CLIMATE CHANGE AND COGNITION: TOWARDS A PEDAGOGY

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Abstract: In the aftermath of 9/11, the National Center for Disaster Preparedness (NCDP), and the Earth Institute of Columbia University launched the American Preparedness Project in order to survey public perceptions on disaster preparedness. The report found that 65% of Americans expressed worry that climate change will have an impact on their community's exposure to disasters. The NCDP recommended integrating the impact of climate change into communications and preparedness programs, given that a comprehensive understanding of the concerns of individuals and families is critical to emergency planning efforts. The NCDP adopted a user-centered design approach to create more informed risk communications and instructional decisions to work towards a pedagogy of climate change. Today, the NCDP deploys online and in-person trainings across the United States where the Center directly engages with the public on disaster preparedness, response, recovery, and resiliency. Leveraging these experiences, the NCDP collects data to analyze the learning efficacy of communication methods of disaster focused curricula. However, despite these strides toward a methodology of teaching climate change, there are several discrepancies in the U.S. public opinion on the degree of urgency in which to prepare for the risks of climate change. Discrepancies are tied to a multitude of factors including partisan affinity, dynamics of in-group or out-group, impersonal versus personal interaction, and perceived thresholds of distance and time. A key relationship between public discourse, cognition, and instruction are introduced in this paper to better set the foundation for a pedagogy of climate change. This paper also provides data-driven recommendations derived from satisfaction surveys and belief statements from learners that have participated in the NCDP's course content on climate change. The recommendations focus on risk communication strategies that can adequately address public opinion discrepancies on the risk of climate change, impact decision making, as well as improve learner understanding of climate change. The solution is not simply to provide more information but to evaluate how to implement different delivery methods aligned with public learning needs and capacities.

Journal of International Affairs, 73, no. 1.

Introduction

For many, the understanding of the self in relation to the climate is an enigma. Much as climate change as a concept succumbs to ambiguous oversimplification—often the result of socially embedded analogies in its presentation—approaches to investigating climate change comprehension and risk aversion often fall victim to a similar object bias (a tendency to treat processes as objects), or mistreatment of a complex process as a single entity.[1] Such object bias runs the risk of oversimplifying the complex cognitive processes responsible for encoding the meaning of climate change from analytical, conceptual, and experiential sources. In addition, "[t]his object bias can become a mental block, preventing people from adopting appropriate mental models to analyze climate change."[2,i] An understanding of climate change as a process requires a comprehensive appraisal and identification of relevant cognitive dimensions of climate change and conditions necessary for human learning.

In this context, cognitive dimensions, a term adapted from computational cognitive modeling, refers to different psychological and social features that relate to the information structures or mental models that control how or whether a cognitive strategy can be adopted.[3] Although climate change is a process, the process is nonlinear and independent of personal time or circumstance. These characteristics impede active cognitive engagement and mental modeling, rendering climate change less a process than a complexity.[4] Unless analyses of existing and new behavioral scientific evidence from domains such as cognition, climate literacy, and education occur, there is little evidence that future instruction will be any more successful in improving public understanding or eliciting behavioral change than will those implemented presently.[5]

This paper, grounded in applied behavioral science and education assessment, presents early stage investigations into the cognitive dimensions of climate change pedagogics and how they may be applied to the cognitive alignment between individuals and complex systems. The early stage investigation, as well as the structure of the paper as signified in the proceeding sections, incorporates academic literature on climate in public discourse; climate change and morality; effective response to climate change; associated mental models and heuristics; and the role of the self. This analysis inevitably calls upon the integration of social cognitive neuroscience, applied learning science, and climate sciences, among others, to posit a heterogeneous discipline of climate change cognition. A more attuned understanding of the cognitive dimensions of encoding the process of climate change may assist in the refinement of methods of instruction, policy decisions,

[i] Xiang Chen, Why do people misunderstand Climate Change? Heuristics, mental models and ontological assumptions in Climate Change, Vol. 108, Sept. 2011, available at https://link.springer.com/article/10.1007/s10584-010-0013-5.

and community involvement, as well as to reframe climate change to help global citizens better respond to shifts in their environments over a duration of time. To provide a practical use case, this paper analyzes identified cognitive dimensions alongside adult learning theory and education assessment within an online course designed for Nurse Practitioners on themes of climate change. The results from the learner interactions within this specific course provide a better understanding of the nuanced cognitive parts that elicit attention and improved understanding of climate change. Early results further support a focus on the cognitive dimension of self-referential processing as a method of user-centered design leading to measurable learning improvements on relatively complex subject matters.

