

Promoting attitude change and expressed willingness to take action toward climate change in college students

Gale M. Sinatra · CarolAnne M. Kardash · Gita Taasoobshirazi ·
Doug Lombardi

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Abstract This study examined the relationship among cognitive and motivational variables impacting college students' willingness to take mitigative action to reduce the impacts of human-induced climate change. One hundred and forty college students were asked to read a persuasive text about human-induced climate change and were pre and post tested on their attitudes about climate change and their willingness to take action to mitigate its effects. Students showed statistically significant changes in their attitudes about climate change and their willingness to commit to take action. A path model demonstrated that openness to change and a willingness to think deeply about issues predicted both change in attitudes and expressed willingness to take action. This research demonstrates that a persuasive text has the potential to promote change around complex socio-scientific issues.

Keywords Attitude change · Persuasion · Conceptual change · Need for cognition · Need for closure · Dispositions · Persuasive pedagogy · Socio-scientific issues

Introduction

Changing students' attitudes about socio-scientific issues, such as human-induced climate change, presents unique challenges (Lombardi and Sinatra 2010; Sinatra and Mason 2008). First, there are conceptual difficulties. With such topics, students often do not understand the true nature of the issue because they may have limited knowledge or misconceptions about the topic. For example, students may believe there is controversy around whether the planet is warming or not, when in actuality, the more debated issue is the degree to which human activity is exacerbating the warming trend (Intergovernmental Panel on Climate Change 2008). The challenges of understanding climate change stem in part from the nature of the issue itself: it is complex, multidimensional, and requires "systems thinking," that is, the ability to think and reason abstractly about systems to appreciate their

G. M. Sinatra (✉) · C. M. Kardash · G. Taasoobshirazi · D. Lombardi
University of Nevada, 4505 Maryland Parkway, Las Vegas, NV 89052, USA
e-mail: sinatra@unlv.nevada.edu

interactive nature (Goldstone and Sakamoto 2003). In addition, complex interactive systems self-organize in a manner that can result in emergent phenomena that cannot be understood by examining the actions of individual agents or components (Chi 2005). Appreciating the intricacies of complex systems and emergent processes has proven challenging for students (Chi 2005).

In addition to conceptual challenges, there are specific misconceptions that may lead thinking astray on the issue of global climate change, such as the distinction between weather and climate (Lombardi and Sinatra 2010). As an example, when students are asked about their views on climate change, they often recall from their personal experience very cold periods and use their recollection of temperature fluctuations in their own lifetime to assess whether the planet is warming. Misattributing short-term weather fluctuations to long-term climate factors may result in part from the conceptual challenges of understanding deep time or the timing and relationship between geophysical events that have occurred during the Earth's history (Dodick and Orion 2003).

Another problem, one presented by socio-scientific topics, is that learners are often committed to their own views on the issue and this commitment may serve as a motivation to actively resist change (Dole and Sinatra 1998). Commitment to a particular point of view may arise from personal experiences (such as recalling a few recent cold winters) but may also arise from one's epistemic beliefs (Kardash and Scholes 1996; Mason and Scirica 2006), or dispositions toward knowledge (DeBacker and Crowson 2008). Strongly committed ideas are highly resistant to change in part due to their rich interconnections with other ideas. Resistance creates various barriers to learning that range from outright rejection of the new idea to deliberate revision of the conception to fit with preexisting notions (Chinn and Brewer 1993). The degree of commitment to one's point of view stems in part from the socio-cultural context in which knowledge is embedded. Jovchelovitch (2006) describes how knowledge representations are "... at once epistemic, social and personal" (p. 26). This suggests that the deep commitment individuals hold for their point of view may in part be due to the interconnectedness of the conception with other ideas.

Attitude change and persuasion

The degree to which students are willing to engage with a socio-scientific topic despite these challenges may depend on the use of a pedagogical approach deliberately designed to promote high engagement. It has been argued that persuasive pedagogy (Alexander et al. 2002; Murphy 2001; Sinatra and Kardash 2004) has the potential to change students' attitudes. As such, research on persuasion in educational contexts, such as the use of persuasive discourse in classroom discussion and the design of persuasive textbook content, has a long history in educational research (see for example, Chambliss 2001; Murphy 2001). Attitudes are described by social psychologists as evaluative judgments about an object or event (Crano and Prislin 2006). Persuasion is the process of promoting a shift in that judgment in a particular direction and is more likely to occur when the individual is provided opportunities to engage with reasoned discourse or argument, much as in typical scientific discourse (Alexander et al. 1997; Dole and Sinatra 1998; Hynd 2003).

