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International perspectives on the pedagogy of climate change

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ABSTRACT

Education is key to the advancement of environmental sustainability. Climate change education is a complex topic where a number of factors play key roles. One such factor, namely the ongoing debate around whether climate change is real poses a significant challenge to the delivery of a climate change curriculum. This factor and others suggest the need to revisit the question of education for sustainability across wider social contexts. The purpose of the following article is to extend previous research and consider how education for sustainability is envisioned across culturally diverse settings around the world. Drawing from survey and interview data, distinguished scholars from Brazil, China, Germany, Mexico, Saudi Arabia, and the United States of America provided detailed analyses of the social context of climate change and their visions of an education for sustainability. Results of the survey data indicated that the U.S.'s withdrawal from the Paris Climate Change agreement, political and economic barriers to climate change, sustainability initiatives, and university-industry linkages were notable contextual features of a climate change pedagogy across the countries studied. In addition, the scholar's visions of an education for sustainability revolved around five main visions: teaching all forms of scientific knowledge as rooted in some level of uncertainty, complexity, and nuance; comprehensive empirical knowledge of climate change that includes its main principles, myths, and debates; critical inquiry, integration, and engagement with global and cross-disciplinary perspectives; transformative and learner-centered pedagogies conducive to a climate change and sustainability curricula; and student-learner authentic participation in the study and mitigation of climate change. The implications for the practice of education for climate change are discussed. It is argued that global insights have the potential to enrich the practice of education for climate change and towards a more sustainable future.

1. Introduction

In September 2017, the strongest Atlantic basin hurricane, Irma, hit the state of Florida causing catastrophic damage. According to Miller (2017), Irma was a Category 5 hurricane with winds above 185 mph that dropped to 135 mph when it hit Florida and the square mileage of its tropical storm winds were 70,000; larger than Florida's territory itself. Irma caused the evacuation of an estimated 6,300,000 people in Florida; the largest evacuation in the United States to date. After Irma's landfall, 1,300,000 people were without power, many roads were blocked, and several neighborhoods were flooded. Overall, Florida's economy took a major impact. Weeks after Irma, hurricane's Harvey and Maria hit Texas and Puerto Rico,

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causing long-term damage. Were these catastrophic natural events or were they human-induced? Experts and laypeople alike, suggest that there is a link between natural phenomena, like hurricane's Irma, Harvey, and Maria, and climate change.

As a pressing social issue, climate change was not in the public interest on an international scale until former US Vice President, Al Gore et al. (2006) underscored the issue of global warming and its anthropogenic causes. This triggered a great deal of interest across several sectors of society to understand climate change. However, many facets of the public have not agreed with anthropogenic causes of climate change, including the current president of the United States of America. In general, however, people accept that the planet is getting hotter with a degree of certainty, but often resist the idea that human-induced behaviors are changing the climate on the planet.

Whatever the cause of climate change, the fact is that climate change happens and society will need to learn how to adapt to it. In response to this challenge, colleges and universities have begun to collaborate with communities by providing climate adaptation education to their graduate and bachelor students in order to obtain the competences related to the new risks posed by a changing climate (Second Nature, n.d). With this purpose, professors around the world are modifying their curriculum across a diverse range of disciplines. Typically, a hard-science perspective has dominated the discourse of climate change because the scientific community and society usually accepts its principles with a degree of certainty (Wachholz et al., 2014). However, climate change is not solely a physical science problem, requiring physics and chemistry for the solution. It is also a social scientific problem and the social sciences are just as central to solving environmental challenges. A climate change curriculum with social content, however, is more complicated largely due to the myriad of location-specific social factors that impact human contributions to and consequences to climate change (Penalba et al., 2012). It has been argued elsewhere that a climate change curriculum needs to be holistic; one that fosters students' ability to take part in a more sustainable future and one that takes into consideration the four thematic areas in the UNESCO Climate Change Initiative: scientific, educational, environmental, and ethical (2010). This means that it requires the will and ability of people to work together regardless of cultural or disciplinary divisions (Glasser, 2009).

Climate change education is a complex topic where external factors play a key role. External factors, namely the ongoing debate around whether climate change is real poses a significant challenge to the delivery of a climate change curriculum. Climate change education is also affected by socio-demographic factors and governing structures (Mycoo, 2015). For example, one of the biggest challenges to date is the US president taking on an obstructionist role around large scale climate change initiatives, like the Paris Climate Agreement (Shear, 2017; Worland, 2017). Moreover, when teaching climate change, it is not unusual for science professors to face significant barriers to the delivery of such curriculum (Colston and Vadjunec, 2015).

1.1. Teaching climate change

The fundamental role of the educator is to help students become better thinkers and life-long learners. This undertaking is not one activity per se, but a collective of practices like the ability to recognize facts, to practice reflective skepticism, and to adopt different perspectives when evaluating new ideas and issues. However, teaching students to become better thinkers and life-long learners is neither content neutral nor is it context neutral. That is, it is simply not a function of how well students master the material in their respective classes. Students enter the classroom with stuff already inside them; they already have deeply rooted conceptions and ideas about the world. The inclusion of complex, contentious, and politically charged topics, like that of climate change present a number of challenges to educators and to a sustainable development curriculum, more broadly. The political dynamics of climate change are among the most controversial involving conflicting interests and values. Sadler et al. (2004) suggest that good instruction in social-scientific issues like climate change and sustainable development involves educators having an understanding of the assumptions, blind spots, and reasoning processes held by students. Therefore, it is important to consider the possible complexities entrenched in a climate science curriculum so as to improve the practice of education for sustainable development.

