

Thinking about global warming: The effect of policy-related documents and prompts on learning about causes of climate change

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Abstract

We examined students' understanding of the causes of a scientific phenomenon from a multiple-document-inquiry unit. Students read several documents that each described causal factors that could be integrated to address the given writing task of explaining the causes of change in average global temperature. We manipulated whether the document set included a document that took a position on climate change policies and whether a reading/writing prompt focused only on understanding the causes ("explain how and why recent temperature changes are occurring") or also included a solution-related addendum ("and what we can do about it"). The results suggest that including a policy-related document can lead to poorer learning outcomes for the causes of climate change, with evidence that students focused upon policy in lieu of, rather than in relation to, a causal understanding of the issue.

Keywords: Multiple-document inquiry tasks, learning from science texts, causal explanations

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New U.S. curricular standards emphasize the need for students to develop complex literacy skills that enable them to understand and construct scientific explanations (Achieve, 2013; Council of Chief State School Officers, 2010; Osborne & Patterson, 2011). These include being able to learn by integrating information from multiple documents, and from a variety of representation formats, text types, and sources. Students, however, encounter difficulties as they attempt to learn about scientific phenomena in this way (Cerdán & Vidal-Abarca, 2008; Griffin, Wiley, Britt, & Salas, 2012; Mason, Boldrin, & Ariasi, 2010; Strømsø, Bråten, & Britt, 2010; Wiley, Ash, Sanchez, & Jaeger, 2011).

When engaging in a multiple-document learning activity, students must construct a representation of each of the individual documents (via abstracting macro-propositions, making connections with prior text and prior knowledge; Kintsch, 1998; van Dijk & Kintsch 1983) as well as constructing an overall representation of the meaning of the documents as a set (via making connections to create an *Integrated Model* across documents; Rouet & Britt, 2011). According to the MD-TRACE model (Rouet & Britt, 2011), students must furthermore represent their task goals and methods for achieving those goals (i.e., their *Task Model*) based in part on their interpretation of the reading prompt and from cues in the documents themselves (Britt & Rouet, 2012). These task-related goals guide the coordination of reading (e.g., scanning, comparing, evaluating) and writing (e.g. summarizing, sourcing, integrating) behaviors.

Several studies have improved students' learning from multiple documents by altering their task models. Some studies have encouraged macro-structure processing (i.e. processing texts for their global meaning) for the individual texts through macro-level questions and

summary writing (Britt & Sommer, 2004), or completing digital note cards (Britt & Aglinskis, 2002). Other studies have attempted to encourage integration with specific questions (Cerdán & Vidal-Abarca, 2008), or inquiry prompts that require connections across texts using different presentation formats (Le Bigot & Rouet, 2007; Naumann, Wechsung, & Krems, 2009; Wiley & Voss, 1996; 1999). These studies show the importance of the task model when learning from multiple documents, and how it can be altered by instructions. A task model, however, is dynamic and other aspects of the context may lead the student to further modify their task goals. For example, an editorial document arguing for or against a policy related to a phenomenon might change how a student interprets the instruction to write an argument or explanation from a document set. If the presence of policy documents affects students' task models and processing goals, then they may engage in less integrative processing while reading from multiple sources. In this study, we tested whether the presence of policy-related information within a set of documents would help students develop a causal understanding of how and why global temperature change is occurring, or if instead it would divert students from their learning goals.

Document Set Effects

As policy-related arguments are often charged with political statements and calls for change, these types of sources may seem more interesting to students than documents that offer only descriptive or analytic information about the causes of the phenomenon. Indeed, educators have called for including texts that argue for policies or discuss values as part of science instruction partially because they are assumed to increase enjoyment (Shoenbach & Greenleaf, 2009). On the other hand, including policy-related information may also cause problems to the extent that it alters the task model. For example, if a document about climate change suggests that we should drive hybrid cars, a student may focus on the idea that driving hybrid cars will

help stop climate change. However, such an essay would not be directly responsive to an inquiry prompt that asked for an explanation of the causes of climate change. If the main goal is to develop a causal understanding of a phenomena, then students who are asked to focus on policy-related solutions, or who are exposed to policy-related arguments like those found in editorials, should ideally evaluate the quality of the proposed solutions in light of their understanding of the causes of the problem (i.e., how and why the basic phenomenon is occurring), and not focus on policy at the expense of developing that understanding.

