

The Adventures of Carbon Bond: Using a melodramatic game to explain CCS as a mitigation strategy for climate change

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Abstract: Policy options for mitigating climate change have been severely limited in the USA by the clash of competing ideologies. People who oppose policies to mitigate climate change have successfully framed climate change as existing outside the realm of fact and empirical reality. Instead, opponents frame the issue as a melodramatic struggle between good and evil. While scientists and engineers tend to be uncomfortable with melodramatic framing, we argue that melodrama resonates with people. Constructing a different melodramatic frame can tap into people's tendency to conceptualize issues in terms of heroes and villains and assist in creating a shift in the political controversy from debating the factuality of climate change to a focus on mitigation. We developed an educational video game that uses this frame to teach students about climate change and carbon capture, and sequestration, to create an understanding of CO₂ as the villain and humans as heroes through participation in mitigation strategies. The hero of this melodrama is aided by science and technology to mitigate anthropogenic climate change. We analyze *The Adventures of Carbon Bond*[®] as a medium for educating students about climate change and shifting framing. We begin with a discussion of melodrama and the rhetorical nature of video games. Then, through statistical analysis of surveys completed by students who played the game, we demonstrate that students experienced a knowledge increase as a result of game play. We conclude by discussing the implications of our findings for productively reframing climate change towards an emphasis on technological mitigation.

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Introduction

Policy options for mitigating anthropogenic climate change have been severely limited in the United States by ideological conflict. One focal point in this controversy is the manufactured debate over whether climate change is factually based. Contingents of people who oppose policy to mitigate climate change have successfully framed it as existing outside the realm of fact and empirical reality. Instead, these opponents of climate mitigation policy frame climate change as a melodrama, which Burke defines as a polarized struggle between good and evil.¹ Scientists, engineers, and others who accept the factuality of anthropogenic climate change tend to be put off by melodramatic framing, and indict it for being irrational. From a political perspective, however, it is more practical to work within the dominant cognitive frame than to denigrate it.

We contend that co-opting the melodramatic frame for climate change can contribute to shifting public discussion in the USA toward mitigation strategies, rather than continuing to argue over whether the climate is changing. Despite the criticism of melodrama as irrational, it represents how people understand and come to terms with complex and daunting issues such as climate change.² In other words, people tend to make sense of complex issues by categorizing the good and the evil and identifying heroes and villains. Instead of ignoring or repudiating melodrama, proponents of climate change mitigation technology and policy have much to gain by adapting a melodramatic frame for their purposes. While the melodramatic frame may be perceived to eschew reason in favor of emotion, we show that a melodramatic frame is compatible with promoting the use of science and reason to solve complex problems. Offering a melodramatic frame that is supported by climate change science enables people to shift their focus from debating the reality of climate change to solving the climate change problem with mitigation technologies. We tested this idea by developing an educational video game that uses the melodramatic frame to teach students: (i) basic carbon cycle information; (ii) how carbon dioxide (CO₂) and other greenhouse gases (GHGs) contribute to climate change; and (iii) how carbon capture and storage (CCS) can be used as a mitigation strategy. In line with the game's effort to avoid presenting an inaccurately negative perspective toward CO₂, the hero of this melodrama is a CO₂

molecule who uses science and technology to solve a problem, or mitigate anthropogenic climate change. The villains are a gang of unruly GHGs, rather than people with different ideologies. By drawing attention to the technologies (CCS in this case) that people can use to address a problem, melodrama moves beyond the unproductive debate over who causes climate change to an exploration of options for mitigating it.

In this paper, we analyze *The Adventures of Carbon Bond*[®] as a medium through which to educate students about climate change and CCS, and shift the framing of climate change toward mitigation strategies. We begin with a discussion of melodrama and the rhetorical nature of video games. Then, through statistical analysis of surveys completed by students, we demonstrate that students experienced a knowledge increase as a result of playing the game. We conclude by discussing the implications of our findings for productively reframing CCS and other strategies for climate change mitigation.

