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Climate change education in China: a pioneering case of its implementation in tertiary education and its effects on students' beliefs and attitudes

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Abstract

Purpose – In view of a lack of evidence on the effectiveness of climate change education (CCE) in China, this study aims to evaluate if a CCE course newly designed based on research recommendations and implemented with established pedagogy was effective in changing the beliefs and attitudes of first-year science students.

Design/methodology/approach – This study took a simple longitudinal approach with surveys administered at the beginning and the end of the course and the differences in the responses analyzed with nonparametric statistical analyses.

Findings – The results showed that the course produced significant changes in the beliefs concerning the anthropogenic causes of climate change and vulnerability to its impacts, which results in inequality of the impacts received. However, the course did not produce significant attitudinal changes among the students. Spearman's correlation, which affirmed the belief–attitude association, revealed that the students already had desirable attitudes toward climate change and these attitudes had not been reinforced. The students' perception of the importance of local government in climate action increased by the end of the course. Multimedia-aid learning, debates and discussions were useful in conveying the concepts of responsibility, ethics and vulnerability, but the addition of student-led community projects will increase personal significance of the course.

Research limitations/implications – This study is instrumental for the development of a regional model of CCE in the mainstreaming of education for sustainable development in China, knowing that the regional approach is crucial to address the nuances in climate change knowledge, hence conceptions and beliefs across regions and, even, between different sectors of a region. This regional experience could also serve as a reference for other similar settings, particularly those of the developing countries.

Originality/value – This study presents one of the very few studies dedicated to gauging the effects of CCE in China, particularly of a newly developed climate change course, on the beliefs and attitudes of students. This permits pedagogical development and continuous improvement of CCE in China.

Keywords Climate change, Education, Environment, Ethics, Sustainable development, Vulnerability

Paper type Research paper

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1. Introduction

With increasing scientific reports predicting a warming Earth, rising sea levels, melting ice and variable precipitation, climate change has been gathering attention from not only the scientific communities but also the global population (IPCC, 2021). Climate change has already manifested in the forms of warming surface temperature as well as retreating glaciers and Arctic Sea ice, which contribute to sea level rise (IPCC, 2021). These changes have pushed the shoreline further in certain parts of the world and threatened the coastal communities (Rajasree *et al.*, 2016; Tang, 2019). They have implications on different aspects of human lives, although the impacts differ widely depending on the vulnerability of the affected individuals or communities. Vulnerability is a complex concept that takes into consideration multiple factors such as income, education level, access to resources and geographical locations, to name a few (Thornton *et al.*, 2014).

Although there are obvious evidences pointing to the changing climate and reliable models predicting future changes of climate, views on the causes of climate change are still dichotomized, with some holding on to the natural variability of climate due to external forcing of the Sun primarily and some advocating the anthropogenic nature of climate change (Leviston and Walker, 2012). Climate change, environmental degradation and their socioeconomic implications drove the emergence of sustainable development, which is perceived to boost adaptive capacities to climate change and alleviate environmental problems (Agbedahin, 2019). Progressive emphasis on sustainable development eventually led to courses and educational programs designed to instill the various facets of sustainable development to learners of different levels. This is widely known as education for sustainable development (ESD) (Agbedahin, 2019).

ESD stemmed from the idea to integrate sustainable development into formal education, which eventually led to the United Nation's (UN) Decade of Education for Sustainable Development. The Decade has seen the transformation of the idea of ESD into a global movement (Bonnett, 1999; Hopkins, 2012). According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), ESD would capture key sustainable development issues, particularly climate change, management of disaster risk, lowering poverty and sustainable consumption (UNESCO, 2013). Tackling climate change is also emphasized in ESD for 2030, which is a succession of the UN's Decade of ESD and the subsequent Global Action Programme on ESD, to upscale the mainstreaming of ESD. It recognizes the central role of education in the move to achieve the sustainable development goals. The UNESCO promulgates a participatory approach in the teaching and learning of ESD to promote attitudinal and behavioral changes among learners while imparting competencies such as critical thinking and collaborative decision-making (UNESCO, 2013). ESD is therefore multidisciplinary, spanning the environmental, social and economic domains, and examining their interrelations as well as their past, present and future implications (Summers and Childs, 2007; Öhman, 2008). In view of the nexus of issues revolving around sustainability, a pluralistic pedagogy has been advocated to embody the diverse perspectives, views and values concerning sustainable development and reflect on such diversity (Rudsberg and Öhman, 2010). However, it is argued that the pluralistic approach would turn attention away from ecocentrism to anthropocentrism, where learners focus more on the economic and social aspects rather than the environmental aspects, and it is uncertain if ESD would garner conscious willingness in solving sustainability problems (Kopnina and Meijers, 2014; Wals, 2007). Without such willingness, it is difficult for ESD to promote attitudinal changes as intended by the UNESCO (UNESCO, 2013).