In the June 5, 2017 New York Times article, "Climate Science Meets a Stubborn Obstacle: Students," psychologist, Dan Kahan notes, "what people believe about global warming doesn't reflect what they know, it expresses who they are (Kahan, 2017)." Indeed, one of the most common and problematic phenomenon is motivated reasoning; a form of reasoning in which people construct arguments in a biased fashion to arrive at a preferred conclusion even if logic and evidence has shown that conclusion to be wrong. Moreover, a number of well-known cognitive biases and blind spots observed in the psychological literature have been shown to affect people's ability to evaluate information effectively. Bias refers to the distorting influences on present knowledge, beliefs, and feelings from previous expectations and experiences (Schacter, 1999). Cognitive psychologist, Fredric Bartlett's (1932) seminal studies on memory were the first to establish that learning and memory are influenced and even distorted by current knowledge and expectations. That is, information that is processed, stored, and later retrieved are highly dependent on and swayed by our biases, pre-existing knowledge, and beliefs. Indeed, students and people alike, have difficulty accepting certain kinds of information because of their biases.

Ideally, one's previous beliefs should be the anchor to the evaluation of new information. Depending on how credible that new information is, one's previous beliefs should be adjusted. However, people are often unable to escape the pull of their prior attitudes and personal beliefs in the processing of new information. Instead, what often happens is that people make adjustments to the new information that they encounter to fit with their presently held beliefs (Kunda, 1990; Sadler et al., 2004). In the psychological literature, this phenomenon is a highly pervasive and profound bias known as the confirmation bias (Wason, 1960). The confirmation bias is an umbrella term used to refer to a variety of phenomena (e.g., confirmatory bias, belief perseverance, myside bias). It refers to the tendency for people to search out, interpret, and remember information in ways that confirm their preexisting beliefs (Oswald and Grosjean, 2004; Wason, 1960). The confirmation bias is a complementary tendency to motivated reasoning in that it involves the automatic propensity to notice data that fit our beliefs. For instance, within a science classroom setting, Roth and Anderson (1988) showed that students often disregard the material in science texts that contradicts their preexisting beliefs. A number of researchers have also found that science students place data that goes against their personal beliefs in abeyance; leaving one's initial beliefs intact and unchanged (Brewer and Chinn, 1991). Similarly, other studies have established that people preserve their personal beliefs by reinterpreting contradictory evidence. In these situations, the individual accepts the new data or evidence as something that should and can be explained by one's preexisting theories (Wisniewski and Medin, 1995). Consequently, people are often resistant to an analysis of their beliefs, especially those formed on the basis of personal experiences. Instead of modifying those beliefs in the face of new data or information, people regularly maintain

old ideas and reject and distort new ones (Chinn and Brewer, 1993, 1998).

Theorists suggest that people believe that their own beliefs are a distinctive and authoritative source of knowledge and place much value on them to the extent to which those beliefs have explanatory power (Preston and Epley, 2005; Williams and Lombrozo, 2013). The idea that personal beliefs and attitudes have a distinct eminence in everyday observations is principal to how many people make sense of the world and is often reinforced by Western cultural norms (Trosset, 1998; Carey and Smith, 1993). Carey and Smith (1993), for example suggest that the assumption about the unique power of one's own beliefs are part of what they call a common-sense epistemology; that all knowledge is subjective, unproblematic, and no more right than any other. They propose that people who hold such an epistemology are unknowing to the influence of their own subjectivity in the establishment of their beliefs.

Research also suggests that our biases are largely driven by affect (Zajonc, 1980). That is, our strongly held beliefs are predominantly informed by affective responses where reasoning about something takes place after an evaluation has been made (Haidt, 2001). Abelson's (1963) concept of “hot cognition” also suggests that all thinking is suffused with emotions that arise automatically within milliseconds. Accordingly, emotions can frequently be blinding, limiting one's ability to reason objectively. What this may mean in a climate science classroom setting is that once students have made their initial gut level evaluation about climate change, they may be unlikely to change their minds or be open to alternative evidence, because of the strong emotional content tied to their particular evaluation. Even in the face of overwhelming contrary evidence, students may still manage to maintain initial views through selective attention, biased reasoning, and affective processing (Vartanian and Goel, 2008).

Taken together, previous research in psychology shows that people are often unable to escape the pull of their prior beliefs when processing new information. As such, students' entrenched, deep-seated, favored personal theories may present a daunting challenge to a climate change and sustainability curriculum. Additionally, students underlying beliefs about knowledge in terms of what knowledge is and what type of knowledge has authority and explanatory power, can also impede the knowledge construction process within a climate change and sustainability curriculum. Finally, once students have made an initial emotion-laden assessment about climate change, they are unlikely to be open to new information. Together, these psychological factors beg the question of how educators for sustainable development can accomplish their educational mission, namely to encourage students to adopt sustainability values. Unfortunately, there is no easy answer. The research suggests that a climate change and sustainability curriculum should include content typically found in a climate change and sustainability curriculum coupled with the psychological; namely the beliefs and practices that students bring into the classroom. This means that educators may need to insist that students evaluate and critique their own beliefs and common-sense epistemologies.

1.2. The current study

In summary, education for sustainable development is key to the advancement of environmental awareness and global responsibility. However, as evidenced by the above review, education for sustainability has its own set of unique contextual and psychological challenges. This suggests the need to revisit the question of education for sustainability across wider social contexts. Hence, the purpose of this article is to extend previous research and consider how education for sustainability is envisioned across culturally diverse settings around the world (Starke-Meyerring, 2010; Wachholz et al., 2014). Specifically, distinguished scholars from Brazil, China, Germany, Mexico, Saudi Arabia, and the United States of America provided detailed analyses of how the international educational community foresees ways in which education and pedagogy have the potential to create a more sustainable world. It is our hope that these efforts will help better inform the practice of education for sustainable development across multiple social and cultural settings.