In the absence of cognitively directed methods of instruction, the current landscape of incomplete working knowledge, uncertain interactions, object bias, and dependencies on historical observations of climate that vastly underestimate the gradually changing environment will persist and become procedurally more serpentine in mental modeling, resulting in the continued misconstruction of climate change understanding. The wider the distance between the self and the phenomena becomes, the more preexisting mental models of climate change will solidify, increasing the difficulty of constructing new mental models.[6] A critical analysis of psychological and sociological factors that enable or inhibit people from processing much of the phenomenon of climate change is essential. Such analysis is currently not well understood and therefore minimally represented in present methods of instruction and communication. It is the intention of this paper to further the discussion of cognition and climate change and to promote the continued experimentation of learning interventions in practice settings by highlighting the intricate relationship between public discourse, behavioral science, and education.

It is important to note that the investigation of the cognitive dimensions examined in this paper is at the individual level, primarily in the context of the United States. However, such investigation holds promise for insights relevant for a broader understanding of how society engages or disengages with climate change throughout the world. Internationally, a similar investigation into cognitive dimensions applied contextually can assist in surfacing specific insights to a localized pedagogy of climate change as well as provide a basis for cross-cultural comparative studies regarding the understanding of the self and community in relation to climate change worldwide. Through a review of relevant literature, as well as early lessons from application, ideas to improve formal and informal learning experiences focused on cognitive process begins a pertinent discussion of empowering individuals to make meaning of this timely phenomenon with the intention to improve understanding and elicit behavior modification in favor of the environmental actions immediately required for the future well-being of all. The development of a pedagogy of climate change is

critical as collectively a new consciousness of climate is required for the betterment of the planet. However, such change in behavior and perception becomes near impossible in the absence of opportunities to learn how and why such change is imperative.

Climate Change In U.S. Public Discourse And Levels Of Concern For Climate Related Harm

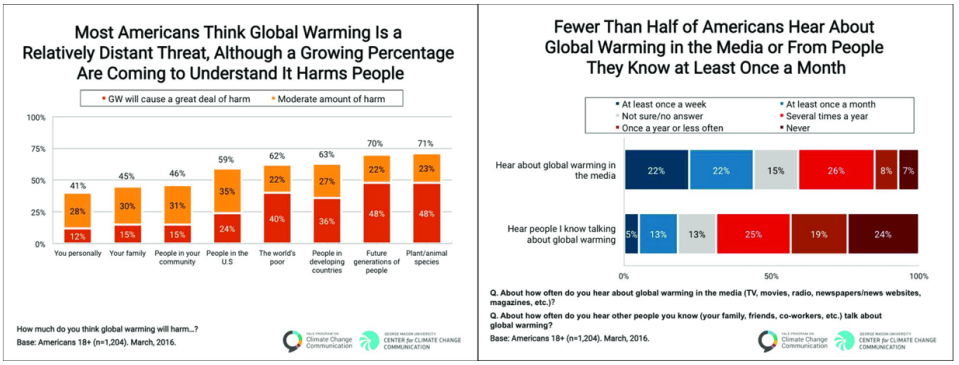
As part of the American Preparedness Project report, 65% of Americans expressed worry that climate change will influence their community's exposure to disasters. [7] NCDP concluded that the impact of climate change on disasters must be better integrated into communications and preparedness programs, acknowledging that a comprehensive understanding of the concerns of individuals and families is critical to emergency planning efforts.[8] The report suggests a need for a pedagogy of climate change as well as an effective method for instruction. However, in the presence of a diversity of mental models of climate change in the United States and limited understanding of the essential cognitive dimensions of encoding change in climate over time, such methods of instruction have yet to come to fruition.