Although not as popular as ESD, courses have been designed to convey general idea or specific facets of climate change to different audiences. In line with how ESD has been

defined by the UNESCO (2013), these courses address an important facet of ESD, namely, climate change. These courses and educational programs are often collectively called climate change education (CCE) and are deemed as a subset of ESD (Læssøe *et al.*, 2009). CCE may cover a wide array of themes ranging from the science of climate change, the arguments revolving around climate change, its socioeconomic impacts and ethics to its adaptation and mitigation (Peñalba *et al.*, 2012). CCE has been regarded as a tool in adapting to climate change through provision of information and knowledge related to climate change, which can facilitate adaptation to and mitigation of climate change via attitudinal changes and research motivation (Feinstein and Mach, 2020). However, CCE has encountered numerous challenges since its inception. It has needed to deal with the ongoing arguments revolving around climate change that are frequently influenced by political factors, causing divisions in how the issue should be addressed. Supporters of economic development would view climate action to reduce emissions of greenhouse gases as a constraint to industrial development (Castán Broto, 2017). Besides, with fossil fuels still having a central role in the world's economy, the switch from fossil fuels to clean energy is challenging and requires careful policymaking. Fossil fuel companies might also be the major funders of political campaigns, thus, adding complexity to how governments respond to the issue of climate change (Matthews, 2015; Tosun and Peters, 2020). In addition to the divisions on how climate change should be addressed, views on the causes of climate change are also divided.

Furthermore, there has been dissonance in the emphasis of CCE, with the scientific community taking a hard-science stance dominated by the physical science behind climate change and the probabilistic nature of climate modeling and predictions (Sandra *et al.*, 2014). Some researchers argue that the multidimensional nature of climate change would also require social scientific approach due to its far-reaching socioeconomic impacts (Peñalba *et al.*, 2012). However, the social content of CCE is complex particularly because the social implications of climate change are influenced by numerous geographically specific factors (Thornton *et al.*, 2014). Perkins *et al.* (2018) advocated that CCE should ideally be wholesome to motivate learners in sustainable practices while addressing the four domains of the UNESCO Climate Change Initiative, namely, scientific, educational, environmental and ethical. This points to the multidisciplinary and multicultural nature of CCE.

2. Conceptions and perceptions of students toward climate change

Generally speaking, the audiences of CCE may already come with preconceptions about climate change that can be deeply ingrained and these preconceptions could be misconceptions. These preconceptions and misconceptions could shape one's belief, hence their attitude toward climate change (Arbuckle *et al.*, 2013) . A belief is frequently defined as one's subjective evaluation of what is true or real about oneself or the surroundings. An attitude, however, is the mental predisposition stemming from a belief or a set of beliefs (Underwood, 2002). One's belief about climate change would influence his or her attitudes or mental predisposition toward climate change. Generally, the association between belief and attitude is portrayed in the psychological theory of planned behavior that a person's accessible belief concerning a behavior shapes his or her attitude toward a behavior, and behavior is the observable response to an issue of concern (Ajzen, 1991). This issue of concern could be climate change. Perkins *et al.* (2018) argued that climate change curriculum is often confronted with engraved prior beliefs about climate change among students, and these beliefs influence the learners' attitudes toward climate change, for instance through selective exposure and recall (Hennes *et al.*, 2020). The link between belief and attitude is also portrayed in other theoretical models, particularly the value–belief–norm theory and

the attitude–behavior–external conditions model, where belief is a determinant of attitude (Sarkis, 2017). In turn, knowledge, whether subjective or objective, is an important determinant of one's belief (Hornsey *et al.*, 2016). As education plays a crucial role to impart knowledge, it is deemed that CCE would have an effect on the beliefs of the learners about climate change, which subsequently influence their attitudes.