Melodrama

The political controversy over climate change in the USA falls within what Burke has termed the melodramatic frame of rhetoric.¹ While melodrama is often referred to as a dramatic form, Burke expanded the concept of melodrama (as well as other dramatic forms) as a way to conceptualize and theorize how people understand the world around them. Melodrama is an overarching frame, or system of interpretation, that emphasizes a polarization between heroes and villains. We follow Schwarze in defining melodrama as 'a recurrent rhetorical form in environmental controversies' (p. 239) that entails 'a focus on socio-political conflict, polarization of characters and positions, a moral framing of public issues, and development of monopathy' (p. 245).³ This definition, while perhaps more operationally oriented, is consistent with the ordinary language definition of melodrama as, 'a work (as a movie or play) characterized by extravagant theatricality and by the predominance of plot and physical action over characterization' (<http://www.merriam-webster.com/dictionary/melodrama>). While some scholars have criticized melodrama for its polarizing perspective,⁴⁻⁶ it remains a dominant way for people to understand and come to terms with complex and daunting issues.² During the 1980s, many scientists and policymakers subscribed to a view of science communication that assumed

members of the lay public suffered from a deficit of information, as well as a deficit in the way that they viewed the world. According to the deficit model, good science communication simply needed to fill the void with correct information, and with training in how to view the world more rationally. It has become increasingly clear, however, that this approach is not effective.⁷⁻⁹ Meaningful engagement requires thoughtful recognition of the validity of people's implicit values, emotions and attitudes, especially with a topic as dynamically complex as climate change.¹⁰

Schwarze argues that in certain situations melodrama can be transformative and 'shift the parameters of ongoing controversies' (p. 253).³ The polarization between heroes and villains is important to the transformative potential of melodrama. Schwarze continues: 'as melodrama polarizes, it can encourage reconsideration of the allegiances and shared substance that might normally lead audiences to accept a certain set of social and political arrangements' (p. 248).³ For climate change, a melodramatic frame can facilitate a shift in thinking from considering one's political opponents as villains to considering CO₂ and other greenhouse gases as villains. A melodramatic frame that places audiences (or players) in the position to act as heroes by taking action to fight CO₂ emissions can challenge here to fore successful efforts to evade the issue of climate change by offering concrete techniques for mitigating it. In this paper, we demonstrate that educational video games hold unique potential to not only incorporate the melodramatic frame into the story of a game but also to reach audiences that may otherwise close themselves off from climate science.

Video games

Video games have often been trivialized as a medium that does not warrant further critical attention. Yet video games, as rhetorical constructs with the power to persuade,¹¹⁻¹⁶ have immense potential to transform their players' perceptions of the world. The rhetorical force of video games can come from both the explicit story of the game and the implicit procedural aspects of a game. Regarding the former, Gee explains that the use of storytelling and narrative forms in video games impact players in the course of gameplay and in their lived experiences outside of the game.¹⁴ In the case of climate change, a video game can use storytelling to reconfigure the main characters in climate

change. For example, in *The Adventures of Carbon Bond*[®], the story involves the player acting as a hero who protects the world by capturing and sequestering CO₂ before it enters the atmosphere. Regarding the latter, Bogost coined the term 'procedural rhetoric' to describe 'the art of persuasion through rule-based representations and interactions rather than the spoken word, writing, images, or moving pictures' (p. ix).¹² That is, procedural rhetoric entails the arguments put forth through the rules of the game. The implicit structure, as well as the explicit narrative, of the game is rhetorical. Procedural rhetoric has the potential to 'disrupt and change fundamental attitudes and beliefs about the world, leading to potentially significant long-term social change' (p. ix).¹² In *The Adventures of Carbon Bond*[®], procedural aspects of the game encourage players to recognize climate change as an anthropogenic problem that is amenable to anthropogenic remedies. Players advance by sequestering GHG emissions and in so doing focus attention on how to mitigate climate change, rather than whether it is occurring or what is causing it. In other words, the procedural rules of the game already assume that it is desirable to prevent more CO₂ from entering the atmosphere. This procedural aspect of the game then provides a learning experience as it nudges US players outside of the debate over whether anthropogenic climate change is happening to experience climate change and climate mitigation strategies in an educational context.