Policy, however, is inherently about value-based prescriptions for what *ought* to be done given subjective goals and may go beyond scientific issues of how various mechanisms (including human actions) causally impact outcomes. Policy positions are evaluative attitudes whose inherent basis in affect-laden preferences makes them qualitatively distinct from either beliefs or knowledge representations about a factual issue open to scientific validation, such as cause-effect relationships (Griffin & Ohlsson, 2001). Students could focus on and be engaged with those aspects of policy that are outside the scope of scientific understanding. Indeed, in one prior study, adding policy-related-editorial documents (including an excerpt of an article by Al Gore) to a multiple document inquiry task led to essays mentioning fewer causes of climate change and containing fewer connections between concepts as part of explanations for how and why recent changes in global temperatures are occurring (Wiley, Britt, Griffin, Steffens, & Project READi, 2012). All students received a core document set about global temperature patterns (Griffin et al., 2012; Sanchez & Wiley, 2006), but the students who also received the policy-related editorials made more mentions of policy-related ideas in their essays at the expense of mentioning causal information, and they were especially likely to cite the document authored by Al Gore.

Policy-related documents could alter students' attention in two different ways. One possibility is that the documents could change the task model from explaining the causes to stating their personal opinion about a controversy, or offering a suggestion for what should be done in the future, based on their own values and the goals they feel are important. Although students may be more interested in writing these types of opinion-based essays (Hidi, Ainley, Berndorff & del Favero, 2007; Mason & Boscolo, 2004), prompting students to write position or opinion essays can lead to poorer learning outcomes than when students are given explanation-based writing prompts (Kobayashi, 2009; Wiley, Steffens, Britt, & Griffin, 2014). A second possibility is that the policy-related information in these documents may include interesting and even emotionally charged language or details that could compete for students' limited resources (Garner, Gillingham & White, 1989; Harp & Mayer, 1998; Sanchez & Wiley, 2006).

Prompt Effects

Another method that could increase focus on policy-related information is attaching a solution-related addendum to the inquiry prompt ("write an essay explaining how and why recent patterns in global temperature are different from what has been observed in the past *and what we can do about it*"). Ideally, adding this solution-related addendum would encourage students to engage deeply in integrating across documents and relating their causal model of the phenomena to proposed solution. To the extent that the documents do not already provide solutions, a task that focuses on finding solutions may lead students to attend to causal information as a means of identifying potential sources for addressing the problem. It may also be a more authentic task (Sandoval, Sodian, Koerber, & Wong, 2014) and students may find it more interesting and engaging which could lead to better learning (Guthrie et al. 2006; Hidi & Renninger, 2006; Renninger & Hidi, 2011; Shoenbach & Greenleaf, 2009). Additionally, such activities closely

align with how students will need to engage with science once they leave school. Thus, for several reasons, a solution-related addendum could improve understanding.

However, the presence of a solution-related addendum may also affect the task model of the student. For example, a student may decide to focus on finding and processing solution-relevant rather than causal information in the documents because they think it may be an easier task. This shift in goals could come at the expense of understanding the causal relationships presented in the documents. Additionally, the solution-related addendum may cause competition for attention as adding a policy task creates two potentially competing goals to be satisfied. This may result in the student producing an underdeveloped integrated mental model after they have finished reading compared to students who focused on processing causal information.

Overview of the Study

In this study, the main goal of the inquiry task for all students was to provide an explanation for how and why global temperatures are changing from a document set that contained several documents, each of which described different aspects of the phenomenon (e.g., Griffin, et al., 2012; Wiley, et al., 2009). While all students were given the same core document set, some students also received an additional document relating to policy changes that could be made to combat climate change. If the additional policy document is distracting to students or if the presence of this document changes their task model to that of writing an opinion essay, then they should focus on this policy information at the expense of causal information. Therefore students with this document should include less causal information in their essays and perform worse on the inference verification task than those with only the core document set.