There are several discrepancies in the public opinion on the degree of urgency in which to prepare for the risks of climate change. Discrepancies tie to a multitude of factors including dynamics of in-group or out-group, impersonal versus personal interaction, and perceived thresholds of distance and time. The solution is not merely to provide more information but to evaluate how to implement different delivery methods aligned with public learning needs and capacities. To understand public learning needs and capacity, it is pragmatic first to analyze the stimuli in which the public engages with climate change. Due to the variance in which an individual may experience and conceptualize climate change, public discourse data provides an insightful baseline of levels of engagement as well as the frequency and the source of touchpoints between the public and climate related information. Most Americans, in fact, are indirectly informed about climate change, often by media outlets, informal conversations, or video footage of events in remote regions.[9] Prior to generating a method of instruction, understanding the climate learner profile is invaluable. Therefore, it is important to generate a realistic understanding of these touchpoints in the United States and how they shape public opinion and learning needs. A detailed appraisal of the experiential processing of information may direct improved communication strategies.[10]

Precepts of information tend to be processed as relative rather than absolute intensity, extent, and frequency.[11] Such is the case with the conceptualization of climate change as perceived as relative to the self, opposed to an observation based on known intensity, extent, and frequency. A glimpse into this phenomenon

provides astounding guidance into the degrees of concern that people apply to the potential harms caused by climate change. By understanding the perceived harm associated with climate change, a corresponding understanding of the priorities people hold is also achieved. Further, the understanding of perceptions and priorities provide a passageway into how information is received, in terms of what is accepted and what is rejected, and the infrastructure of the mental models that influence conceptualization. The filtering process described between the self and information further supports the notion that discourse is associated with the formation of self-view.[12] For this reason, an analysis of discourse warrants attention. In surveys conducted as part of the Yale Project on Climate Change Communication, two primary concerns with implications to cognition arose. The first is that most Americans believe global warming is relatively distant.[13] Americans perceive that the most harm will be inflicted on plant/animal species and the least amount of harm will be caused to themselves (Figure 1a).[14]

Figure 1:



Source: *Yale Project on Climate Change Communication (Yale University and George Mason University, New Haven, CT)* (2015).

However, it is important to note that the second highest perceived harm is for future generations of people. The consideration of the livelihoods of future generations suggests that people feel the consequences of climate change are remote. The second point of concern (Figure 1b) is that fewer than half of Americans hear about global warming in the media at least once a month or from people they know.[15] Sixty-eight percent falls into the categories of Never, Several Times a Year, and Once a Year for how often they hear people they know talking about global warming.[16] These two results provide troubling insights about how little the public is engaging with themes of global warming and climate change. This creates an obstacle for educators and scientists to present information in a way that elicits discussion, attention, and personal engagement. Public discourse and perception are characterized by psychological, social, moral, institutional, and cultural processes.[17]

New methods of instruction must address each process by investigating the nature of encoding and internalizing information at the cognitive level. The survey data aids in illustrating a realistic baseline of how Americans are engaging, prioritizing and disengaging with themes of climate change. Such a baseline delineates a starting point where behavioral science can begin to investigate variables of engagement and disengagement, such as climate change and morality, affective response to climate change, associated mental models and heuristics, and the role of the self. In a cyclical relationship, insights from public discourse, behavioral science, and experimental learning and teaching should continue to fine-tune one another through constant interaction. This paper is organized in the precise sequence which it proposes with subsequent sections dedicated to a treatise of cognitive dimensions and insights from applied learning and teaching, respectfully.

Climate Change As A Moral Dilemma

Climate change from the vantage point of morality widens related literature in breadth and utility by extending the climate dilemma to a broader scope of researchers as well as building upon a repository of existing work on ethics. In his article *Climate ethics: with a little help from moral cognitive neuroscience,* Grasso defines climate change as a fundamentally ethical issue.[18] Grasso's main argument is that the moral foundation of climate change relates to avoiding and preventing harm. The moral dilemma that arises from Grasso's perspective is one that addresses the ethical underpinnings of the choice people have today to either act or not act and the consequential harm this decision has on others presently as well as for future generations. Currently, climate change entails two moral commitments: the first one relates to addressing anthropogenic greenhouse gases, and second one relates to obtaining the necessary support and funding to prevent further climate change or adapt to its effects. Obstacles to such actions stem from mental models encompassing ontological assumptions, cognitive biases, and misunderstandings of harm and risk. Each obstacle holds implications that traverse political, socioeconomic, and moral aspects. In discussions of morality, inaction originates from relatively impersonal moral violations and its inherent temporal and transgenerational character. Insights on relevant moral processes and judgments that may surface from moral cognitive neuroscience have the potential to provide valuable conceptual and empirical aid in developing harm-centered climate ethics. Interdisciplinary integration is necessary to understand the cognitive and neural mechanisms that underlie moral behavior.[19]

