


Figure S1. Submitted assignment debunking the "cold weather disproves global warming" myth.



The image above is a graphic that I created using a digital art app called Procreate on my iPad. In the graphic I capitalized on the myth that CO2 is plant food, so therefore its increase will lead to greening of the earth. The first premise being made is that CO2 occurs naturally and is needed for life. This is incorrect and can be attributed to as a single cause fallacy, the assumption that one factor creates a result. Secondly, this statement indicates that CO2 will enhance a greener earth which would be identified as jumping to conclusions. Without the proper science and evaluation, one could not unequivocally state that plants absorb CO2 and therefore CO2 will not contribute to climate change. This assumption concludes that CO2 will not contribute to climate change as it is overall natural and beneficial to the plants. This conclusion is incorrect because this myth does not take into account the mass amount of CO2 that is in the atmosphere and not every bit of carbon will find its way to a plant to be absorbed, such as by way of ocean. Although a portion of the statement stating that plants absorb CO2 is true (which can actually be identified as cherry picking in this myth), it only absorbs 25% while 50% remains afloat in the atmosphere.

Figure S2: Submitted assignment debunking the “CO2 emissions are good because CO2 is plant food” myth.

[1] https://youtu.be/cjuGCJJUGsg

[2]

https://leaderboard.crankyuncle.info/FAIRBORNOH/YELLOWSPRINGSOH/DAYTONOH/BEAVERCREEKOH/XENIAOH

[3] https://crankyuncle.com/which-climate-scientists-are-in-the-97-consensus-poster/

[4] https://youtu.be/HS1xWAqqhLE