In our research, we have explored whether students can adopt a more positive (and conversely less negative) attitude towards scientific phenomena through persuasive instruction (Broughton et al. 2011). As an example, in a recent study, 5th and 6th grade students read a persuasive text and engaged in classroom discussion that explained the International Astronomical Union's decision (IAU) demoting Pluto to dwarf status. As a result, students were persuaded to have a less negative attitude towards the scientists'

decision. They also demonstrated less negative emotions and greater acceptance of Pluto's new status (Broughton et al. 2011). This instruction was coupled with instruction in the nature of science (Lederman 1992) so that students better appreciated that the change in Pluto's planetary status had a specific scientific rationale and that changes such as re-classifications based on new data and evidence are part of "normal science" (Kuhn 1970).

Of course not all persuasive messages, including those conveyed through text, will result in attitude change. However, research has demonstrated that carefully crafted persuasive text can promote both conceptual change and attitude change (Alexander et al. 1997; Chambliss 1995; Hynd 2003; Kardash and Scholes 1995). According to Murphy (2001) a persuasive text should be structured to promote understanding and the view that the alternative perspective is worth considering.

This suggests that reading a persuasive text about human-induced climate change could be effective in promoting attitude change. However, in the case of climate change, attitude change about human's role in global warming is not sufficient. That is, if everyone believes that the planet is warming, but individuals do not take actions to reduce their "carbon footprint," then persuasive pedagogy would fail to make a significant impact in promoting sustainability. In this and other socio-scientific issues of import, we must change our actions as well as our attitudes.

Our goal was to examine whether a persuasive text could promote both attitude change and an expressed willingness to change one's behavior. There has been much research on creating effective persuasive text (Chambliss 2001). However, in our web-based information society, on-line news stories are often coupled with an image or photograph. Clearly, news editors believe that a picture will attract readers' attention to the story. In addition, extensive research in social psychology on advertising suggests that images are indeed persuasive (Messaris 1997). To our knowledge, previous studies examining persuasive text have not included images. We included the image that originally appeared with the text to enhance the ecological validity of the text (Brewer 2000).

Epistemic motivation and dispositions toward knowledge

Even with effectively designed persuasive materials, attitude and behavior change are difficult to achieve due to individual differences in willingness to engage with challenging or controversial tasks (DeBacker and Crowson 2006). Specifically, the likelihood of change is affected by one's stance toward knowledge, or what Kruglanski has called "epistemic motives" (1989). Epistemic motives focus on knowledge as an object (Kruglanski 1989). Kruglanski and his colleagues have described two specific epistemic motives, seeking and avoiding closure, that are particularly relevant to the present study. Individuals who are motivated to seek closure have a desire for definitive answers and tend to avoid ambiguity and uncertainty whenever possible (Kruglanski 1989, 1990). The uncertainties surrounding scientific as well as political debate on human-induced climate change could cause what Kruglanski calls "freezing," or coming to a decision too quickly, which can result in close-mindedness toward an issue (Kruglanski and Webster 1996). Conversely, avoiding closure can promote a desire to seek out new information and additional answers to questions in the hopes of resolving discrepancies. This motive could also present a problem for students studying climate change as many argue that action must be taken quickly before all the issues are definitively resolved (see for example, Intergovernmental Panel on Climate Change 2008).

Epistemic motives are closely related to dispositions such as need for cognition (Cacioppo et al. 1996). Dispositions are "relatively stable psychological mechanisms and

strategies that tend to generate characteristic behavioral tendencies and tactics” (Stanovich 1999, p. 157). Individuals with high degrees of need for cognition tend to approach ideas in an open-minded fashion, enjoy effortful thinking, and tend to engage in critical thinking. Those with the opposite tendencies toward knowledge are more close-minded, avoid the effort necessary to consider complex issues, and are less willing to engage in critical thought or discourse. These dispositions have been shown to relate to acceptance of socio-scientific issues in previous research, with results showing that students with a high need for cognition are more accepting of scientific perspectives (Sinatra and Southerland 2010; Sinatra et al. 2003).

Willingness to act

Willingness to act to reduce climate change has been examined in previous research (Fortner et al. 2000). In a study geared toward understanding the media’s role in the public’s understanding of climate change, Fortner and his colleagues also assessed individuals’ willingness to take action to reduce global warming. Their results showed a fair degree of willingness to take actions such as supporting environmental education programs and installing energy efficient light bulbs, but low levels of willingness to take action to support increases in gasoline prices or use of public transportation (Fortner et al. 2000). It is important to note that the Fortner study was conducted immediately following the 1997 Kyoto conference. Our study was conducted in 2008, just after the release of the second Intergovernmental Panel report which contained much stronger conclusions about the role of humans in global warming, suggesting a need to re-evaluate whether individuals may currently report greater willingness to take mitigative action.