2. Methodology

2.1. Research approach

The research approach used was qualitative in nature. The choice of this approach followed from the overarching research question, the exploratory nature of the research project, and the researchers' interpretivist/descriptive theoretical position (Creswell and Creswell, 2017). In contrast to testing predetermined hypotheses, qualitative research is an approach to research that emphasizes “exploring and understanding the meaning individuals or groups ascribe to a social or human problem” (Creswell and Creswell, 2017, p. 4). Such approaches are most often used for broad open-ended research questions where data are a rich, holistic, and complex description of a social phenomenon rooted in real life contexts. With an emphasis on real life contexts and “thick description”, a qualitative research approach was well suited to the topics of education as it relates to climate change and sustainability.

2.1.1. Participants and sampling method

Six university professors were chosen to contribute via a purposive sampling method. These specific professors were chosen because of their high academic ranking including emeritus, senior, and tenure status or he/she had been the principal researcher on sustainability projects related to climate change. Moreover, each professor was based in a country with high carbon dioxide emissions: Brazil, China, Germany, Mexico, Saudi Arabia, and the United States of America. The professor's respective universities were of varying sizes and located in a range of different environments.

2.1.2. Method and procedures

In this study, two methods were used to provide insights into the scope of knowledge about teaching climate change via different international perspectives as well as the socioeconomic disparities specific to each culture. First, an electronic survey was given to all professors to fill out. A survey was used to capture general background data on the social context of climate change and sustainability across each professor's country. The survey questions were open-ended and developed from the relevant research literature in the field (Levy and Patz, 2015). Key questions included the following: What measures/actions have been proven to be effective at cutting down greenhouse gas emissions in country?; According to the specific circumstances of your country, what is, in your opinion, the best possible alternative energy source to produce electricity and why?; How does the government and private companies ensure sustainability?; What are the major barriers obstructing the national climate change targets in your country?; What's the citizen's role to comply with the Paris Commitments?

To provide a more in-depth commentary on teaching climate change, asynchronous-online semi-structured, open-ended interviews were conducted with each professor. The interviews were designed to explore a range of different issues related to climate change and sustainability in higher education institutions in each

professor's country. The discussions were largely unstructured and the primary task of the interviews were to initiate discussions. But certain themes were explored, as well as allowing each professor to describe their particular experiences and perspectives. In addition, two main questions were used to stimulate and guide discussions: What are your general experiences about international perspectives of climate change? How should climate change and sustainability be taught in your country in order to form the future generation of bachelor students?

2.1.3. Analysis

The primary objective of the survey was to identify and describe the contextual features embedded in the pedagogy of climate change across multiple cultural locations. Because of the open-ended nature of the survey, experts' responses were analyzed using thematic analysis. Thematic analysis is a general term that includes a wide range of research traditions. Braun and Clark's (2006) widely cited work define thematic analysis as, "a method for identifying, analyzing, and reporting patterns (themes) within data" (p. 79). The analysis includes a search for themes that emerge from data that describes some phenomenon of interest. Thematic analysis is a useful and flexible research analytic approach that allows for a rich and detailed thematic account of data. The thematic analysis of the survey data was informed by Braun and Clark's (2006) guidelines. To start, the data was read several times to get a general sense of it as a whole. Next, using an inductive coding strategy, repeated words, sentences, and phrases were noted to identify preliminary features of the data. Third, the initial codes were read several more times using tables and visual mapping noting relationships and feedback loops between codes. The main purpose of this step was to identity potential themes emerging from the data. The themes were then 'defined and refined' with the aim of articulating the 'essence' of each theme and to the larger narrative the themes were describing regarding a climate change pedagogy (Braun and Clark, 2006). Finally, the validity of the themes (described in detail below) were tested, going back to our initial steps when necessary. More pointedly, how the themes gave evidence to the various contextual features involved in an education for sustainability across multiple social and cultural locations were considered.

The experts' particular visions for an education for sustainability were analyzed and reported in two forms. First, following instrumental case study and participatory action learning approaches that both emphasize diverse, local, contextual, first-hand knowledge, the research team aimed to understand the scope of knowledge around teaching climate change from the standpoint of the participants/experts themselves (Kemmis and McTaggart, 2005; Revans, 1982; Stake, 1995). As such, each expert's vision for teaching climate change are presented in full. The intention was to understand the experts' perspectives in an open-ended manner with the researchers' interpretive influence minimized. A more concise general understanding of these data using broad thematic analysis are provided in the discussion section (Braun and Clark, 2006). In particular, a similar thematic analytic strategy as described above was used to theorize their broader application to the scope of knowledge around teaching climate change. The results presented in this way fulfill the aforementioned purposes of this research.

2.1.4. Verification and validation

To evaluate the validity of the analysis, the concepts of credibility, dependability, and trustworthiness were exployed (Lincoln and Guba, 1985). Firstly, Lincoln and Guba (1985) argue that credible, dependable, and trustworthy data comes from close collaborations with research participants throughout the research process. Taking these ideas into account, participant's views were built directly into the study. In particular, participants were involved in every aspect of the research project as co-researchers and co-authors. Secondly, Lincoln and Guba (1985), describe member checking as the most crucial practice for determining credibility. Member checking is a systematic check of the data via taking it back to the participants themselves. To facilitate this process, research participants reviewed, commented, and added onto the findings. To this end, their recommendations were incorporated into the analysis and final write-up.

3. Results

The results are reported in two sections. The first section are the results of the supplementary survey data. As noted above, the purpose of this section is a consideration of the various external factors and key circumstances that play a role and are embedded in the pedagogy of climate change. The second section are the results of the interview data. This section describes each professor's vision of an education for sustainable development within higher education institutions.

3.1. Complementary survey

Participants' survey responses were diverse, complex, and nuanced to their particular socio-cultural location. However, four main themes were identified that describe the contextual features of a climate change pedagogy: the Paris Agreement, political and economic barriers to climate change, steps toward sustainability, and university-private sector linkages. These four themes are elaborated below.