Video games, therefore, are not only persuasive, but also hold the potential to transform the way we think about the world. Indeed, according to Chang 'games could affect our understanding of real-world environmental issues, either by implicitly or explicitly modeling different forms of our individual and collective environmental agency' (p. 60).¹⁷ Therefore, constructing a game that uses the melodramatic frame to represent mitigation strategies for climate change has the potential to move beyond the ideological gridlock in contemporary US political discussions of climate change.

The Adventures of Carbon Bond

The Adventures of Carbon Bond[®] is an Internet-based videogame geared toward teaching students about climate change and geologic CCS as a mitigation strategy.¹⁸ The game was created for the Southwest Regional Partnership on Carbon Sequestration and the Southwestern United States Carbon Sequestration

Training Center as a means of engaging youth in discussions of climate change mitigation through CCS while also providing imagery for geologic CCS, which is difficult for many people to visualize. Based on a review of public school curricula to see where material on climate change and CCS might best fit, we chose to design the game for students in grades six through eight, from middle and junior high schools (age 11–14). Players have the opportunity to learn: (i) the basic science of climate change; and (ii) the science and technology behind geologic CCS, which is an important option for mitigating climate change but is still not well understood within the public realm.^{18–20}

Beyond these informational goals, the narrative of the game creates a melodramatic frame that focuses on climate change mitigation by positioning players as heroes through capturing and sequestering villainous CO₂ molecules. The storyline of the game focuses on a main character, Carbon Bond, who is on a mission to save the planet by capturing as many rogue CO₂ molecules as possible and sequestering them in an underground formation. Being a CO₂ molecule himself, Bond separates himself from anthropogenic CO₂ at the beginning of the story by claiming to be 'naturally formed' through the carbon cycle, thus distinguishing for players the difference between natural CO₂ and CO₂ from industrial operations. Bond's adventures take him from the smokestacks of an integrated gasification combined cycles power plant, to the stormy coasts of the Gulf of Mexico (impacted by increased storm intensity related to climate change), and finally to a CO₂ storage facility in the Southern Rockies where the Greenhouse Gas Gang (anthropogenic GHGs) is locked away. The narrative begins with the assumption that climate change is a factual problem that needs to be solved, offers CCS as a technological solution to mitigating climate change, and positions players to be a part of the solution by capturing and sequestering CO₂ molecules. Following a melodramatic frame, the game presents anthropogenic CO₂ as the villain and players (through the game persona of Carbon Bond) as the heroes.

The game is made up of four progressive gaming activities interspersed throughout the melodramatic narrative: (i) a shooting activity, using a 'Goo Gun', to capture members of the Greenhouse Gas Gang at a local power plant; (ii) a driving activity with the goal of avoiding collision with storm debris while hauling the gang to prison; (iii) a storage activity to imprison the gang in an underground formation; and (iv) an

entrance exam into the National Energy Technology Laboratory as a secret agent like Carbon Bond (Fig. 1). This final activity tests players on their knowledge of the carbon cycle, GHGs, energy production, rock formations, and climate change. If enough points are earned, players can print their own badges. The video game provides opportunities for students to: (i) learn through activities presented within a social/environmental context; (ii) define a problem and create solutions; and (iii) transition from being a fictitious hero to a real-life hero.

Research questions

Through the creation of *The Adventures of Carbon Bond*[®], we attempted to recast the narrative about climate change from one of dueling political ideologies to a drama focused on technological solutions. We hypothesized that an educational video game could provide an appropriate vehicle to present a controversial topic such as climate change mitigation within a melodramatic structure that placed players (and by extension, all humans) in the role of hero. We developed *The Adventures of Carbon Bond*[®] to enable students to learn about the science and technology related to climate change in an atmosphere relatively free from ideological conflict. To examine the effectiveness of the game we posed the following research questions:

RQ1: Do students learn basic science information related to climate change through playing *The Adventures of Carbon Bond*[®]?