Knowing that belief is a predeterminant of attitude, it is of interest to know how university students generally perceived climate change, as perception is often influenced by one's belief. It seems that students' perceptions of climate change differ geographically and even by their study majors. Nursing students in Sweden interviewed in a qualitative study expressed that climate change could have negative consequences on human and human health and that climate change is anthropogenic in nature (Anåker *et al.*, 2021). They opined the waste of resources as a contributor to climate change and realized their roles at individual level to promote climate action but saw a lack of connection between their job and the environment (Anåker *et al.*, 2021). Another study conducted among final-year undergraduate students in Bangladesh revealed that most of the respondents related climate change to human activities, and some perceived it as an act of God, thus implying the religious influence in their perceptions of climate change causes (Haq and Ahmed, 2020). A study involving college students in the United States on their perceptions of climate change news sources informed that students were concerned and aware of climate change but were cautious of where the information about climate change came from due to overwhelming misleading information, increasing anti-intellectualism and a lack of digital literacy (Cheng and Gonzalez-Ramirez, 2021). In Fiji, students from two organizations of a university demonstrated discrepancy in their understanding of climate change, with those of one organization linking climate change to coral bleaching, alteration of natural habitats and the source of many other environmental problems, whereas those of the other organization linking climate change to drastic weather changes, fish feed shortage and entry of toxins into the sea (Prasad and Mkumbachi, 2021). There is an overall consensus that climate change is of concern, but views of its causes, reliability of its sources of information as well as its nature and impacts diverge. To some extent, it relates to the knowledge a student has about climate change.

In regard to teaching and learning, students could come to class with different conceptions about climate change due to their beliefs and perceptions. It is common for students to mistake weather for climate and equate climate change with environmental pollution (Sandra *et al.*, 2014). An investigation specifically on students' conception of the uncertainties in climate change unveiled climate modeling as the major cause of uncertainties rather than the limited knowledge of and the complex anthropogenic factors affecting climate change (Schauss and Sprenger, 2021). It was also reported that a substantial number of survey respondents comprising students of two universities in the United States had difficulty distinguishing climate change from other environmental issues, had insufficient understanding of climate change and were confused about the mitigation strategies (Huxster *et al.*, 2015). It emerges at this point that the beliefs, hence conceptions and perceptions toward climate change, among university students are influenced by factors ranging from their knowledge of climate change and the media to religion, which are associated with education system and sociopolitical forces. This makes the regional studies of CCE crucial, as the beliefs of university students about climate change are likely to differ regionally, prompting contextualization of CCE.

3. CCE in China

There is increasing emphasis on ESD in the educational system of China over the past two decades. It started with the introduction of environmental education in the primary and

secondary school curricula in 2003 (Wiedenbach, 2020). Subsequently, efforts were made to educate the public about emission reduction as well as energy and resource conservation to mitigate climate change. The National Climate Action Plan 2014–2020 extended and upscaled the efforts to foster low-carbon lifestyle and behaviors (Hu and Chen, 2016). To date, environmental topics encompassing desertification, waste segregation, responsible consumption, recycling and low-carbon behaviors have been incorporated into the courses offered at primary and secondary levels. In primary schools, a subject has been offered to increase students' appreciation of the nature and the living environment, where teachers have the flexibility to include topics such as climate change and pollution. In secondary schools, environmental topics inclusive of climate change are embedded into science subjects, particularly geography (Wiedenbach, 2020). The delivery of these topics tends to take on a utilitarian approach, stressing that environmental protection is instrumental to sustainable economic development of China and the well-being of the populace (Niu *et al.*, 2010).