3.1.1. Theme one: The Paris Agreement

A notable contextual feature all professors noted to be interconnected to a climate change education was the Paris Agreement; the first international agreement where each country determines and plans how they will reduce Greenhouse Gas Emissions (GHG) by 2030. Interestingly, the level of public awareness of the Paris Agreement varied across the countries studied. In Germany, for example, the large majority of Germans are very much aware of climate change and are strongly in support of Germany's energy transition. The Chinese, Brazilian, Mexican, and Saudi Arabian experts also coincided in the need to raise awareness to comply with the Paris Commitments. Despite the unevenness of awareness, most of the countries in this study, except for the United States of America, are expected to reach important reductions in the carbon intensity of their Gross Domestic Products (GDP) in response to the Paris Agreement. For instance, by 2025, China is proposing a 40–45% reduction in its carbon intensity of GDP and by 2030, they plan to lower their carbon intensity of GDP from 60% to 65%, below 2005 levels. The national reduction target in Germany by 2020 is minus 40% and by 2025 is minus 45%, taking the 1990 levels as a baseline. Similarly, Mexico created a General Law on Climate Change that has a national reduction target of 22% by 2025 and 50% reduction target by 2030 of its GHG, taking the year 2000 as a baseline. Similarly, Brazil is expected to reduce their GHG by 37% by 2025 and 43% by 2030. Although, Saudi Arabia has not set a baseline, they seek to reduce their GHG by 130 $MtCO_2e$ in 2030. Moreover, they aim to increase the share of its renewable energy capacity in the total energy mix to 9.5 GW by 2023. These optimistic projections, however, are in contrast with the current vision in the United States of America, which has decided to withdraw from the Paris Agreement. The United States of America is now the only country opposing the Paris Agreement.

3.1.2. Theme two: political and economic barriers to climate change

While all climate change targets are laudable, professors noted that there is still the issue of whether sustainability initiatives are compatible with economic growth. So far, in Mexico, energy reform has not yet reflected in a healthier economy. Similarly, China and Brazil are in the process of changing their economic model based on fossil fuels; therefore, effects on their economy have not been evaluated. In Germany, however, the experience in the environmental protection sector dictates that the economy has strengthened sustainability initiatives. The same situation is expected in Saudi Arabia particularly because diversifying the economy is one of the major goals of the government's Saudi Vision 2030.

Despite the uncertainty of economic growth, the Arabian and Brazilian experts felt optimistic about accomplishing the climate change targets in their countries. Yet, in China, the question of whether sustainable initiatives cause economic growth was a major barrier. In particular, there was uncertainty around whether sustainable initiatives would grow the economy. In Germany, the major barrier was the continued reliance on fossil energy, the national electricity mix still missing grids for power transportation, and missing storage technologies. Moreover, the German expert also noted that Germany made the mistake in restricting the use of nuclear power until December 2022. The expert from Mexico noted that the biggest barrier in Mexico are political forces and private interests that could potentially overhaul the new Climate Change Law. This was the same worry for the American expert who claimed that the current political party in power in Congress and the Presidency has directly affected climate change programs and regulations. Furthermore, all experts noted the US president's skepticism on Climate Change was a big disruptor of the Paris Agreement and that such actions may create a domino effect for other countries.

3.1.3. Theme three: sustainability initiatives

The current efforts to reduce GHG emissions in each country were broad and diverse revolving around decarbonizing the energy sector and enhancing the use of renewable energies. China, for example, is working on developing projects to decrease its carbon consumption. Germany's energy transition (Energiewende) is moving its energy sector towards renewable energy sources having reached 38% of its brutto electricity consumption in September 2020. Germans are also increasing the energy efficiency in buildings and industry. These efforts have been successful in terms of reducing GHG, although the 2020 reduction target of minus 40% vs. 1990 level cannot be achieved without reducing its electrical power generation from lignite combustion. Mexico is one of the few countries that developed and enacted a Climate Change Law. The law contains sweeping provisions to mitigate climate change. The country also promulgated Energy Reform to enhance clean energy. With these policies in place, Mexico expects to reduce Black Carbon and to promote renewable energy. Despite these positive changes, it has not been without criticism. Specifically, the Mexican government has been criticized for including natural gas as clean energy despite the fact that is a fossil fuel and emits Carbon Dioxide.

In Brazil, it has already reduced the consumption of hydrochlorofluorocarbons (HCFC). Brazilian sustainability efforts have focused on converting the use HCFC gases to more sustainable alternatives. The country also stopped using 168.8 tons of the HCFC141B gas in the foam sector and 51.5 tons of HCFC22 in the refrigeration sector. Efforts to reduce deforestation in the Amazon and increase energy use from hydropower and other renewable sources, including wind, solar and biomass have also been implemented.

The Saudi Arabian government has taken various steps toward sustainability including a five-year plan to reduce energy consumption through policy initiatives, such as the National Energy Efficiency Program, and the Saudi Energy Efficiency Centre (SEEC). The latter is a royal decree established by the King Abdullah City for Atomic and Renewable Energy that conduct research and implements national atomic and renewable energy policies. The country has also adopted renewable energy policies for electricity generation. The United States of America presents a bleaker picture, however. After the current president signed an executive order to rescind the Obama Administration's Climate Action Plan, the current practices to reduce the climate are uncertain. For instance, the current administration rescinded the CO_2 Emission control regulations from Power Generating plants issued by EPA in 2017. Fortunately, for climate change lobbyists, several states, cities, universities, and private organizations keep working to lower their cap on carbon emissions.

Regarding the question of alternative energy sources for the future, according to the experts in China, Mexico, and the USA, wind, solar, and hydroelectric power are the best possible alternative energy sources to produce electricity in future. In Saudi Arabia, photovoltaic and concentrated solar power are important alternative sources of energy in Saudi Arabia and also offer opportunities for students to conduct research. Brazil is the largest renewable energy producer in Latin America and has been successful at using hydropower, its' the major source of alternative energy, followed by wind power. Finally, in Germany, offshore and onshore wind power has the potential to be a major alternative energy source and due to significantly dropping production costs have nearly reached grid parity.