RQ2: Do students learn how CCS contributes to climate change mitigation through playing *The Adventures of Carbon Bond*[®]?

RQ3: Do students enjoy the learning process through playing *The Adventures of Carbon Bond*[®]?

In addition to these questions, widespread USA interest in attracting more females into Science, Technology, Engineering, and Math (STEM) fields, such as climate science, led us to ask:

RQ4: Do boys and girls learn differently through playing *The Adventures of Carbon Bond*[®]?

Methods

Students in grades six through eight, from middle and junior high schools (age 11–14) in the states of Michigan, North Carolina, and Texas (n = 116) played the

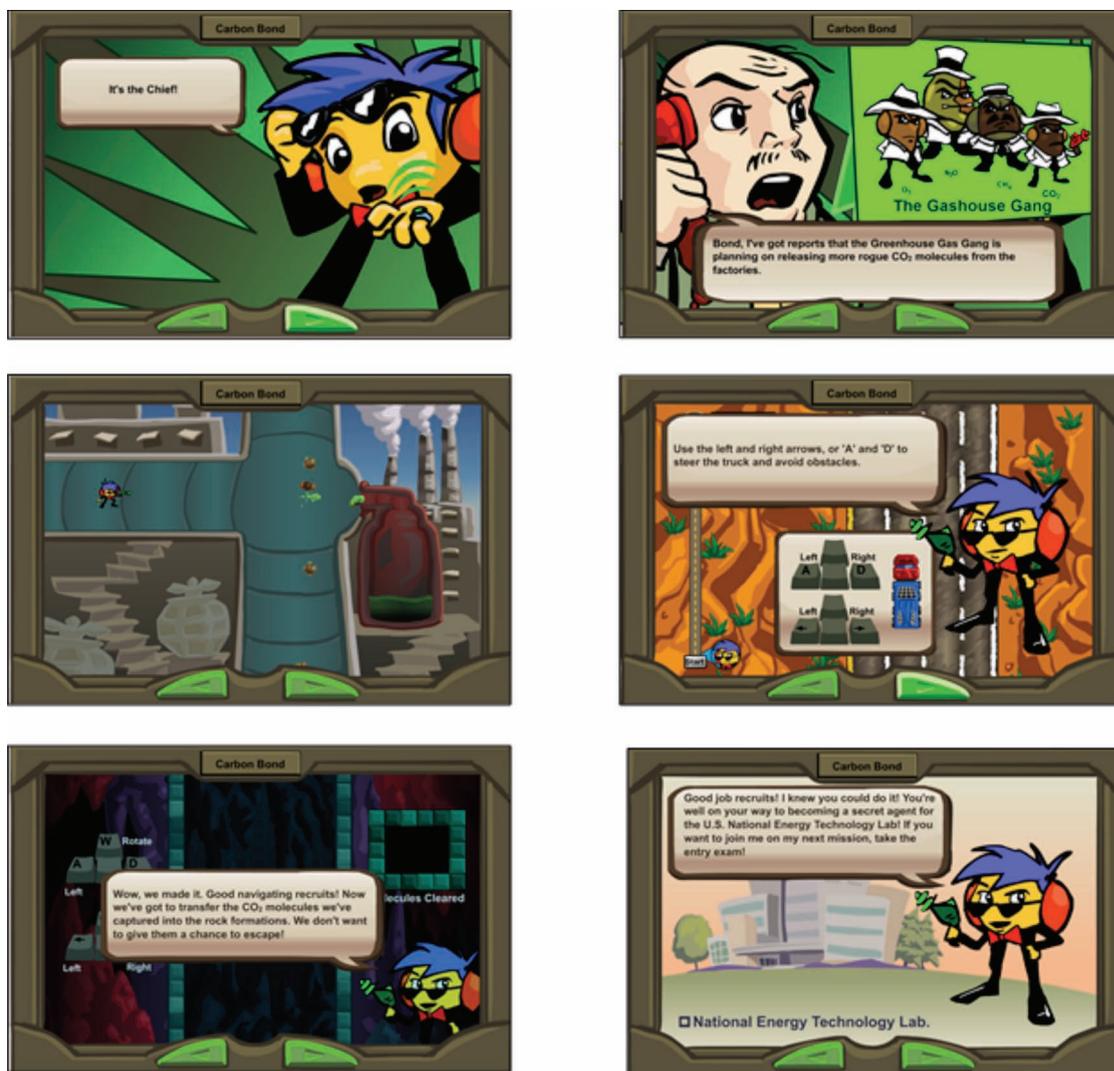


Figure 1. Images from *The Adventures of Carbon Bond*.

game. We conducted pre- and post-game surveys to determine knowledge gained and enjoyment accrued from students' gaming experience. The study period was from May to December 2011. Video game play and surveys were administered online. We used Survey Monkey to administer the pre- and post-game surveys. Survey material included: (i) a knowledge test covering information from the storyline and activities; (ii) questions pertaining to activity enjoyment; and (iii) questions addressing demographics. The entire process (game play and two surveys) took a total of 30 to 45 minutes, or one class period, to complete. Differences in delivery time depended on class size and teacher preparation.

For data analysis, we used JMP 9.0 to conduct paired t-tests on the pre- and post-game knowledge data and descriptive statistics for questions addressing gaming enjoyment. This study was conducted in accordance with the Texas A&M University Institutional Review Board.