In addition to manipulating the document set, the inquiry prompt was also manipulated. All students received the same basic inquiry instruction prompting them to focus on explaining

how and why recent patterns of global temperatures are different than in the past (causal prompt condition). In addition to receiving this causal prompt, students in the causal-plus-solution condition were also asked to address what can be done about this. If introducing the addendum about solutions alters the task model and students focus on solutions or policy at the expense of explanation, or if it introduces competition for attention, then students who receive the additional prompt should include less causal information in their essays and perform less well on the inference verification task. However, if the solution-related addendum increases motivation or the perceived utility of constructing an explanation for climate change in order to use that information to generate policy/solution suggestions, then students should include more causal information in their essays and perform better in inference verification.

Given the call for students to read more authentic science material and the belief that considering solutions or involving students in policy-related discussions can better engage students' interest, it is important to demonstrate whether these activities lead to benefits in understanding. It is also important to probe whether students actually enjoy a policy-related task so we included a self-report item to assessment task enjoyment.

Methods

Participants. Forty-six 7th grade students from a Midwestern middle school participated in the experiment (31 female). The students participated as part of their normal science class activity. The average age was 13.2 years ($SD = .36$) and the classes were ethnically mixed (36% White, 30% Asian, 17% Multiethnic, 6% American Indian, 6% Other, 4% Hispanic). Students were randomly assigned to conditions within classrooms.

Design and Materials.

Design. The experiment used a 2 Document set (core vs. policy-plus-core) x 2 Prompt (causal vs. causal-plus-solution) between-participants design.

Document set. All students read a document set about changes in the global climate (see Table 1 for descriptive information). All informational documents were adapted versions of, or created with information from, reliable scientific sources such as usgs.gov. However, the information in the documents was attributed to fictional sources in order to create a multiple source, multiple document scenario. Students received either the core document set (n = 22) or the policy-plus-core document set (n = 24). Both conditions were given the same core document set. This document set was intentionally designed to provide students with the information necessary to respond to the inquiry prompt and construct a basic causal model about the factors responsible for global climate change (Griffin, et al., 2012). The documents each presented different parts of the causal model (e.g., the carbon cycle, the greenhouse effect, energy sources) and several graphs (e.g., CO₂ and temperature patterns). Information was connected locally within the documents, but no distal connections between documents were made. In order to generate a complete causal model of how and why global climate change is occurring, students would need to make these distal connections on their own.

The policy-plus-core document set contained the same core documents; however, it also included one extra document (“The Climate for Change”) arguing for personal and public policy changes related to climate change (234 words) (See the Appendix for this document). The policy document was similar in causal connective incidence to the other texts (as shown in Table 1). The information was mostly limited to content focusing on specific solutions, but did imply a causal connection between human activities like energy use and deforestation and carbon levels. This causal information was redundant with content in the core documents. In the policy-plus-

core document condition the policy document was the second document in the set, behind the document that provided background information about climate change. The core-document set was 2,357 words, while the core-plus-policy set was 2,591 words.

While the order of documents in the folder was the same for all students within each condition, the documents were not stapled together. Students could rearrange and read the documents in any order and as often as they felt necessary.

Inquiry Prompt. The inquiry prompt was also manipulated. All students were given the same general instructions:

“The primary purpose of reading in science is to understand the causes of scientific phenomena. This means your goal for reading is to understand how and why things happen. To reach an understanding of a new topic in everyday life, we often need to gather information from multiple sources. In today’s task your goal is to learn about the causes of global temperature changes from several documents. You will have to piece together important information across the documents to construct a good understanding. No one text will provide the answer. This task is interesting because you are one making the connections across documents and coming up with an explanation. No author has already done the work for you. It is also important that you use information from the documents to support your explanation of the causes.”

The specific instructions varied between the causal prompt condition and the causal-plus-solution prompt condition. The instructions specific to the students given the causal prompt (N=20) were:

“Your task is to use this set of documents to write an essay explaining how and why recent patterns in global temperature are different from what has been observed in

the past. Be sure to use specific information from the documents to support your conclusions and ideas.”

The instructions specific to the students (N=26) given the causal-plus-solution prompt were:

“Your task is to use this set of documents to write an essay explaining how and why recent patterns in global temperature are different from what has been observed in the past and what we can do about it. Be sure to use specific information from the documents to support your conclusions and ideas.”

The only difference was that the causal-plus-solution prompt added the instruction “and what we can do about it” to the end of the standard causal prompt “write an essay explaining how and why recent patterns in global temperature are different from what has been observed in the past.”