Misconceptions, deep commitments, epistemic motives, and dispositions toward knowledge can present challenges when learning about non-controversial topics. However, with socio-scientific topics, these issues may co-occur and may be heightened in their valence due to the issues’ complexity or even their controversial nature. For example, in a recent study, Mason and Scirica (2006) showed that epistemic dispositions relate to the quality of students’ arguments about human-induced climate change, suggesting that dispositions influence the quality of students’ engagement in critical thinking about socio-scientific issues. The co-occurrence of these factors and their potential for interaction with the likelihood of change led us to examine the interaction of these factors when faced with a persuasive text.

Purpose of the present study

The purpose of the present study was to extend the previous research on the effectiveness of persuasive text by examining whether a persuasive text could promote a more accepting attitude toward human-induced climate change, as well as a willingness to take mitigative action to reduce these effects in college students. A second goal was to examine the degree to which change in attitudes and expressed willingness to take action are predicted by students’ dispositions toward knowledge.

Two research questions guided this investigation: (1) could a persuasive text promote a change in attitude as well as expressed willingness to take action on climate change? (2) what is the relationship among epistemic motives, dispositions toward knowledge, and change in attitude and expressed willingness to take action? Based on previous research, we expected the persuasive text to promote both a change in attitude and a change in expressed willingness to act. We also expected that epistemic motives and dispositions would relate to attitudes and willingness to act.

Method

Participants

Study participants were from a pool of students enrolled in required educational psychology courses at an urban university in the southwestern United States. One hundred forty students participated in the study, most of whom were female (85%) and White (60%). Three students were removed from the data analysis due to missing data on one or more of the measures. The ethnicities for the rest of the participants were Hispanic or Latino (27%), Black or African American (7%), Asian (4%) and Native Hawaiian or other Pacific Islander (2%). Participants ranged in age from 18 to 57, ($M = 24.8$, $SD = 7.9$) and represented all undergraduate levels, with 3% Freshmen, 17% Sophomores, 59% Juniors, and 21% Seniors.

Procedures and materials

Students participated in the study through the university's online course management system and were first asked to complete a demographics survey, and then, four questionnaires examining their (a) attitudes about global warming, (b) willingness to take action, (c) need for cognition, and (d) need for closure. Cronbach α tests of reliability for all measures can be seen in Table 1.

The first questionnaire measuring attitudes about global warming was created by the researchers. The 13 items in the questionnaire were based directly on recent conclusions made by the United Nations' expert panel on global climate change (Intergovernmental Panel on Climate Change 2008) as reported in a February 3, 2007 *New York Times* article on global warming which served as the text for this study. For example, one item read, *Human activity has been the driving force behind the warming trend over the last 50 years*, and another read, *The Greenland ice cap is melting faster than had previously been thought*. The *New York Times* article strongly supported these conclusions. Thus, the items as constituted are a measure of participants' attitudes towards specific text content

Table 1 Correlation matrix, means, standard deviations, skewness, kurtosis and reliability for the model variables

Variable	1	2	3	4	5	6
1. Closed-mindedness						
2. Need for cognition	-.37**	–				
3. Pre-attitude	-.01	.09	–			
4. Post-attitude	.04	.09	.74**	–		
5. Expressed willingness (pre)	-.23**	.35**	.37**	.23**	–	
6. Expressed willingness (post)	-.16	.22*	.32**	.26**	.86**	–
<i>M</i>	2.84	3.57	3.67	4.17	2.51	2.77
<i>SD</i>	.68	.53	.55	.58	.55	.61
Skewness	.31	-.07	-.60	-.81	.57	.18
Kurtosis	.10	-.06	.91	.15	.02	-.30
Cronbach's α	.69	.86	.85	.85	.87	.89

* $p < .05$; ** $p < .01$

(See Appendix A for the complete scale.) The participants rated each item on a 5-point Likert scale gauging their agreement with the expert panel's conclusions, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). As DeVellis (2003) recommends, we attempted to create attitude questionnaire items that were strongly worded, unambiguous declarative statements without jargon.

Also created by the researchers, the willingness to take action questionnaire described 12 personal actions that could help reduce global warming. The students indicated how willing they would be to take these actions using a 4-point Likert-type scale, ranging from 1 (*not willing at all*), to 4 (*willing enough to convince others*). Similar to the attitudes questionnaire, the willingness to take action items were free of jargon, unambiguous and declarative statements (DeVellis 2003). For example, one item read, *I'm willing to stop using plastic grocery bags and use recycled bags instead*. (See Appendix B for complete scale.)