Results

From our analysis of the students' knowledge tests (RQ1 and RQ2), we found a statistically significant difference between pre-game ($M = 6.862$, $SD = 1.7688$) and post-game scores ($M = 8.448$, $SD = 1.7212$, $t = 9.5226$, $DF = 115$, $P < 0.0001$) as well as a change in score

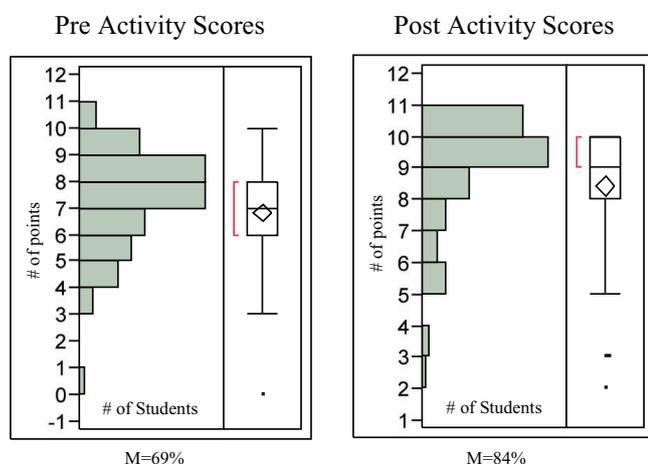


Figure 2. Differences in pre and post distributions for players in grades 6 through 8. Highest score possible is 10 out of 10 points. Diamond indicates student mean ($n = 116$). After playing the game, students scored significantly higher on the knowledge test, with the mean score increasing from 69% to 84%.

distribution from pre- and post-gaming (Fig. 2). Table 1 depicts an overall increase in average scores by question. These results demonstrate an increase in basic knowledge of the carbon cycle and other information relevant to student learning about CCS and anthropogenic climate change. These increases are in light of students reporting that 73% had learned about CO_2 prior to playing the game, and 86% about climate change.

In response to RQ3, we found that students enjoyed playing *The Adventures of Carbon Bond*[®] in the classroom, with 55% of students saying that they would play it again on their own, and 66% saying that they thought other students would enjoy the activity. Of the four separate activities that make up the game, the shooting activity involving the Goo Gun was the favorite, with the Entrance Exam being the least favorite but admittedly most educational (Fig. 3).