Verification task. To provide converging evidence for comprehension, we included the inference verification task used in Griffin et al. (2012). In this test, students rated, from memory, the extent to which 18 statements were potential connections that could be made based on the texts. The scale ranged from inconsistent (1) to consistent (6) with the ideas in the texts. Half of the items were true and half were false. Student responses were reverse coded so that items which had correct responses on the lower half of the scale (1, 2, or 3) now were on the upper half of the scale (6, 5, or 4 respectively). Scores were then calculated as a proportion out of the total possible points, 108 (18 items x 6, the highest score per item).

Procedure. Students completed the experiment over the course of two class periods spanning two days. During the first day students were given the document set and inquiry prompt. Students had all information available during the essay task and were allowed to

organize their reading and writing time as they wished. This meant that students were able to refer to the documents while they wrote their essays. With ten minutes remaining in the second period the essays were collected and students completed both the verification task and the demographic survey which included a 6 point Likert item to measure their enjoyment of the task. The enjoyment question asked, “How much did you enjoy this type of task compared to your normal science assignments?” While there was slightly more information for students to read in the policy-plus-core document condition (2,591 versus 2,357 words), none of the students were pressed for time while completing the task.

Coding. Essays were scored for five main features: coverage of the seven important concepts for explaining global warming, the underlying causal structure of the essays, the use of policy information, whether the essay provided an explanation for global climate change, and the presence of references to the source they read.

Coverage scores. Coverage scores were derived by coding students’ essays for the correct usage of seven critical causal concepts relating to climate change based on an *a priori* causal model. These concepts included:

1. Heat coming from the Sun varies.
2. Temperatures change in cycles, and we are in an unusually long warming period.
3. CO² is stored in, and cycles through, various “sinks”.
4. CO² levels in the atmosphere are at a historical high.
5. Fossil fuel use releases CO².
6. CO² is a greenhouse gas.
7. Greenhouse gasses in the atmosphere trap heat and cause warming.

Two raters independently coded the coverage scores of 20% of the essays and achieved an inter-rater reliability of Cohen's $k = .74$. Any discrepancies were resolved through discussion.

Causal structure. The causal structure underlying each of the essays was assessed by scoring how many explicit causal connections were made between concepts that ultimately connected to the final outcome, global climate change (Hastings, Hughes, Britt, Blaum, & Wallace, 2014). While scoring essays, coders identified key idea units that were part of the causal model present across the documents, as well as connectives that linked them. Using this method, a final causal chain, or set of chains, was created for each participant. Essentially, the causal structure score represents the total number of the causal connections to climate change that students made in their essays. For example, a student who writes, "burning fossil fuels causes an increase in global temperatures" would be making one connection. However, if a student were to say that, "burning fossil fuels leads to more CO₂ in the air which causes higher global temperatures", they would be making two connections. Other methods have been used to measure causality in essays before by simply counting the number of causal phrases used in essays (Britt & Aglinskis, 2002; Wiley & Voss, 1999). However, that method of scoring doesn't take into account concepts in the essay that are causally connected to the final outcome. Given the complexity of the document set, there were twenty-two possible connections. Two raters independently coded the causal structure of 20% of the essays and achieved an inter-rater reliability of Cohen's $k = .85$. Any discrepancies were resolved through discussion.

Policy-related information. To determine how much of the information that students included in their essays was about the possible policies that might be adopted to address global climate change, each sentence in the essays was coded for whether or not it contained policy-relevant information (e.g., "We should also be less dependent on fossil fuels, non-renewable

resources, which adds to the pollution [*sic*] problem.”, “We could do more things such as driving plug in hybrids that run on renewable electricity.”). While students in the core-documents condition did not have policy documents to directly obtain policy or solution-based sentences, they did spontaneously generate such statements (e.g. “We can carpool or walk to lower the amount [of CO₂] when we travel individually by cars.”). The policy sentences were divided by the total number of sentences in each essay to create a proportion score. Two raters independently coded the policy-related information in 20% of the essays and achieved an inter-rater reliability of Cohen’s $k = .90$. Any discrepancies were resolved through discussion.