3.1.4. Theme four: university-industry linkages

All respondents considered the potential for instituions of higher education to be change agents in the advancment of more sustainable practices. The experts coincided that engagement with industry is fundamental to transforming today's climate crisis and universities have to strengthen their relationships with local key stakeholders. Science and technology are the main drivers of innovation and university-industry linkages are vital to this process. Currently, all countries have forged partnerships with varies industries to strengthen their capacity for sustainable development. In particular, industry-university partnerships to develop Clean Development Mechanisms projects (CDMP) are found in each of the expert's respective counties. The experts also noted that partnering also brings many direct benefits to students themselves. Specifically, it enables students to put to practice in industry the knowledge they obtain in the classroom about climate change.

3.2. Visions of an education for sustainability

The next section are the results of the interview data of each professor's vision for an education for sustainable development within higher education institutions. As noted previously, each expert's vision for teaching climate change is presented in full and then a more concise general understanding of these data using thematic analysis are provided in the discussion section.

3.2.1. The American vision

It is not possible to discuss the US perspective on climate change education without acknowledging the country's abrupt withdrawal from the Paris Climate Change Agreement of 2015. The Paris Agreement was signed for the US by then-President Obama in April 2016, together with 195 other nations. The withdrawal by the next US president on June 1, 2017, appeared to put a symbolic damper on the efforts of the US to control climate change. However, a strong reaction against the withdrawal was made public by US states, major cities, educational institutions, and businesses. The vigorous

scientific work on climate change continues unabated in the US. This includes academic institutions such as universities, research institutes, and NGOs engaged in teaching and research about climate science. Many academics continue to develop curricula and research-to-practice projects aimed to increase the understanding of altered and degraded ecosystems caused by climate change.

Programs from climate Science-to-Practice have developed across academic institutions in the US. Extensive summaries of knowledge and strategies are found in three recent comprehensive resources on the subject (Balbus et al., 2017; Levy and Patz, 2015; Luber and Lemery, 2015). The focus of the textbooks and report cited above is appropriately the impact of climate change on human health. Higher education programs in climate science must pay serious attention to the human health consequences as a basic educational topic.

All the authors in these comprehensive references agreed that students from multiple scientific disciplines must have access to curriculums covering the following topics: the scientific basis of Climate Change Science; impact on public health; threats to human security and welfare; mitigation and adaptation strategies to extreme weather events, and special preparation for public health and clinical health professionals.

The challenge to higher education is to provide the scientific basis for understanding and acting to address climatic change as a key element of this sustainability revolution. First, there is a need to communicate to policy makers and the general public on the policies necessary to transition to a clean energy economy. This includes sustainable transportation, sustainable agriculture, and sustainable industrial production. Second, there is also a need to communicate with health professionals and scientists on the policies, methods and tools to systematically analyze, assess and recommend actions on the new health threats to public health caused by climate change.

Applying public health context to climate change leads to an understanding that the “first line of defense” to mitigate climate change effects on population health are the workers on the service industries in the world. Health care practitioners should be alerted to attend to the health impacts on these “first line of defense” workers who would be the “climate canaries” of climate negative changes (Roelofs and Wegman, 2015).

There will be an increase in frequency, intensity, and duration of extreme weather events, temperature, precipitation, hurricanes, tornados, wildfires, and infectious diseases, caused by swelling vector populations at warmer temperatures. These climate mediated conditions especially affect “first line of defense” workers who work outside, such as many in the sectors of construction, utilities, energy, communication, and transportation. Educational institutions need to educate and develop strategies for the protection of these workers as one of the new important tasks to address climate change. There will be a necessity to develop new policies and curriculum to address the occupational health hazards and the amplified risk of mitigation related jobs. The task is to translate abstract science into plans for healthy living and survival, through a research-to-practice continuum.

3.2.2. The Brazilian vision

Like in many other countries, the worldwide economic recession has had a negative effect in the fight to reduce GHG as pledged in the Paris Agreement. Moreover, the intentions of the US to abandon the Paris Agreement would affect to some extent the achievements of the Brazilian targets in the future. The magnitude of this effect in Brazil is uncertain; however, it can be minimized by increasing climate change awareness and knowledge in Brazilian society.

Nowadays, climate change is perceived among Brazilians as a phenomenon that might change the lifestyle and behaviors of Brazilians, but there still is a lot of confusion due to a diversity of opinions. The means, the politicians, and public administrators are accountable for the lack of public awareness due to their short-term vision that does not allow people to realize the seriousness around climate change. The lack of visionary leaders had forced higher education institutions to form future leaders with strong science and social knowledge to counterattack climate change. Taking into account this context, the strategy to strengthen climate change pedagogy should contain the following key strands.

First, it is necessary to provide empirical knowledge about global warming. This has to be done not only with students in engineering or hard-science colleagues, but also among social disciplines where students have difficulty in understanding how emissions cause global warming. Clearly, the use of experiments in the classroom has a key role because it allows students to understand how the excess of greenhouse gases cause global warming.

Second, the physical principal of greenhouse gases must be taught. In general, there is still a lot of ignorance about how greenhouse gases increases the temperature on the Earth. The relation between radiation and matter is harder to understand for non-science oriented students and for this reason, a climate change pedagogy must include tools to facilitate learning of these hard concepts to non-science students.

Third, teachers must dispel archaic ideas and paradigms about climate change. The myth that global warming has occurred since the beginning of the planet and will repeat in a cyclical manner has to be broken. This paradigm has been used a lot among global warming skeptics in order to not harm business productivity. In this context, it is important to teach students that the evolution of the Earth has always been irreversible and from that perspective, no process is repeated.