Greene et al. present an empirical investigation of the neural imaging that corresponds with emotional engagement and moral judgment. Greene et al. argue that moral dilemmas vary systematically contingent on the extent to which they engage emotional processing. The extent to which emotional processing is engaged

should determine the influence on the corresponding moral judgment. The researchers observed correlations between the patterns of neural activity in emotion-related brain areas, patterns in reaction time, and the distinction between actions that are "personal" versus "impersonal."[20] Greene et al. provide the imaging of the distinction drawn from Grasso that supports further attention to the dynamics of personal versus impersonal moral judgments. The data suggests a complex dynamic between the connection of moral and personal dilemma and moral and impersonal dilemma.[21] Personal moral dilemmas significantly differed from other conditions in terms of activations of areas associated with emotion and working memory.[22]

Moral phenomena emerge from the integration of contextual social knowledge,[23] social semantic knowledge,[24] and motivational and basic emotional states.[25,26] An understanding of the neural process of moral cognition can help shape environmental, educative, and psychological interventions that facilitate prosocial behaviors.[27] Evidently, people's values influence decision-making in difficult situations.[28] Extrinsic and intrinsic motivations in value systems hold significant importance on behavioral modification.[29] Perhaps critical to surfacing a pedagogy of climate change, research has shown that intrinsic motivation for understanding climate change relies on eliciting a desire for self-knowledge, emotional intimacy, and community involvement.[30] The repeated activation of intrinsic motivation and corresponding values may lead to individuals attaching higher importance to intrinsic values at a cultural, collective level.[31] Such motivation and moral awareness are critical for an effective pedagogy of climate change. An in-depth investigation of morality in the context of climate change is required to best accommodate future methods of instruction. The start of this process is acknowledging climate change as a social dilemma with personal implications. This acknowledgement may rely on affective response to apply personal, intrinsic values to different forms of stimuli in relation to the individual and broader climate system.

Affective Response To Climate Change And The Power Of Narrative

The public utilizes a multidimensional and complex assessment in perceiving risks.[32] Risk perception is not only influenced by scientific and technical displays of information, but by an array of psychological and social factors underpinned by affect, emotion, imagery, trust, personal experience, values, and worldviews.[33] Morris et al. identify climate change as an issue that elicits low engagement, as reflected in public discourse analysis, even among the concerned segments of the public.[34] Morris et al. investigated the efficacy of the presentation of factual information in comparison to narrative-style methods in communicating climate change in ways to elicit pro-environmental behaviors. Morris et al. found that stories are more effective than informational narratives, as stories heighten affective and emotional

engagement, and increases the likelihood of action-taking.[35]

Morris et al. sought to understand how narrative-structured information influences engagement with climate change through emotional triggering, decision making, and the corresponding final action.[36] The authors define engagement as a personal state of connection at cognitive, affective, and behavioral levels. Importantly, Morris et al. address the variability of response between the presentation of factual and scientific information. Morris et al. attribute this discrepancy to the social and neurological costs of updating beliefs, which can inhibit cognitive flexibility and factual accuracy.[37] Previous studies have found similar cognitive process advantages of vivid instances over extensive statistical information, despite the statistical data providing more evidential value.[38] Vivid descriptions prompt learners to place themselves within the story and imagine the actions they would take in a low risk environment.[39] Experiential information can supersede statistical information unless the statistical information is visually or narratively expressed in ways enmeshed with personal experience.[40]

The mental models that one develops can maintain illusory order out of convenience. The learning necessitated by climate change will inadvertently challenge longstanding mental models. Every locality is challenged with socially pervasive values and attitudes resistant to change.[41] However, action will become less likely with failure to challenge these preconceptions. An awareness of the status of mental models and how they are formed is required for climate change reasoning.