Essay Type. Students were asked to write an essay “explaining” changes in “global temperatures”, but some students did not follow this instruction. Even students in the causal-plus-solution prompt condition, who were asked to address what could be done about climate change, were first asked to explain how and why changes in global temperature were occurring. Despite their instructions, not all students attempted to write an explanatory essay. Other essay types commonly used were opinion-based or position-based essays arguing whether or not global climate change is occurring (rather than explaining *why* it is occurring), or essays that discussed the consequences of global warming or called for political or personal action against climate change. Each essay was coded categorically for whether or not it attempted to provide an explanation for global climate change. An essay could be marked as attempting to provide an explanation for global climate change even if the explanation was incorrect. As long as a student was attempting to explain causal mechanisms that led to global climate change, their essay would be marked as an explanation, even if they also suggested solutions or policy changes that could help reduce climate change. Two raters independently coded the essay type of 20% of the essays with an inter-rater reliability of Cohen’s kappa of $k = 1.0$.

References. Each essay was coded categorically for whether or not the student explicitly mentioned a source or made a general citation connected to identifiable information in either the core documents or the policy document. We used a categorical coding system for this measure, instead of analysing average numbers of references, because the overall number of references made by students was low and the distribution of references was not normal. Two raters independently coded the essay type of 20% of the essays and achieved an inter-rater reliability of Cohen's $k = .84$.

Results

Being dichotomous measures, References and Essay Type were analysed with Chi-Square. All other variables were analysed using Analysis of Covariance (ANCOVA), where essay length (number of sentences) was entered as covariate, although observed means rather than estimated means are reported. For all ANCOVA analyses the interaction of the main effects were not significant ($p > .05$), showing that the slopes were not significantly different and the assumption of homogeneity of slopes was met. Effect sizes are reported using Cohen's d due to uneven sample sizes in our analyses (Cohen, 1988).

Coverage. Essays were an average of 19.60 ($SD = 6.56$) sentences long, with no differences between condition, all F s (1, 41) < 1 . Essays in the core-documents condition provided more coverage of the important concepts ($M = 4.59$, $SD = 1.30$) than did essays in the policy-plus-core document condition ($M = 3.79$, $SD = .88$), $F(1, 41) = 4.80$, $p = .034$, $d = .79$. No other effects were significant. Essays in the policy-plus-core document condition were even less likely (46% versus 64%) to include the concept of human energy sources releasing CO₂, which is the same connection that is used to support fuel-use changes in the policy document.

Causal structure. Students in the core-documents condition produced more causal connections ($M = 3.09$, $SD = 1.90$) than students in the policy-plus-core document condition ($M = 1.88$, $SD = 1.54$), $F(1, 41) = 6.46$, $p = .015$, $d = .70$. No other effects were significant.

Use of policy information. Students in the policy-plus-core document condition included a higher proportion of policy sentences ($M = 12\%$, $SD = .10$) than those in the core-documents condition ($M = 7\%$, $SD = .07$), $F(1, 41) = 4.41$, $p = .04$, $d = .58$. Students in the causal-plus-solution prompt condition also included a marginally higher proportion of policy sentences ($M = 11\%$, $SD = .09$) than those in the standard causal prompt condition ($M = 7\%$, $SD = .08$), $F(1, 41) = 3.87$, $p = .056$, $d = .47$. The interaction was not significant.

Essay type. Since essay type was scored categorically, differences in essay types were examined with Chi square. Students in the core-documents condition were more likely to write essays that contained causal explanations of global warming (96%) than those in the policy-plus-core document condition (71%), $X^2 = 4.84$, $p = .028$. No differences were seen due to writing prompt.

References to sources. Overall, 41% of students referenced at least one document in their essays, but there were no differences due to either prompt or document set. Only three students exposed to the policy document cited it.

Verification task. Four students were missing scores on 1 of the 18 verification items, so the missing value was replaced with the sample mean for that item. A 2x2 ANOVA on verification task performance showed no effect for document set, but students in the causal-plus-solution prompt condition performed better on the verification task ($M = .70$, $SD = .09$) than those in the standard prompt condition ($M = .64$, $SD = .08$), $F(1, 42) = 4.75$, $p = .04$, $d = .68$. The interaction was not significant. Follow-up analyses revealed that this effect was driven

by only 3 of the 18 IVT items which dealt with human activities of the sort targeted by policy recommendations (i.e., fossil fuel use and agriculture). When inference verification scores were computed without these three items, the prompts did not differ, $F(1, 42) = 1.81, p = .19$.