Fourth, in the classroom, students must be taught that what is known about climate change is limited. So far, it is understood how climate change occurs and there is reasonable ground for suspecting that anthropogenic sources are increasing the temperature in the Earth. Yet, there is a lack of knowledge to explain with certainty how anthropogenic sources aggravate this natural phenomenon.

International perspectives are inherent to the strands presented above, Brazilian professors must be aware that climate change is a global phenomenon that happens everywhere; therefore, cultural differences need to be taken into account when teaching climate change courses.

3.2.3. The Chinese vision

The US withdrawal from the Paris Agreement reflects a rejection of multilateral agreements. This is an invitation for rethinking global governance and amounts to an encouragement to China to play a more important role. China has adopted proactive policies and taken active actions to mitigate climate change, including the strategy and plan to construct a knowledge system of global climate change in higher education institutions.

Global climate change education involves a broader range of issues, not only science but also political and economic issues, such as climate negotiations, carbon reduction, and carbon tariffs. Moreover, as a general education, global climate change education is mainly aimed at non-geoscience undergraduates. Chinese universities created an Environmental Science and Public Policy curriculum for undergraduates. The purpose of this curriculum is to train students to understand the scientific and technical side of complex environmental problems as well as its' economic, political, legal, historical, and ethical dimensions, so as to enhance their awareness of global climate change and toward capacity building of China's response to climate change.

Global climate change education should have the characteristics

of an inter-disciplinarily, cross-sectional, practical, and comprehensive course of study. In this regard, it is necessary to actively explore teaching modes suitable for global climate change education and continuously improve and innovate existing teaching methods. For example, traditional teaching methods have to be changed to more inquiry based-teaching, case teaching, and special lectures, making full use of multimedia (i.e., pictures animation, audio-visual, etc.) to stimulate students' enthusiasm for autonomous learning. Secondly, developing a global resource database of education on global climate change (e.g., China Carbon Emission Accounts and Datasets and China Multi-Area Input-Output Database) and using technology to dynamically enhance climate change awareness among university students, are all necessary to carry out a global climate change education. Finally, a global climate change education should motivate students to use the knowledge and skills learned in the classroom to real life through various forms of extracurricular activities. More broadly, attention should be paid to the organization and management of general education on climate change, to guide the development of environmental associations in universities. For instance, because of low carbon education practice across campuses, bikesharing is experiencing a surprising renaissance in China.

Finally, global climate change education should not only enhance students' practical application ability, but also raising public awareness of the environment, outside of the university. That is, a global climate change education should encourage students to collaborate, conduct research, share experiences with government administrative departments (e.g., Ministry of Environmental Protection, Ministry of Science and Technology, the State Council), NGOs (e.g., Shangri-la Institute and WWF), and enterprises (e.g., BP, Shell, Toyota).

More broadly, because of the many layers involved in climate change, effective education on climate change must be interpenetrated with other disciplines. Therefore, content related to climate change should be embedded into existing knowledge systems in all disciplines so as to ensure that the theme of climate change can penetrate into the entire national curriculum system effectively and persistently. For example, incorporating climate change and ancient civilization into archeology and history courses, adding environmental law into legal disciplines, adding carbon tariffs into economics classes, etc., and other disciplines are all examples of ways in which a global climate change curriculum can be incorporated into courses traditionally taught in higher education institutions.

3.2.4. The German vision

Despite world turbulence around climate change, recent public-opinion polls in Germany show a clear picture: climate change and environmental protection are one of the most important problems to be tackled in Germany, followed by migration and crime, civil security, and peace (Benthin and Gellrich, 2017). The importance of climate change issues increased slightly compared to the precursor study in 2014. Paradoxically there also seems to be an increase in skeptical opinions toward the scientific proof of anthropogenic climate change from the more populistic political wings, like the AfD ¼ "Alternative fuer Deutschland"; which won more than 13% in the national election as of 24 September 2017. This is often discussed as post-truth politics, in which debate is framed largely by emotions and beliefs, but is disconnected from scientific consensus or by presenting so called alternative facts.

There are a large variety of teaching modules and programs on climate change in German higher education which has the potential to have wider application. The "science approach", for example, is comprised of lectures about the evidence of climate change, namely its' causal-relationship. There are also ring-lectures where the topic of climate change mainly caused by fossil fuel consumption and the need to reduce GHG e.g., through renewable energies use are quite prominent and a vast majority of students in universities are required by decision of the university senate to take this mandatory courses. While these lectures are comprehensive at the bachelors-level, there are other masters-level modules where the topic is treated in more detail. Usually, the lectures aim at helping students understand the complex interplay between climatic systems and anthropogenic causes via the emissions of greenhouse gases. Moreover, these lectures aim to appraise the potential of mitigation technologies in the energy and transportation sector.

Competencies can be understood as a set of skills and functions a graduate student should fulfill in order to perform in a defined work setting. The starting point for curriculum development is, therefore, the job requirements and profile of a sustainability oriented manager. This is a professional who works in the sustainability or EHS department of a company, taking the responsibility for the implementation and effective operation of standardized management systems; e.g., ISO 14001, ISO 9001, ISO 45001, ISO 50001, ISO 27001.

Another approach is the "walk the talk: environmental management systems approach." From environmental psychology, it is well known that knowledge alone will not necessarily trigger a change in individual behavior, in terms of life style and consumption patterns or even a sustainability alignment of a company. This is one of the reasons why students are largely involved in the environmental management system (EMS). Several German universities have implemented an EMS on campus with the aim of facilitating a learning environment where the students can trough their project work, their audits, and actively contribute to the EMS. They experience success and, of course, obstacles in a real-life case study.

Finally, "dealing with skeptics approach". Despite climate change awareness in German society, there is something that could be described as 'soft denial' in a way that decisions in favor of climate mitigation (i.e. energy transition, mobility transition, agricultural transition) are not taken seriously enough, but instead are postponed. A psychological explanation may be: If one is accepting of anthropogenic causes of climate change with all its negative implications, the logical consequence would be a significant change in lifestyle towards lower-carbon footprints. This, however, is considered to be uncomfortable and, thus, unwanted. Although scientists often refuse to participate in political debates and activism in order to maintain their credibility, it seems necessary and the responsibility of the educator to avoid misleading, post-truth, alternative facts-based argumentation about climate change.