Heuristics And Mental Models

Climate change portrayal is a new, emerging attitude object.[42] The manifestation of climate in the form of frequent natural disasters provides an overwhelmingly evident visualization of climate. The impeding consequences following a disaster in the forms of economic and housing devastation also contributes a glimpse into climate change as more than an object but a complex system with several far reaching, tangible and intangible, integrated parts. However, the misleading and hegemonic acceptance of object categorization of climate change currently dominates and presents difficulty in changing pre-existing mental models. Clarity of mental models as they pertain to climate change is of high priority as mental models play an active role in developing expectation.[43] Language serves as a conduit for presenting objective information as well as representing objects and relationships.[44] However, language runs the risk of developing culturally specific root metaphors that frame process in analogical terms that can hold a misrepresented cognitive schema within a cultural group.[45] If the root metaphor becomes hegemonic without questioning, then attention and debate may be diverted from its accuracy.

In *Why Do People Misunderstand Climate Change? Heuristics, Mental Models and*

Ontological Assumptions, Chen introduces an interesting case for the misunderstanding of climate change.[46] Chen concludes that people may be erroneously making sense of climate change as a static object even though climate change belongs to a different more process-like category. Chen argues that a more appropriate heuristic of climate change is to identify the components that characterize climate change as a dynamic process within a broader system. Chen claims that people have developed an object bias about climate change, and that this object bias is causing a mental block that prevents people from adopting the appropriate mental models to analyze climate change holistically. Chen believes a remedy to this object bias is a fundamental transformation from object-only analysis to a new method that distinguishes between how one treats objects and processes. To do this, Chen calls for basic knowledge of system dynamics and thinking – knowledge of patterns in which events emerge, interconnectedness of system elements and the role of feedback loops within a complex system.[47] Chen takes special note that cognitively encoding objects differs from encoding processes, since objects consist of matter. In addition, the properties of objects require different process times by the visual system. In the context of climate change, static objects create mental models that are incongruent with the cognition required to understand climate change as a system of interactions.[48]

To move beyond this hurdle, Chen calls for the need to aid the public in their understanding of the effect of time delays associated with changes of processes as well as impacts of modifications to process. Chen notes ridding of the object bias will be no easy task as object bias originates from cognitive development beginning at four months old.[49] To equip future generations as well as the current generation with the systems thinking necessary to grapple with time defining complexities, it is pertinent for leaders in policy and education to incorporate knowledge of system dynamics into school curriculum at developmentally appropriate times.

The Role Of The Self

Yoshimura et al. investigated the neural activity associated with self-referential processing of emotion probing stimuli through whole-brain fMRI scanning. Participants were instructed to make judgments about positive and negative trait words within four conditions: self-reference, other-reference, semantic processing, and letter processing.[50] In comparison to the semantic processing condition, the self-reference condition showed significantly more activity. This study supports previous research concluding that processed material, particularly emotionally stimulating material, with reference to oneself is more readily remembered. Despite that, little is known regarding brain activity during the self-referential processing of emotional word stimuli, the self-reference effect involves processes both at the encoding and retrieval phase. The identified activated brain regions in the study are associated

with emotion-related cognitive processing, such as self-referential processing, self-generated emotional feelings, autobiographical memory, and evaluative judgment.[51] Each functional characteristic serves important roles in climate reasoning and learning. Visualization of climate change as moral dilemma is inhibited without an understanding of the self in relation to others. The self-reference effect may hold pedagogical value in diminishing historical cognitive gaps.

Decety and Sommerville call attention to the ability to identify with others and to distinguish between the self and other as an integral component of intersubjective transactions.[52] Similarly to the work of Yoshimura et al., the researchers work to locate self-functions within the brain. Decety and Sommerville suggest there is a shared neural network that plays a distinct role in interpersonal awareness. [53] The researchers position the self as a multi-dimensional construct that is dependent on a distributed neural network comprising a shared self and representation of others. The authors identify the importance of others and other people's perspectives insofar as promoting one's self-monitoring, self-regulation, and self-reflection. The researchers suggest that people interpret their own moral behaviors as deriving from a vastly different source than the source that produces the moral behaviors of others. The treatment of one's own moral compass as different than the moral compass directing others generates an obstacle for community building in the context climate disruption. Pedagogical techniques that encourage perspective taking may assist in constructing a sense of togetherness between the self and others. The researchers note that first-person information is qualitatively different from third-person information. This model supports the notion that development and learning occur due to the increasing integration of first- and third-person information, and the involvement of imagination over perception in generating cognitive representations.[54]