Policy versus causes trade-off. There were 3 conditions in which a combination of documents or prompt encouraged including policy ideas. The correlations between use of policy and use of causal information were tested by first partialing out any variance due to either the prompt or document manipulation. Independent of overall effects of the manipulations, those who included more policy sentences included fewer causal concepts ($r = -.50, p = .009$), but the negative coefficient for causal structure was not significant ($r = -.10, p > .05$). It is possible that explicitly prompting students to consider problem solutions in relation to considering the causes of the phenomenon somewhat altered the way they thought about policy compared to spontaneous inclusion of policy ideas when only prompted to explain causes. To examine this we computed the above correlations separately for the causal and causal-plus-solution prompt groups, partialing out the effects of document set. For the causal prompt group we found negative correlations between policy mentions and both coverage ($r = -.53, p = .011$) and causal structure ($r = -.48, p = .022$). However, for the causal-plus-solution prompt group, there was only a negative correlation with coverage ($r = -.55, p = .003$), but a slight positive non-significant coefficient for causal structure ($r = .14, p = .25$).

Task enjoyment. Self-reported task enjoyment had a mean of 2.91, but varied considerably across the full range of the 1-6 scale, with a 1.6 standard deviation. An ANCOVA showed no significant effects of either manipulation on task enjoyment, all F s less than 1. However, enjoyment was positively correlated with concept coverage in the essays ($r = .26, p = .04$), yet negatively correlated with inclusion of policy information ($r = -.28, p = .03$).

Discussion

The results of this experiment suggest that the inclusion of a single brief policy document can impact performance on a multiple-document inquiry task: altering the type of information students include in their essays, reducing inclusion of key concepts and causal links needed to provide the requested causal explanation, and increasing inclusion of policy-related information. While the results generally suggest that including a policy-related document in a document set can be disruptive, the results for the solution-related prompt were more positive. The experiment showed a possible benefit from the solution prompt in performance on the verification test suggesting that adding the solution prompt to the causal prompt can help student comprehension of causes specifically relevant for a particular policy or solution.

Overall these results indicate that being exposed to a policy document while attempting to understand the causes of a scientific phenomenon can be harmful for learning. This finding is important because it suggests that these types of documents may pose special challenges to students. We found that including a policy-related document in a document set tended to derail students from the task of constructing a causal explanation. It is critical to emphasize that these effects were not contrasting policy documents versus scientific documents, but rather the effect of merely adding a single 234 word policy document to a larger set of 7 scientific documents totaling 2,357 words plus graphical information. This minor addition negatively impacted the way students understood and utilized the relevant information in the other documents. This effect is consistent with the notion that adding policy documents to a scientific inquiry task may be altering students' task models away from the explicitly stated task of building a causal explanation for a phenomenon.

The investigation of only a single topic in this study necessarily limits generalization of the results. It is worth noting that the particular phenomenon used in this study is one that students may have had prior knowledge, beliefs, and attitudes about. Prior policy attitudes could have an effect on the students' propensity to switch their task goals when they encounter a policy text. If the students agree with the policies they may focus on them while reading because they are familiar and easier to read than causal information (Nussbaum & Kardash, 2005; Wiley, 2005; Wolfe & Britt, 2008). On the other hand, if they disagree, students may focus more on them as a way to counter to the policy claims made in the text (Eagly, Kulesa, Chen & Chaiken, 2001; Maier & Richter, 2013). In either case, students' focus is drawn away from important causal information. Would multiple policy documents arguing conflicting sides prompt students to attend to all relevant information? A prior study that added two conflicting policy documents to a core causal document set found results that were highly similar to the present study in that policy mentions and side-taking came at the expense of including causal information (Wiley et al., 2012).

Of course, students could also have prior knowledge or beliefs about the factual issue of the causes of climate change and thus agree or disagree with the core documents. However, prior beliefs on factual issues do not appear to trigger the same type of biased processing as prior attitudes related to matters of policy or moral questions (for a review, see Griffin & Wolfe, in preparation). For example, the classic attitude-polarization effect (also known as the backfire-effect; Lord, Ross & Lepper, 1979), shows that people become more extreme in their attitudes when reading counter-attitudinal texts (e.g., texts that present arguments that are incongruent with the reader's own position). However, this does not appear to hold for when reading texts that disagree with the readers' prior beliefs on factual questions. In the latter case, readers do

actually change their beliefs in the direction argued by the texts, regardless of their prior belief. To disentangle the effect of prior beliefs, attitudes, and knowledge on text processing, additional research which examines the effects of policy texts within document sets on topics that are less familiar or unfamiliar to students is needed.