We measured the extent to which people engage in and enjoy effortful cognitive activities by using the 18-item short form of the *Need for Cognition Scale* (Cacioppo et al. 1996). The participants rated each item on a 5-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Similarly, we used the *Need for Closure Scale* to examine students' "motivation with respect to information processing and judgment" (Webster and Kruglanski 1994, p. 1049). This scale has 42 items that ask participants to rate their need for—or desire to avoid—cognitive closure using a 6-point Likert-type scale, ranging from 1 (*strongly disagree*) to 6 (*strongly agree*). The scale is comprised of five subscales measuring how need for closure is manifest: (a) preference for order and structure, (b) discomfort with ambiguity, (c) decisiveness in judgment and choices, (d) affording predictability to future contexts, and (e) close-mindedness. Higher scores reflect a greater need for closure.

After completing these four questionnaires, the students read a text describing current scientific information about global climate change. The text was derived from the same February 3, 2007 *New York Times* article (Stevens 2007) based on the report from the Intergovernmental Panel on Climate Change (IPCC) and was 1,122 words in length with a readability of 13.1 according to the Flesch-Kincaid Index. We argue that the text was persuasive in nature based on the definition of persuasive text from prior literature. According to Chambliss and Gardner, a message is considered to be persuasive, "if it is structured to counter the current beliefs of a typical reader as well as to present new ones by capitalizing on a reader's existing knowledge and beliefs (Chambliss and Garner 1996, p. 294). The text was structured to counter the view that whereas there may be evidence for global climate change, there is not much evidence to support that humans are contributing to this trend. The article used persuasive language to convey the strength of the IPCC Report's conclusions regarding human's impact on the environment such as there is "mounting evidence" that human activity is now "the driving force," and that the argument has changed from "whether humans are warming the planet, to what to do about it." Further, the article builds on the prior knowledge of some readers that there are some climate change skeptics by noting that the argument is "over" and that "major objections of skeptics have evaporated."

Participants read the persuasive text with a provocative image that appeared in the original *New York Times* article. This image showed an Earth globe being heated by a blow torch and was clearly designed to be attention grabbing and persuasive. After reading the text, the students retook both the attitudes about climate change and willingness to take action questionnaires.

Results

Preliminary analyses

Data were examined for outliers using ± 3 standard deviations from the mean as the removal criteria, and using this standard, no outliers were found or removed. Table 1 reports the means, standard deviations, skewness, and kurtosis for all outcome variables. Intercorrelations among these variables of interest are also reported in Table 1. An independent-samples *t*-test for gender and an ANOVA for race indicated no differences in these variables for these groups. Dependent samples *t*-tests indicated a significant difference from pre to post-test on attitudes towards climate change and willingness to take action.

We conducted dependent samples *t*-tests to examine changes in attitudes toward climate change and willingness to take action for pre and post reading of the persuasive text. Differences in attitudes toward climate change were statistically significant, $t(139) = 14.40$, $p < .001$, with more favorable attitudes post reading of the persuasive text ($M = 4.16$, $SD = .57$) than pre ($M = 3.67$, $SD = .54$). Similarly, differences in willingness to take action was statistically significant, $t(139) = 9.74$, $p < .001$, with a greater willingness post reading ($M = 2.78$, $SD = .61$) compared to pre ($M = 2.52$, $SD = .55$).

Path model

The present study tests a model that includes the closed-mindedness subscale from the Need for Closure scale and need for cognition as predictors of both change in attitudes and expressed willingness to take action. Initially, the 140 students were randomly divided into two text conditions, where one group read the text with the provocative image and the second group read the same text, but without the provocative image. This was done in order to see if the inclusion of a provocative image alongside a persuasive text has a greater effect on attitudes and willingness to take action above and beyond that of a persuasive text alone. Results indicated that there were no significant differences among the two groups on any of the demographic or model variables. For this reason, the two groups were combined for all analyses ($N = 140$).

Based on existing research, the model shown in Fig. 1 was developed. As can be seen in the figure, closed-mindedness was expected to influence expressed willingness to take action at pretesting, indicating that students who are more closed-minded will be less likely to express a willingness to take action to reduce human impact on global warming. A high need for cognition was expected to positively influence both expressed willingness to take action and attitudes at pre-testing. Attitudes at pre-testing were expected to positively

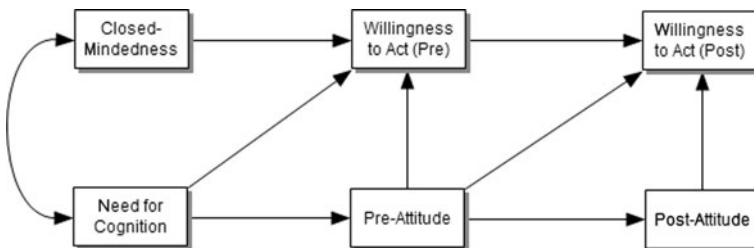


Fig. 1 Model of attitude change and willingness to commit to take action

influence expressed willingness to take action (at both pre- and post-testing) and post-attitude. Further, post-attitude was expected to be positively linked to expressed willingness to take action at post-testing. Expressed willingness to take action at pre-testing was expected to be positively linked to willingness to take action at post-testing.