It is noteworthy that there is a lack of standardization in the breadth and depth of environmental topics covered, as these topics are often incorporated into other science subjects and there is a lack of dedicated subjects to serve the purpose (Niu *et al.*, 2010). This could lead to highly variable conceptions and perceptions among the Chinese students toward climate change, and the variability does not seem to reduce in universities. The reason could again be a lack of dedicated courses in universities to deal with the complex contents of climate change. This deficiency might be attributed to a lack of national policies to address CCE specifically (Han, 2015). A study pointed to the higher propensity of Chinese students to believe in the anthropogenic nature of climate change than US students, as the latter were relatively more skeptical about the scientific consensus on anthropogenic climate change. US students gave higher importance to the economy than the environment, whereas Chinese students perceived both as equal (Jamelske *et al.*, 2013). In contrary, another Chinese study involving students of five universities highlighted that the students did not have adequate knowledge about the causes and consequences of climate change (Yang *et al.*, 2018). This could imply a unique scenario in China pertaining to the variability of climate change knowledge among university students. With increasing joint ventures between Chinese and foreign universities in tertiary education, entities have been established to offer new courses, many of which are in English, and this provides an opportunity for consolidation of CCE in China through the design of courses dedicated to climate change (Lin, 2016).

4. The design of CCE courses

Having known the potential bottlenecks of climate change curricula in China and the opportunities that come with educational collaboration with foreign universities to offer new courses, the design of new CCE courses has gained interest. Monroe *et al.* (2019) identified through a systematic review that effective CCE should therefore aim to make the contents relevant and meaningful to the audiences in an interactive manner. Learners of CCE should be engaged in discussions as well as school or community projects while having their misconceptions addressed. One common misconception about climate change is an underestimation of human influence on climate change (Monroe *et al.*, 2019). With the ongoing arguments about the natural and human causes of climate change, the general public could be ambivalent about the causes, leading to the misconception. This could also be complicated by religious factors attributing climate change to the act of God (Haq and Ahmed, 2020). Besides, there is conflation of climate change and air pollution though they are fundamentally different (Sandra *et al.*, 2014). Although certain air pollutants are

greenhouse gases, thus contributing to climate change, not all types of air pollution have implications on climate change. Similarly, treating climate change as equivalent to other environmental pollutions could prevent students from truly comprehending what it really is. In view of the complexity and multidisciplinary nature of CCE, Stubbs *et al.* (2018) designed a climate change course targeting to convey the fundamental climate change science, the uncertainties of climate change, the natural and anthropogenic causes of climate change and its effects on the natural and human system as well as the variability of climate change in relation to geographical, sociocultural and economic factors. They advocated critical thinking and scientific inquiry in the delivery of the course. Similarly, Perkins *et al.* (2018) recommended that CCE should cover the underlying science with the concepts of uncertainty, complexity and nuance incorporated. They proposed approaches such as myth-busting, debates, critical inquiry and interactions in CCE. They deemed that CCE should confer global and cross-disciplinary perspectives, adopt learner-centered pedagogies and garner authentic participation.