There may be multiple potential reasons for the negative effect of a policy document on learning observed in this study. First, the inherent focus of policy documents on highlighting a problem and advocating policy change could alter students' task model away from the required task of forming a causal explanation for a phenomena. Policies or solutions *can be* tied to scientific understanding but do not need to be (and often are not). Even if a policy document mentions causal factors, students can ignore these when writing their essay (as students in this study did) or selectively ignore causes mentioned by policy stances they do not agree with. Another possible reason is that students may view policy arguments as a form of personal opinion essay that is easier to write; thus they take advantage of the perceived license to write an opinion piece rather than a scientific explanation. This latter possibility seems supported by the policy-causality trade-off analyses in which, independent of document condition and when not explicitly prompted to consider solutions, students who chose to focus more on policy included fewer causal concepts and connections. Also, even though policy documents did not impact enjoyment, those with less enjoyment of the task chose to include more policy information and less causal concepts. This fits with an account that policy arguments can provide unmotivated or struggling students with an easier approach to completing the unenjoyable assignment.

Yet, students still have to sort through these types of policy documents in and outside of school, and an important milestone of science learning in school is to be able to evaluate the potential solutions based on a deep understanding of science phenomena (Sandoval et al., 2014).

In addition to reading expository texts describing causal model elements, students also need to develop skills in understanding editorial documents. This is recognized by the US Common Core and Next Generation Science Standards which call for students to recognize the utility of science that is taught in classrooms, not just how to conduct scientific experiments (Achieve, 2013; Council of Chief State School Officers, 2010). Thus, the results of the present study suggest that more attention is needed in instruction to help students to be able to read and evaluate opinion-based texts like political editorials, and to distinguish between scientific information about causes and policy stances that might make use of that information. We cannot expect students to have the skills they need to process specialized texts like editorials (Schooler, Kennet, Wiley, & Voss, 1996). Students will likely need specific training in how to identify and evaluate these documents, and how to use information from them when completing an inquiry activity.

Importantly, asking students to use information to solve a problem by giving them a solution prompt in addition to the causal prompt led to more consideration of policy issues without having the same negative effects on essays as including a policy-related editorial. At least in terms of the verification task results, the addition to the writing prompt seems to have helped them learn about some specific solution or policy-relevant causes, even if this did not improve the overall explanatory quality of their essays. When writing in a scientific domain it is important to be able to construct explanations of scientific phenomena and support them with evidence rather than simply take a stance and find evidence to support that opinion. Although having students write an essay only about their position on a policy might have negative consequences on learning about the causes of scientific phenomena (Wiley et al., 2014), in this experiment combining the causal prompt with the solution prompt was able to prevent students from thinking the writing task was only about solutions or policy. It is important to note the

solution portion of the prompt entailed only 7 words of the 190 word instruction that otherwise emphasized causal understanding. Given the negative impact of the policy-oriented document, solution-focused inquiry prompts that do not primarily stress the importance of identifying causes may also be disruptive to learning. By combining prompts, students may be able to experience a benefit from the solution aspect of the prompt. It is important to note that we did not have a prompt that focused only on thinking about policy-related solutions while reading. Investigating the effect that different prompts have on learning may be a beneficial future direction for this type of research. The trade-off analyses suggest that although the added solution prompt reduced the trade-off between policy ideas and causal structure, there was still a trade-off with key causal concepts. Thus, even with such a prompt, students who focus too much attention on policy ideas in their essays still do so at some expense to their causal explanation.