When examining differences in scores due to sex (RQ4), we found that girls' pre-game mean scores ($n = 56$; $M = 6.786$, $SD = 1.8262$) were lower than those of boys ($n = 60$; $M = 6.933$, $SD = 1.7258$), but their post-game mean scores ($M = 8.625$, $SD = 1.5083$) were higher than the boys' post-game scores ($M = 8.283$, $SD = 1.8964$). Thus, girls learned more than boys from playing the game. However, the differences between pre- and post-game mean scores for girls ($MD = 1.840$) and pre- and post-game mean scores for boys ($MD = 1.350$) were not statistically significant ($P = 0.1429$). Changes in the distributions of pre- and post-game scores by sex can be seen in Figs. 4 and 5. Similar to sex, no statistically significant differences were found when we attempted to differentiate between the different grade levels (grades 6-8; $P = 0.9229$).

To summarize, playing the game enabled students to learn about the carbon cycle, climate change, and geological CCS. Girls' knowledge of these topics increased more than boys' knowledge. Both boys and girls reported that they enjoyed playing the game.

Table 1. Difference in means by question between pre and post responses for players in grades 6 through 8.

Question	Pre-activity Mean	Post-activity Mean	Difference
Carbon dioxide (CO_2) is...	74%	73%	-1%
Carbon is the building block for all living things.	35%	86%	51%
How does your home and school get electricity?	91%	91%	0%
Rock formations have spaces underground that hold resources such as oil and natural gas.	82%	92%	10%
Planting a tree or other plants could help lower carbon dioxide (CO_2) in the atmosphere.	76%	93%	17%
The temperature on Earth is...	82%	91%	9%
How can you help cut carbon dioxide (CO_2) emissions?	80%	89%	9%
Reducing carbon dioxide (CO_2) emissions helps control climate change.	84%	93%	9%
Carbon dioxide (CO_2) can be captured from a factory...	38%	55%	17%
Carbon dioxide (CO_2) can be stored in underground rock formations.	47%	84%	37%

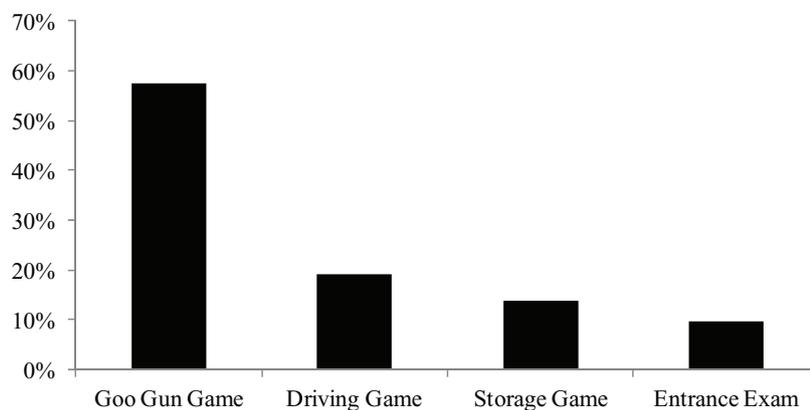


Figure 3. Distribution of students' favorite activity within *The Adventures of Carbon Bond*

Discussion and conclusions

When it comes to the mitigation of climate change, controversy and ideological hostility have constructed a significant hurdle to policy action. This hurdle stems from multiple causes, including the complexities of modern society with its pluralistic value systems (i.e. cultural, economic, political, scientific). When faced with phenomena of such scale and complexity as climate change, humans often resort to melodrama as a way to make sense of the complexity through

narratives with heroes and villains. In this study, we demonstrated one way that the strategic use of this commonly used frame can enable science educators to work within melodrama by recasting what is constituted as *good* and *evil* or *villainous* and *heroic*. The enjoyment and significant knowledge gains of student players suggest that *The Adventures of Carbon Bond*[®] has the potential to reframe the issue of climate change to villainize GHGs and make heroes out of people (the students in this case) who combat these emissions.