Because all of our variables were *observed* rather than *latent*, because there was one measure of each variable, and because we had prior hypotheses about the causal relationships among our variables, we used the structural equation modeling (SEM) technique of *path analysis* to examine the hypothesized relationships among our variables (Kline 2005). Using path analysis, our specific goals were to estimate the direct and indirect effects in our model, to control for the correlations among the hypothesized causal variables, and to “decompose” the correlations we observed into their component parts (causal and spurious). Although a correlation, in itself, does not imply causation, path analysis makes it possible to cautiously draw causal inferences from patterns of correlations.

To satisfy the conditions of path analysis for the inference of causality, our hypothesized relationships involved time precedence and a logical direction of causality, consistent with the research reviewed. Also, our relationships were hypothesized to remain intact when external variables were held constant. Finally, our model was *recursive*. The sources of unexplained variance (*disturbances*) were assumed to be uncorrelated and the causal effects to be unidirectional.

Correlations

As can be seen in Table 1, there was a significant and negative correlation between closed-mindedness and need for cognition. There was also a significant and negative correlation between closed-mindedness and expressed willingness to take action at pretesting. Although there was not a significant correlation between need for cognition and attitude at pre-testing, there was a significant and positive correlation between need for cognition and expressed willingness to take action at pretesting. There were significant and positive correlations between pre-attitude and post-attitude, and pre-attitude and willingness at both pre- and post-testing. Further, there was a significant and positive correlation between post-attitude and expressed willingness to take action at post-testing. There was a significant, positive, and large correlation between expressed willingness to take action at pre-testing and expressed willingness to take action after reading the persuasive text.

Path analysis was used to test the model. Before empirically testing the model, the data were examined for normality and homoscedasticity. Based on the data plots (histograms of the variables), examination of skewness and kurtosis statistics (see Table 1), and Mardia's coefficient = 1.08, the data met the assumptions of both univariate and multivariate normality. Based on a DeCarlo macro test, no skewness, kurtosis, or outliers were found, also suggesting normality of the data. LISREL Version 8.80 (Jörkeskog and Sörbom 2006a), with a covariance matrix generated by PRELIS Version 2.80 (Jörkeskog and Sörbom 2006b), was used to test the model by means of the maximum likelihood method of estimation.

The overall fit of the model was very good, as indicated by a number of fit indices, all of which are described in detail in the paragraphs below. Any given index evaluates only a particular aspect of model fit. Therefore, to evaluate the fit of the model, it is recommended that several fit indices be used (Kline 2005). First, the χ^2 statistic was used. The χ^2 is a fit index that addresses the degree to which the variances and covariances implied by the model match the observed variances and covariances. A *non-significant* χ^2 indicates that the model is a good representation of the underlying covariance matrix. The chi-square, χ^2

(6) = 7.28, $p = .30$, indicated a good fit because the p -value was greater than .05. Further, the χ^2/df ratio was 1.21, suggesting a good fit based on Kline's (2005) rule that values less than three indicate a good fit.

The standardized root-mean-square residual (SRMR) is an index based on the residuals between the observed and estimated covariance matrices. The advantage of the SRMR is that it is sensitive to model misspecification (Hu and Bentler 1999). A value below .08 indicates a good fit (Hu and Bentler 1999). The SRMR for this model was .03.

The Steiger–Lind root-mean-square error of approximation (RMSEA) assesses a lack of fit of the population data to the estimated model. It is an index that includes adjustments for model complexity so that evaluation of fit is not overly influenced by the number of parameters in the model (Steiger 1995). The RMSEA for this model was .04, which was below the cutoff value of .06 suggested by Hu and Bentler (1999).

The incremental fit index (IFI) is a fit index that is sensitive to model misspecification, but not to sample size (Bentler 1990; Hu and Bentler 1999; Widaman and Thompson 2003) making it a valuable indication of fit. The IFI compares the model to a baseline model in which all variables are assumed to be uncorrelated. This is the standard “null” model (independence model) that assumes zero population covariances among the observed variables. The IFI values range from 0 to 1, with larger values indicating a better fit. A value greater than .95 is considered to indicate an excellent fit (Hu and Bentler 1999). The value for this model was 1.00.