Efforts to increase student interest and engagement need to be cautious about introducing things that students may use to divert their focus away from their central task of learning about causes and processes. While we recognize that we did not have a direct measure of engagement, we used methods that others have suggested should increase engagement (Shoenbach & Greenleaf, 2009). Also, although our measure of task enjoyment was only a single item, it was not affected by the presence of policy documents or solution prompts, and was negatively related to individual differences in focusing on policy. Perhaps a more engaging solution-based activity would improve learning overall, but our results suggest it must engage students to more carefully consider causal explanations, and not just make them find the policy ideas themselves more engaging. Again, we did not directly measure engagement, but we believe that the effects that policy documents and solution prompts have on engagement are in need of further exploration.

One way of interpreting the results of the current experiment is that features of the policy document are acting as seductive details. Textbook authors and instructors use striking facts and interesting information to give import and relevance to what might otherwise be seen as dry scientific prose (Garner, Brown, Sanders, & Menke, 1992; Hidi & Anderson, 1992). However, research has shown that including such information can impede learning (Harp & Mayer, 1998; Sanchez & Wiley, 2006). These additions to the prose may increase interest, but not interest in learning the key target information (Kintsch, 1980). Policy editorials may highlight the importance of the issue, but ultimately all policy positions rest upon sets of subjective societal values and goals that go beyond the contents of any valid scientific argument. Unlike many seductive details, this policy document did contain some information relevant to the task of casual understanding, yet the focus on specific policies and societal goals seemed to undermine constructive use of this information. Thus, without instruction and maintenance of a proper task model, students may focus upon policy in ways that reduce attention to the underlying scientific issues. If policy questions are to be tethered to scientific questions, students will need to be taught how to recognize the critical difference between such questions and the different type of information that is relevant for addressing them.

These results also point to the importance of instilling appropriate goals for reading for understanding in science which can help students to have proper task models. When reading on the Web, students are going to encounter a wide variety of documents on scientific topics, including opinions and editorials (Phillips, & Norris, 1999; Zimmerman, Bisanz, Bisanz, Klein, & Klein, 2001). Prior work has shown that students' epistemic beliefs about the nature of knowledge and knowing in science can influence how they choose which information to attend to when trying to learn about scientific topics (Bråten, Britt, Strømsø, & Rouet, 2011; Bråten &

Strømsø, 2009; Britt, Richter, & Rouet, 2014; Gil et al., 2010; Griffin et al., 2012; Wiley et al., 2009). Teaching students about the difference between policy and explanation, and the importance of attending to causal information in order to understand how and why phenomena happen, should help them learn effectively in multiple document contexts, and use policy information appropriately to make informed decisions.

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Table 1.

Descriptive Information of Document Sets

Document Title	Type of Document	Number of Words	Causal Connective Incidence
Changes in Global temperatures	Informational/Background	272	22.388
Global Temperature Changes and Ice Ages	Informational	235	23.364
The Carbon Cycle	Informational	463	16.807
CO2 Concentrations over the Last 400,000 Years	Graph	15	NA
The Greenhouse Effect	Informational	271	21.978
Sunlight and the Earth	Informational	369	19.169
Energy Sources and Fossil Fuels	Informational	369	35.04
The Climate for Change	Policy Editorial	234	25.316

Note. Causal connective incidence was measured using Coh-Metrix 3.0, index 53 (Graesser, McNamara, Louwerse, & Cai, 2004).

Appendix

The Climate for Change

Global warming has become perhaps the most difficult issue facing world leaders. Warnings from scientists are becoming louder about the dangerous changes occurring to our climate system. Fortunately, there are many things we can do about this. We need to start by replacing 19th-century energy sources like coal and gas. We need to find new ways to power our cars, homes, and factories. We need to find ways to get our energy from the sun, the wind, and the natural heat of the earth.

It's not likely that Americans will make any major changes without some nudging. A good first step would be for the President and Congress to offer rewards for building new electric plants that get their energy from the sun and wind. Another smart move would be to help America's automobile industry to convert quickly to plug-in hybrids that can run on renewable electricity. But, changing the cars we drive is not enough. Over 40% of the energy we use comes just from heating our buildings. We should also better insulate our old buildings and install energy efficient windows. Choosing energy-efficient appliances and lighting will also help. Finally, we need to stop destroying our forests. Making these changes could reduce carbon levels to go back to what they were before the 1950s.

World leaders need to take action to make these changes. These changes are necessary to save our planet and ultimately ourselves.

Source: Jeffrey Kluger (2011). "What we should do to stop Global Warming?" Opinion-Editorial piece in the New York Times.