More broadly, professors can strengthen teaching with the use of instruments to facilitate the discussion of climate change within a rational framework. This has the potential to enhance students to think critically about the necessity for taking action in order to reduce GHG emissions. However, taking actions often requires the sacrifice of resources. As such, there may also be a social cost related to a restriction of liberties and democratic participation (Stern, 2007). The cost of action may be irrelevant compared to the cost of not acting at all (Harris et al., 2015; Stern, 2007; Nordhaus, 2008), as a global catastrophe would destroy life as we know it (Schellnhuber, 2010; Ehrlich and Ehrlich, 2013) (Mann, 2009). The main goal is to form and prepare students to take decisions in complex systems.

3.2.5. The Mexican vision

With the promulgation of the climate change law and the current Energy Reform, better environmental conditions are expected to fulfill Mexico's pledge to the Paris Agreement. Yet, global

challenges could erode this expectative. The withdrawal of the US from the Paris Climate Accord could dismantle, at least partially, the climate change policy in other countries including Mexico. Fortunately, if this occurs, it won't be official until the end of 2020. In the meantime, Mexico will keep addressing mitigation and adaptation initiatives to fulfill the Mexican targets related to the Paris Agreement and higher education institutions play a fundamental role because they provide the leadership to form a responsible society.

Climate change is a complex phenomenon that has its political bias. For this reason, professors at institutions of higher education should consider that education for climate change mitigation and adaptation must encompass not only the science knowledge to understand the phenomenon, but to understand that this is affected by social factors. Of course, students must learn the various elements that form this complex system. However, the intersection of other factors, including lifestyles, cultural diversity, gender as noted by the Sustainable Develop Goals 2030 need further integration into climate change curriculum.

One element that characterizes climate change education aside from other curricula is uncertainty. In this sense, universities need to prepare students to take and evaluate future-uncertain sceneries. For this, critical thinking has to be an essential attribute necessary for innovative strategies related to climate change. Critical thinking motivates the questioning of current industrial, economic, and social models, which is necessary to break paradigms beyond business as usual.

Another element is its multidisciplinary nature. Climate change cannot be mitigated by one single discipline. The climate change literature bears this out in the need for a multidisciplinary approach. The argumentation is simple: because the problem is complex, this has to be solved from different perspectives. The multidisciplinary approach mandates that climate change be explored from different disciplines connected by a unifying thread that reinforces learning. The goal of a multidisciplinary approach is that students are able students propose meaningful solutions across disciplines.

Becoming a de-carbonized society will require universities to prepare students for the employment market and to educate them to be agents of social change. At the end, the hope is that students will graduate and help the entire society foster positive personal practices that results in a reduction of their carbon footprint as a contribution to achieve the Paris Agreement goal of limiting Global Warning to well below 2 □C.

3.2.6. The Saudi Arabian vision

Arabian students must be aware of the global perspectives of climate changes in order to gain a deeper understanding of this issue, developing cognitive skills, and build their personal opinion. Saudi Arabia is one of the largest oil exporters in the world, generating more than 90% of its revenue from oil (Nurunnabi, 2017). Because of this, climate change is an important issue for the development of the country. In fact, the “Saudi Vision 2030” clearly entails the target of generating 9.5 GW (GW) from renewable energy by 2023.

The vision in higher education must be aligned with the Saudi Vision 2030, as well as the goal of academic programs related to climate change must be aligned to strategy vision in universities. For this, it is necessary that academic programs address the national vision, raise awareness, and prepare the future leaders of climate change.

Climate change programs should focus on socio-economic drivers of climate change, consequences, and associated policy agenda discussions. Teaching should typically involve a combination of lectures, seminars, and pre-learning. Some sessions should also involve computer lab sessions, which would require of the engagement of peer-to-peer teaching as well as the organization panels and debates.

Although curriculum could vary, each of them should take into consideration the following issues:

- □ To enhance critical thinking among students in order to debate how the current development in the country incorporates climate change at different stages
- □ To understand how climate change interacts within different socio-economic systems in Saudi Arabia
- □ To promote critical understanding of key social scientific frameworks applied in the field of climate change
- □ To understand what magnitude of change is required to antagonize the climate change problems regarding reform
- □ To develop certain graduate attributes or skills to produce the next generation of environment and development professionals
- □ To engage with climate policy and practice interface
- □ To address lifelong learning, extensive independent reading, research, and cognitive skills.

Program's modules should be drawn from a wide range of disciplinary perspectives, concepts, and methods including environmental science, geography, business, economics, human geography, environmental law, and social development. The programs should cover vital issues such as gender, social justice, energy access, poverty, and social protection in Saudi Arabia.

Curriculum design should be an ongoing process that incorporates a broad overview of climate change and prioritize learning objectives. Moreover, curriculum should utilize students' cognitive skills, conceptual knowledge, as well as practical skills. Students should be able to recognize climate change mitigation and adaptation from both micro and macro perspectives. Students must be able to use data and evidence to justify claims relating to climate change, adaptation, and mitigation plans. The practical skills will also include problem solving and computer skills, and evaluating the effects of alternative climate change policies in Saudi Arabia. Through various cases and fieldwork, students would gain insights into key concepts in the discourse of reality of climate change in Saudi Arabia. Linkages with local lectures in government and industry would speed up this process.