Finally, the adjusted goodness of fit index (AGFI) is a measure of the proportion of the observed covariance that is accounted for by the model. The AGFI is adjusted for degrees of freedom so that evaluation of fit is not overly influenced by the number of parameters in the model. The AGFI values range from 0 to 1, with larger values indicating a better fit. A value greater than .90 is considered to indicate a good fit (Schumacker and Lomax 1996). The value for this model was .94.

The standardized path values and their associated t -values for the model are reported in Table 2; the model with standardized path values can be seen in Fig. 2. A cutoff value of $t = 1.96$ for a two-tailed test was used to determine if direct and indirect paths were statistically significant. In terms of size and influence of the standardized path values, we used Keith's (1993) recommended criteria: Standardized path values ranging from .05 to .10 are small, but meaningful influences; path values ranging from .11 to .25 are moderate in size and influence, and path values above .25 are large in size and influence. The criterion R^2 (proportion of variance explained) by pre-attitude was .01, by post-attitude was .55, and by willingness to act (pre) was .22, by willingness to act (post) was .09.

Decomposition of effects

The decomposition of effects can be seen in Table 2. Of the eight direct paths, six were significant. Need for cognition had a significant and large (.31) influence on expressed willingness to take action as assessed during pretesting. Thus students who are more inclined to approach ideas in an open-minded fashion, enjoy effortful thinking, and engage in critical thinking are more likely to express a willingness to take the actions needed to reduce global warming. In addition, pre-attitude had a significant and large (.35) influence on expressed willingness to take action at pretesting, indicating that students who have a more accepting attitude toward human-induced climate change are more likely to express a willingness to take action. This more accepting attitude at pre-testing also had a significant and large (.30) influence on students' expressed willingness to take action at post-testing after students read the persuasive text. Further, pre-attitude had a significant and large (.74)

Table 2 Decomposition of effects in the model

Predictor	Criterion	Effect			
		Direct		Indirect	
		PC	<i>t</i>	PC	<i>t</i>
Closed-Mindedness	Willingness (pre)	-.12	1.57		
	Willingness (post)			-.11	1.57
Need for cognition	Willingness (pre)	.31	3.57	.03	1.01
	Willingness (post)			.26	3.52
	Pre-attitude	.09	1.03		
	Post-attitude			.07	1.03
Pre-attitude	Post-attitude	.74	12.73		
	Willingness (pre)	.35	4.64		
	Willingness (post)	.30	3.84	.40	4.94
Post-attitude	Willingness (post)	.14	2.23		
Willingness (pre)	Willingness (Post)	.86	18.58		

Note. PC refers to standardized path coefficient. A cutoff value of $t = 1.96$ for a two-tailed test was used to determine if paths were statistically significant. In terms of the relative size and influence of the standardized path coefficients, paths ranging from .05 to .10 are considered small, but meaningful influences. Paths ranging from .11 to .25 are moderate in size and influence, and paths above .25 may be considered large in size and influence (Keith 1993)

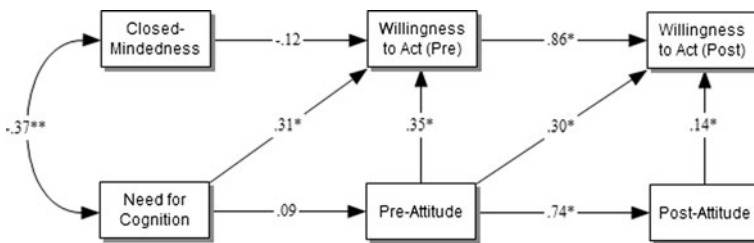


Fig. 2 Model of attitude change and willingness to commit to take action, with standardized path values. Significant paths are marked with an asterisk

influence on post-attitude. Expressed willingness to take action at pre-testing had a significant and large (.86) influence on the expressed willingness to take action at post-testing. Post-attitude had a significant and moderate (.14) influence on the willingness to commit to take action at post-testing after students read the persuasive text.

Indirect paths and associated t -values can also be seen in Table 2. Need for cognition had a significant influence on expressed willingness to take action at post-testing through its influence on pre-attitude and expressed willingness to take action at pre-testing. However, it was the large and significant path from need for cognition → pre-action → post-action that mainly contributed to this influence as the path from need for cognition → pre-attitude → post-action was small in comparison. Pre-attitude had a significant influence on expressed willingness to take action at post-testing through its influence on both post-attitude and on expressed willingness to take action at pre-testing.

Thus, in addition to the direct paths indicating the importance of need for cognition and attitude on expressed willingness to take action, the indirect paths emphasized the importance for the need for cognition on attitude and expressed willingness to take action, and illustrated that pre-attitudes not only influence post-action directly, but do so indirectly through post-attitudes and expressed willingness to take action at pretesting.