Towards Methods Of Instruction

Public understanding of climate change is time-sensitive and crucial for the future well-being of the planet and its inhabitants. The problem is not solely "illiteracy" of climate science as it is often framed. In comparison with the rest of the world, the American public has an average level knowledge about climate change as a phenomenon.[55] In turn, U.S. adults that grapple with themes of climate change and associated risks exhibit not only a deficiency of knowledge, but a different understanding of it.[56] The discrepancies between mental models and scientific evidence suggest the need for an educational process that does not focus solely on factual knowledge construction but in eliciting conceptual change. The complexity of climate change calls for a method of instruction that directly involves the most relevant cognitive dimensions required to meet learning needs. Collaboratively, for

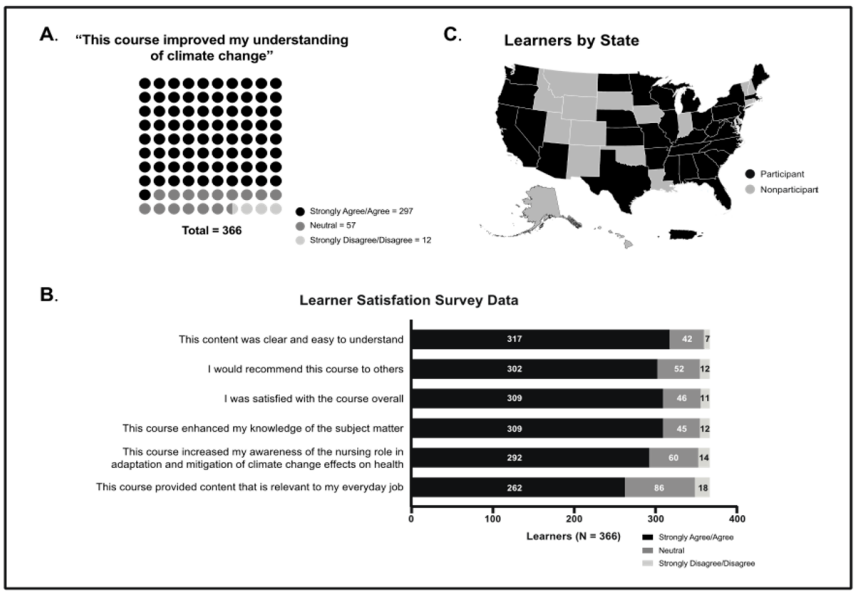
scientists and educators to address gaps in understanding, it is essential to analyze the stimuli to which the U.S. public is susceptible. Scientists and educators can jointly facilitate a pedagogy for climate change as a process by shifting to "non-persuasive communication."[57] A non-persuasive platform would require moving towards an informative position that engages the public as opposed to trying to garner support for specific policies. It would help Americans build more appropriate mental models for understanding climate change, while shedding the polarizing content of U.S. climate discourse.

In Practice

Solving climate change will require the support of those within a multitude of professions.[58] As the climate change system continues to effect every facet of existence directly and indirectly, most decision-makers will be required to have a working knowledge of climate change as it relates to their area of expertise.[59] Efforts to provide learning opportunities for decision-makers, referred to as decision support, represent a unique opportunity for climate change pedagogy to influence how audiences conceptualize climate change as a process, a process that involves them directly. This unique opportunity presents a window of plasticity to refine mental models in the context of social role responsibility. It is also critical to underpin the grave implications that arise from miscalculation of relevant cognitive dimensions and methods of instruction. Experimental learning and teaching as an *in vivo* experiment and an iterative process is essential for accurately identifying cognitive dimensions for learning on climate change.

Through the NCDP Learning Management System (LMS) and a comprehensive distance-learning program, the identification of specific interpretative communities is possible at the occupational level. In addition to investigating decision support focused curricula, insights from learning design allow for an additional investigation into the accuracy and effectiveness of applied cognitive dimensions (i.e., self and self-referential systems). Data collected from the LMS helps to measure the effectiveness of decision support and user-centered learning on themes relating to climate change. One such example is data synthesized from an online course designed for nurse practitioners to gain a working knowledge of climate change and the impending effects on healthcare.