4. Discussion

Over the last several decades, climate change has received greater global attention. This had led to a series of inquiries regarding the role of education in global efforts to combat climate change. Since then, education has been one of the fundamental programmatic initiatives to sustainability (UNESCO Climate Change Initiative, 2010). In extending this work, this article concerns education in relation to climate change and sustainability. In particular, the current research examines visions of education for sustainability across multiple culturally diverse settings. Notable scholars from six different countries and four continents provided their pedagogical analyses of sustainable development as it relates to environmental education. Scholars first provided detailed analyses of the multiple contextual factors embedded in a climate change education within their respective countries. They then outlined their particular visions of an education for sustainability within higher education institutions.

The research findings suggest that experts had a range of different conceptions of what an education for sustainability should look like. A notable contextual feature of the results that was tied to and interrelated to the broader effort of education for sustainability was the US's withdrawal from the Paris Climate Change Agreement (Robinson, 2017). Generally speaking, there was uniformity in

experts' views regarding the significance of international collaboration. However, there was significant variability in interpretations regarding the consequences of the US's departure from this collaboration. For some, it represented a symbolic and long-term setback. Others noted that it had the potential to galvanize other countries to play a more central role in global climate mitigation efforts.

Moreover, these results suggest the need to incorporate more content about the Paris Climate Agreement into curriculum design. In particular, the Paris Climate Agreement could be used as model to discuss the controversies and opportunities to mitigate climate change. Although there are not miracle instructional methods that fits with all situations in each country, some prescriptive methods can be applied. One of the most popular methods among educators is the Gagne's instructional design model that describes nine instructional principles in order to enhance learning into real-life application and relevance (Buscombe, 2013). However, it is not the only one; most of the instructional models are problem-centered and involve students in activation of prior experience, demonstration skills, application of skills and the integration of these skills into real-world situations (Merrill, 2002).

Using games as a teaching approach to climate change can be an efficient instruction tool for enabling students to acquire specified skills, knowledge, and attitudes in an enjoyable environment. The use of simulation and gaming among educators for exploring and teaching climate change has increased, particularly to teach climate change in complex and highly interactive environments (Reckien and Eisenack, 2013). Simulation and gaming has a long tradition in the climate change field because players can develop a deeper and more robust understanding of complex systems embedded in climate change (Waddington and Fennewald, 2018). In the context of results, gaming might be an appropriate instructional method to operationalize and contextualize the implications of the Paris Climate Agreement.

Regarding the expert's vision of an education for sustainability, five common visions and characteristics were identified. These visions are summarized hierarchically, starting with the expert's broad pedagogical visions to more specific visions related to student's relationship to sustainability.

- Teaching science differently where all forms of scientific knowledge are understood to be rooted in some level of uncertainty, complexity, and nuance
- Comprehensive empirical knowledge of climate change that includes its main principles, myths, and debates
- Critical inquiry, integration, and engagement with global and cross-disciplinary perspectives
- Transformative and learner-centered pedagogies complementary and conducive to a climate change and sustainability curriculum
- Student-learner authentic participation in the study and mitigation of climate change

Specifically, experts highlighted the importance of taking into account multiple social and cultural locations in designing and as enriching a climate change curriculum. These results suggest that cross-cultural engagement and global interchange are vital dimensions to climate change and to the pedagogy of climate change, more broadly (Starke-Meyerring and Wilson, 2008; Starke-Meyerring, 2010). In other words, a climate change educational framework should be simultaneously local and global. The results also suggest that an education for sustainable development need to be learner-centered demonstrating how climate change is made real for students within a local and global and global context. The experts cited an array of pedagogical techniques and approaches including critical thinking and engagement with skepticism, research-to practice projects, fieldwork and experimentation, and cross-cultural exchange to bear these issues out.

Likewise, because climate change is a complex topic with scientific and social components, the experts' noted a business as usual approach is ineffective. There was a rejection of the dominant model of pedagogy rooted in the idea that knowledge is static and that teachers have monopoly over it in the classroom. The expert's visions of a climate change education would require the use of tools to enhance experiential and learning across several disciplines. Moreover, the experts underscored the premise that climate change is a multidimensional issue that requires multidisciplinary pursuits outside of the traditional physical science subject areas. The participant experts coincided in the need to include social science knowledge. This makes sense according to the American Anthropological Association that defines global climate change as a human problem that intensifies underlying social problems, accelerates migration, destabilizes communities and nations, and worsens the spread of disease (Shaffer, 2017). Fortunately, the climate change debate is also occurring in social disciplines such as politics science, economics, anthropology, geography, and criminology (Gilmore, 2017).

Taken together, education for sustainability is uniquely unorthodox. Climate change challenges the capacity for educators to teach on an issue that is inherently complex and politically charged. Despite this, the results point to the necessity of education for sustainability to embody global perspectives. We believe these data show how global insights have the potential to enrich the practice of education for sustainable development.

5. Conclusion

The nature of climate change requires a globalized approach. The strength of this study lies in its scope with insights from researchers from six nations across four continents. Together, the results offer several important insights. Firstly, no country is immune to the consequences of climate change. Secondly, it is argued that education is the primary means for achieving the goal of sustainability. There is an imperative need to educate and build awareness of climate change across multiple social and cultural locations. Thirdly, cultural context are important dimensions to the issue of and pedagogy of climate change. Specifically, sustainability embedded into theory and practice needs to be consistent with a globalized world. Different cultural insights can advance the knowledge base of the anthropogenic causes of climate change. The results also highlight the necessity to integrate local and global manifestations, impacts, and responses to climate change within the classroom. Taken together, for education to create environmentally sustainable citizens, the results suggest that a sustainable pedagogy cannot be unidimensional. It necessitates instead a pedagogy that requires students to think critically, interdisciplinarily, and globally about climate change. Such insights have the opportunity to influence the ways students engage with the question of climate change. This means that educators need more interdisciplinary and cross-cultural collaborations and more new and creative methods of teaching. The hope is that grounding the pedagogy of sustainability locally and globally will lead to better learning outcomes, improved scientific literacy, and towards a more sustainable future according to the fourth goal of the Sustainable Development Goals 2030.

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