Discussion

Students are often confronted with socio-scientific topics in the course of instruction. The topic of human's contributing role in climate change is conceptually difficult and some students perceive it as controversial, presenting unique challenges for engaging students productively with the content. Persuasive texts have been used as part of a pedagogical approach to shift students' attitudes toward a topic (Murphy 2001). Our goals were to examine whether a persuasive text could promote more receptive attitudes toward human-induced climate change as well as greater expression of willingness to take action to reduce human impact. In addition, we were interested in examining the relationship among epistemic motives, dispositions toward knowledge, attitudes, and willingness to take action.

Typically in attitude or conceptual change research, promoting a change in perspectives or knowledge is sufficient to claim that a pedagogical approach has merit. However, with the topic of global climate change, promoting a willingness to change behavior is a key step toward adopting sustainable lifestyles. Our results indicated that students were persuaded toward more receptive attitudes about the topic after reading the reported conclusions from the IPCC. More importantly, they also expressed a greater willingness to take mitigative actions to reduce their own "carbon footprint" post reading.

Most important to us in furthering our research agendas on motivation, persuasion, conceptual change, and science learning, was the exploration of the interrelationships among the variables of interest in the present study. The results of the path model suggest that personal dispositions toward knowledge are related to expressed willingness to take action to reduce climate change. As one would expect, need for cognition and close-mindedness were inversely and significantly related to each other. The correlations, as well as the direct and indirect paths in the model suggest that need for cognition and close-mindedness were significantly related to expressed willingness to act both pre and post reading. Thus, our findings suggest that students who are more inclined to approach ideas in an open-minded fashion, enjoy effortful thinking, and engage in critical thinking are more likely to express a willingness to take the action needed to reduce global warming. The model also demonstrates that attitudes toward global climate change are related to expressed willingness to take action. Specifically, students who have a more accepting attitude toward human-induced climate change are more likely to express a willingness to take action. The persuasive text did create a shift in attitudes, suggesting that if attitudes and willingness to act are related, persuasive texts geared toward shifting attitudes may also be promising for promoting shifts in students' willingness to commit to take action to reduce their carbon footprint. Moreover, shifts in willingness to take action may serve as a precursor to taking action, a connection that should be examined in future research.

Every study has limitation and ours is no exception. In addition, as anyone who has made a commitment to change their own behavior knows, stating a willingness to change and actually enacting behavioral change are by no means always linked. Examining actual behavior change post reading would have to be examined to determine if actual behavior change results. Another concern is that respondents may have given "socially acceptable"

responses, and while this explanation is plausible, it would not explain the pattern of relationships demonstrated among the variables seen in the path model. That is, socially acceptable responses would not account for the demonstrated influence of dispositions towards knowledge and would not necessarily explain the shift in both attitudes and expressed willingness to take action from pre to post.

Instructional implications

Students are often confronted with ideas in science classrooms that conflict with their personal perspectives. Thus, complex socio-scientific issues, such as human induced climate change, are likely to be met with resistance on the part of some students. As noted by one of our reviewers, scholars of civics education have identified several factors that promote change in civic and political commitments and the likelihood of action. Our results indicate that reading a persuasive text should be added to that arsenal of factors, as it may be a useful component of a pedagogical approach designed to lessen students' resistance to considering alternative ideas. We would recommend that persuasive text be considered for inclusion in any instructional approach designed to promote engagement in classroom discourse about socio-scientific issues.

Our results also suggest that educators should be aware that there are individual differences in the degree to which individuals are open to persuasive arguments. Some students are open-minded, have a high degree of interest in complex topics, enjoy effortful thinking, and are willing to engage in collaborative argumentation about socio-scientific issues. Others may react differently when faced with instruction on socio-scientific issues that requires a high need for cognition or argumentation (Nussbaum and Bendixen 2003). The awareness of these individual differences suggest that promoting a classroom culture of enhanced critical thinking and an open-minded epistemic stance toward knowledge (Sinatra and Chinn 2011) may be important components of any pedagogical approach to teaching about socio-scientific topics.

Suggestions for future research

The limitations in our study suggest some clear directions for future research. First, it would be interesting to see if the effectiveness of a persuasive text might be augmented by discussion or argumentation, strategies with an empirical record of effectiveness with refutational texts (Broughton et al. 2011; Mason et al. 2008).

It would also be important to follow-up with persuaded individuals after a delay to determine if any actual behavior changes have occurred. Self-reported ratings of actions (recycling, changing light bulbs, reduction in plastic bag usage, etc.) could be compared pre-reading and again after a suitable delay to examine whether willingness to act translates into actual behavioral change. Furthermore, it may be revealing to examine the degree of change associated with different actions. Our results tentatively suggest that students have a stronger willingness to act when there is a perceived lower cost (e.g., changing light bulbs) and/or greater social benefit (e.g., purchase a hybrid gasoline/electric vehicle) when compared to a higher perceived cost (e.g., support a 50 cents gasoline tax used to mitigate impacts from climate change).