Figure 2.



A) Reflects learner response data (N=366) after the completion of the online course to the extent which learners agree, disagree or are neutral to the prompt "This course improved my understanding of climate change." B) Provides learner responses to additional prompts in the post-course satisfaction survey. C) Geographic depiction of state and territory coverage of learners who participated in the course. The darkened states and territories represent states and territories in which learners participated in this course. They are as follows: AL, AZ, AR, CA, FL, GA, IL, IN, KS, KY, ME, MD, MA, MI, MN, MS, MO, NE, NV, NJ, NY, NC, ND, OH, OR, PA, SC, TN, TX, VA, WA, WV, WI, DC, PR.

The online course on the nurse's role in climate change is exemplary of the integration of cognitive attributes to approaching learning on climate change as a process. By design, the course applies themes of climate science to the context of nursing and healthcare. By doing so, the course incorporates the learner into the broader system with a clear personal, self-referential linkage between the individual and complex system. The course yielded unusually positive results as reflected in learner satisfaction surveys. 81 percent of learners strongly agreed or agreed that the course improved their understanding of climate change. A little less than 4 percent strongly disagreed or disagreed with this statement. The majority of the learner population for this course strongly agreed or agreed that the course was clear and easy to understand (despite the introduction to intermediate-level climate science), and indicated that they would recommend the course to others; they were satisfied overall; the course enhanced their knowledge on the subject; they have an increased awareness of a nurse's role in adaption and the effects on health; and finally, the course provided content relevant to their everyday jobs. Learners represented over 30 states across the United States.

These results align with the adult learning theory, stating that adults requiring experience as the basis of activity are most interested in learning subjects that are

relevant to their professional and personal lives, that adult learning is problem-centered, and that learners perform best when involved in the evaluation of their instruction.[60] Additional factors in favor of the climate learner, in this case, the "nurse's role in the climate change" course are the characteristics of self-direction in an online learning environment, the use of previous experience as a resource for acquiring new learning, a readiness to learn, orientation to learning for immediacy of application, and an intrinsic motivation.[61]

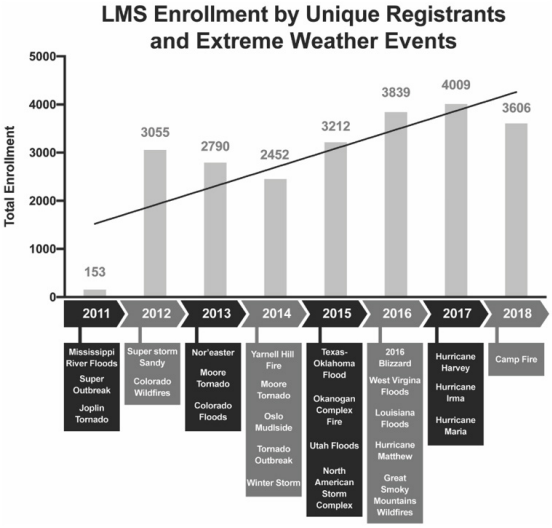
Important considerations and limitations in this method include online modality, potential job requirements, and limited knowledge of behavior modification. Online modalities provide a unique learning environment where learners are at the liberty to take cognitive risks that otherwise may be muted in physical learning environments. The expression of perspectives and willingness to test preconceived mental models may be less constrained in an online training. The level of intrinsic motivation of learners engaging in the course is unknown. Methods of instruction that address professional roles in the workplace are susceptible to the learning initiative becoming assigned as a job requirement (i.e. annual required training), which threatens to undercut learner motivation. The learning satisfaction data is an excellent measure of immediate reaction to the course content; however, it is limited insofar as behavioral change may also occur outside of the course. Further research using the self-reference effect must go beyond initial response data and examine the effectiveness of tangible behavior modification as well as surface the interplay of additional cognitive dimensions.