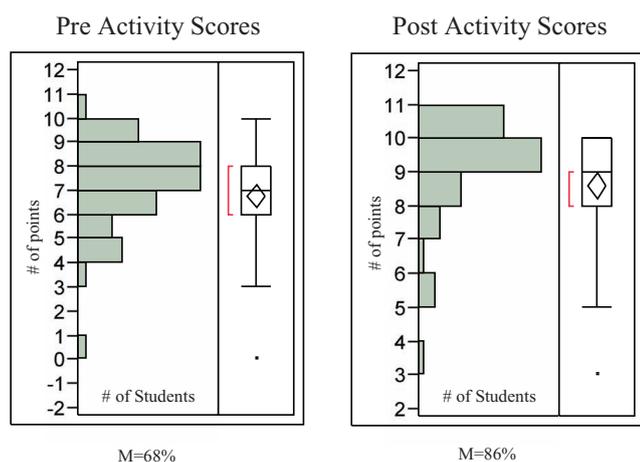


Figure 4. Differences in pre and post distributions for girls grades 6 through 8. Highest score possible is 10 out of 10 points. Diamond indicates student mean ($n=116$). After playing the game, girls scored significantly higher on the knowledge test, with the mean score increasing from 68% to 86%.

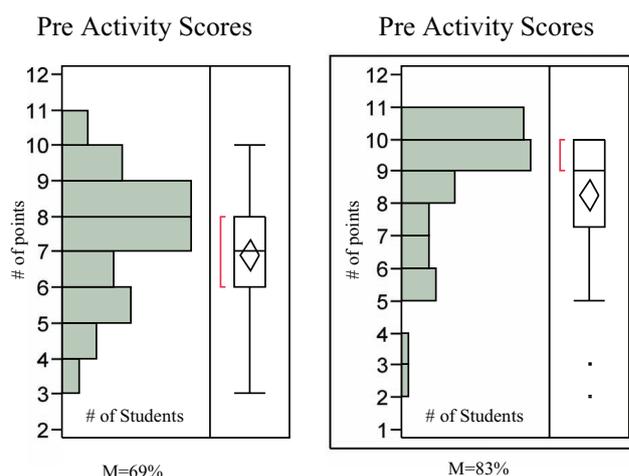


Figure 5. Differences in pre and post distributions of boys grades 6 through 8. Highest score possible is 10 out of 10 points. Diamond indicates student mean ($n=116$). After playing the game, boys scored significantly higher on the knowledge test, with the mean score increasing from 69% to 83%.

Though the knowledge gain and enjoyment of game players is a strong demonstration of the value of reframing the melodrama of climate change through game play, it did not fully address the potential value of recasting the melodramatic frame through video gaming. We recommend more extensive research, including: (i) interviews and focus groups with students and teachers to explore changes in perspective toward climate change action attributed to game play; and (ii) the addition of more study participants to the current dataset to further explore the significance of sex differences noted above.

In conclusion, we found that game play freed players from the ideological tensions that surround climate change in US society, and that prevent engagement with climate change mitigation. Youth are both aware of and deeply embedded in the conflicting claims made by the adults in their lives; they also can be powerful ambassadors for science and technology.²¹ Because *The Adventures of Carbon Bond*[®] is clearly a game, it invited students to play with an issue that is fraught with conflict. Once they began playing, they learned how climate change connects to basic science, and were able to explore CCS as a potential technology for working through the contemporary challenge of anthropogenic climate change. Although we recognize that important differences in preferences for individual climate change mitigation technologies remain, reframing all humans (i.e. energy producers and consumers, environmentalists, consumer advocates) as the 'good guys' is an important step toward involving non-scientists in a positive exploration of policy options designed to mitigate climate change.

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