Our research demonstrates that reading persuasive texts about human-induced climate change is effective in promoting both attitude change and a commitment to take action. Our results highlight the importance of dispositions toward knowledge and suggest that creating a classroom culture that fosters an open-minded and critical epistemic stance may

be promising for promoting change in students' views of controversial topics. Previous research has indicated that openness and willingness to engage in effortful thinking can affect the type of conclusions students draw from controversial information (Kardash and Scholes 1996). Our results advance this literature by demonstrating the effects of such dispositions on expressed willingness to take action.

Appendix A

Rate the degree to which you agree with the following statements:

1. Scientific evidence points to a warming trend in global climate.

Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1	2	3	4	5

2. Human activity has been the driving force behind the warming trend over the last 50 years.

Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1	2	3	4	5

3. The release of CO₂ (carbon dioxide) from human activity (such as smoke stacks and car emissions) has played a central role in raising the average surface temperature of the earth.

Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1	2	3	4	5

4. The surface temperature of the earth has risen by more than 1 degree Fahrenheit since 1900.

Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1	2	3	4	5

5. The Greenland ice cap is melting faster than had previously been thought.

Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1	2	3	4	5

6. Human activity is responsible for the continuing rise in average global temperature.

Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1	2	3	4	5

7. The speed with which the melting ice caps may raise sea levels is uncertain.

Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1	2	3	4	5

8. The likelihood that emissions are the main cause of the observed warming trend of the last 50 years is between 90 and 99%.

Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1	2	3	4	5

9. Former Vice President Al Gore's documentary, "An Inconvenient Truth," about global climate change is just propaganda.

Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1	2	3	4	5

10. Natural phenomena such as solar variations combined with volcanic activity are the real cause of the warming effect.

Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1	2	3	4	5

Table a continued

11. Humans have very little effect on climate temperature.				
Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1	2	3	4	5
12. An increase in CO ₂ (carbon dioxide) is directly related to an increase in global temperature.				
Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1	2	3	4	5
13. It is arrogant to assume that humans can influence climate temperature.				
Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1	2	3	4	5

Appendix B

In order to reduce the effects of global warming, we may need to make some sacrifices. Listed below are several examples of action that could help to reduce global warming. Please use the rating scale below to indicate how willing you would be to take action to reduce global warming.

1. I'm willing to stop using plastic grocery bags and use recycled bags instead.			
Not willing at all	Somewhat willing	Totally willing	Willing enough to convince others
1	2	3	4
2. I'm willing to stop buying bottled water because the manufacturing process for plastic water bottles is carbon intensive.			
Not willing at all	Somewhat willing	Totally willing	Willing enough to convince others
1	2	3	4
3. I'd be willing to trade in my SUV for a smaller car.			
Not willing at all	Somewhat willing	Totally willing	Willing enough to convince others
1	2	3	4
4. I'd be willing to car pool.			
Not willing at all	Somewhat willing	Totally willing	Willing enough to convince others
1	2	3	4
5. I'm willing to pay more money to buy a hybrid car.			
Not willing at all	Somewhat willing	Totally willing	Willing enough to convince others
1	2	3	4
6. I'm willing to replace all the light bulbs in my house with energy efficient fluorescent bulbs.			
Not willing at all	Somewhat willing	Totally willing	Willing enough to convince others
1	2	3	4

continued

7. I'm willing to pay a .50 cents surcharge per gallon of gas to go toward greenhouse gas reduction.

Not willing at all	Somewhat willing	Totally willing	Willing enough to convince others
1	2	3	4

8. I'm willing to keep my home air conditioning system set no lower than 75 degrees in the summer.

Not willing at all	Somewhat willing	Totally willing	Willing enough to convince others
1	2	3	4

9. I would vote in favor of requiring car manufacturers to raise the number of miles per gallon their cars get, even if it meant all cars would cost more.

Not willing at all	Somewhat willing	Totally willing	Willing enough to convince others
1	2	3	4

10. I'm willing to reduce the numbers of hours a week I use electronic devices (computer, cell phone, TV, etc.).

Not willing at all	Somewhat willing	Totally willing	Willing enough to convince others
1	2	3	4

11. I would support legislation reducing the legal speed limit to 55 miles per hour.

Not willing at all	Somewhat willing	Totally willing	Willing enough to convince others
1	2	3	4

12. Regardless of the posted speed limit, I'm willing to drive no faster than 55 miles per hour in order to reduce energy consumption.

Not willing at all	Somewhat willing	Totally willing	Willing enough to convince others
1	2	3	4

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