Discussion

Since 2011, the NCDP hosts a Learning Management System (LMS) that offers a vehicle for disseminating critical pedagogy. It also serves as an instrument for incorporating climate change knowledge into relevant learning instances designed for a vast array of decision makers. The NCDP's LMS hosts over twenty thousand learners with significant growth per registrant per year (Figure 2). Astonishingly, no comprehensive marketing of the LMS has occurred since approximately 2014, even though the severity and frequency of disasters have elicited an organic demand for learning opportunities. Climate change is a contributor to extreme weather-related events, and such extreme weather events help the public conceptualize the larger process of climate change. The organic demand demonstrates the public's desire for training on matters of preparedness, recovery, and climate. In response to the demand, an onus to find and improve methods of instruction become even more prevalent to meet the needs of learners in an effective way. Data from public discourse and behavioral science, and insights from learning and teaching, helps one to gauge useful cognitive dimensions relevant for mental modeling and the learning

efficacy of their application. Such learning efficacy, in relation to increased demand and urgency for learning opportunities, has reached near apotheosis to respond to climate change and equip people to navigate the many implications.

Figure 3:



Timeline shows year to year unique enrollments to the NCDP LMS. The timeline includes an abridged list of extreme weather events in the United States from 2011 to 2018. Note that 2011 was the first year of a public-facing LMS and therefore has a dramatic uptick in trendline.

Global Context

There is a need for comparative studies conducted across countries and cultures that differ on socioeconomic, political-ideological, and other dimensions to obtain a more encompassing method of instruction.[62] Historically, public understanding in other countries appears to be much more cohesive with scientific understanding than it is in the United States.[63] That said, the denialist movement, previously a phenomenon unique to the United States, is spreading across the globe.[64] There is a need for multiple methods of instruction for climate change, as it is abundantly clear a single method is far from sufficient. Though the intention of this paper was to discuss one such method, leveraging cognitive dimensions to appeal to adult decision support stakeholders within an interpretive community in order to refine existing mental models of climate change. Informational interactions on the themes of climate change, in the form of media and informal interactions, have contributed to an impersonal object bias of how people in the United States understand climate change. Such interactions have imparted a metaphor that presents a series of cognitive obstacles of how to move understanding beyond the static object understanding of climate change and towards a systems level understanding. Educators and scientists

globally are tasked with designing new methods of instruction that account for the locally relevant information transactions and the identification of cognitive dimensions, universal and local, that hold human action collectively at a standstill. Climate change and morality, affective response to climate change, associated mental models and heuristics, and the role of the self are cognitive dimensions that demand attention. However, it must be noted that cognitive dimensions may have different levels of importance culturally to processing specific phenomena. In line with Social Cognitive Theory, factors that contribute to this variance are economic conditions, socioeconomic status, education, and family structures.[65] Additionally, the understanding of the role of the self in collectivist cultures versus individualistic cultures is another such example of the localized dichotomy of cognitive dimensions. Globally, analyzing public discourse, identifying additional cognitive dimensions, and active experimenting in learning and teaching will assist in surfacing learning that leads to pro-environmental cognition and action. Methods of instruction must not experience a similar oversimplification that neglects the unique ways in which every individual engages with the planet. ♔

Acknowledgements

A special gratitude to Dr. Thomas Chandler, Dr. Sabine Marx, Leona Nease and the NCDP Staff.

Notes

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[6] Jack Mezirow, Transformative Dimensions of Adult Learning (San Francisco: Jossey-Bass, 1991), 4-5.

[7] Climate change for this paper refers to the anthropogenic carbon emissions produced by a diverse group of people globally, which by consuming a shared resource, such as atmospheric absorptive capacity, threatens climate systems and harms people of present and future generations. Marco Grasso, "Climate Ethics: With a Little Help from Moral Cognitive Neuroscience," Environmental Politics 22, no. 3 (2013); Elisaveta P. Petkova, Jeffrey Schlegelmilch, Jonathan Sury, Thomas E. Chandler, Cynthia Duran Herrera, Shwetha Bhaskar, Erin M. Sehnert, Stephanie Martinez, Sabine M. Marx, and Irwin E. Redlener, "The American Preparedness Project: Where the US Public Stands in 2015," (Research Brief, National Center for Disaster Preparedness at Columbia University's Earth Institute: 12 May 2016), http://dx.doi.org/10.7916/D84Q7TZN.

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