With the opportunities arising from educational ventures in the design and offering of a climate change course and with the recommended strategies, approaches and pedagogies of CCE in mind to address the misconceptions and complexity of climate change, a new climate change course has been rolled out. It is among the very first climate change courses to stem from Sino-foreign educational ventures. Therefore, it is of interest to examine whether the CCE course encompassing climate change science, impacts as well as the adapting and mitigating strategies would have an impact on the beliefs and attitudes of students. Beliefs and attitudes are of special interest because they have been identified as the major challenges of CCE in multiple literature (Wei *et al.*, 2014; Hornsey *et al.*, 2016; Perkins *et al.*, 2018). Moreover, studies in CCE's effectiveness are far and few. Monroe *et al.* (2019) found only 43 papers of acceptable quality centering on empirical evaluation of educational interventions in CCE, and only 11 addressed CCE in colleges and universities. Most of the 11 studies are cross-sectional studies aiming to gauge or improve climate change literacy, and few are longitudinal surveys on effectiveness of a particular activity in CCE (Nam and Ito, 2011; Cox *et al.*, 2014). Lambert and Bleicher (2014) conducted a longitudinal study on 15 students to examine the changes in their knowledge, perceptions and ability to engage in climate change discourse before and after a CCE course. Although adopting a simpler longitudinal design, this study is different in the sense that it focuses on the effects of the course on the beliefs and attitudes of a significantly larger pool of students toward climate change. It is also one of the first studies on the implementation of CCE in China. The course examined in this study aims to address certain misconceptions that have been thought to alter the beliefs of the students about climate change. In view of this, it is crucial to examine whether the CCE course has an influence on the beliefs and attitudes of the students in China. Besides, this study diverts from the tracking of knowledge, as there are already studies that look into whether a CCE course enhances the knowledge of climate change (Nam and Ito, 2011; Lambert and Bleicher, 2014). In regard to the background of the course, and the interest in its effects on students' beliefs and attitudes described earlier, this study is grounded on the question of whether the new climate change course, designed and delivered in reference to the recommendations in literature, could influence the beliefs and attitudes of students. As an extension to the main research question, it is of interest to examine if students of different courses and gender showed differences in their beliefs and attitudes, as the course was offered to students of the environmental science and applied psychology majors. Basing on the belief–attitude theory, this study also intends to explore how the association plays out in this specific setting.

5. Methods

This study examines whether implementation of CCE in China has an effect on the beliefs and attitudes of students through a newly developed CCE course. An overview of the method is shown in Figure 1.

5.1 Development of a CCE course

A CCE course called "Climate Change" has been developed and offered for the first time in a major higher learning institution (Sino-foreign joint venture) in China as a response to the mainstreaming of ESD, particularly CCE in China. The course was offered to students of the environmental science and applied psychology majors during this initial stage of its implementation. The course covers an array of general topics related to climate change encompassing:

- the internal and external forcings of climate change;
- the positive and negative climatic feedback;
- the arguments revolving around climate change;
- the evidences and indicators of climate change;
- the anthropogenic and natural causes of climate change;
- the basics of climate models and predictions;
- the impacts of climate change particularly on the ecosystem, agriculture and society, including public health;

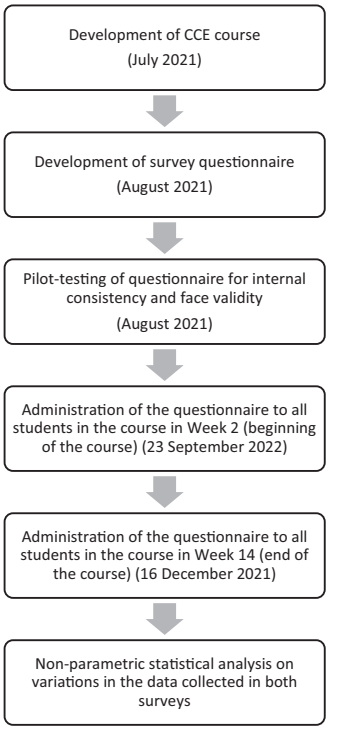

Figure 1.
Flowchart showing the execution of the study

- the policies related to climate; and
- adaptation to and mitigation of climate change.

The course was delivered over a duration of 14 weeks by a course instructor with the help of a teaching assistant and was not designed to delve into specific facets of climate change such as the physical and chemical processes in depth. Nonetheless, the course addresses the crucial aspects of climate change, namely, the science, probabilistic nature, complexity, evidences and debates with global and multidisciplinary pedagogies (Perkins *et al.*, 2018; Monroe *et al.*, 2019). It includes the social implications of climate change, particularly the impacts of climate change on human health (Nam and Ito, 2011). The course also addresses certain preconceptions on the causes and consensus of climate change in addition to the vulnerability to and actions against it. During implementation of the course, students were engaged in debates on the causes of climate change and the uncertainties associated with it. They also participated in various interactive discussions about the impacts, adaptations and mitigations. Besides, they conducted team research and presentations on regional climate change and its impacts. They were exposed to experts' arguments on climate change through video learning.

5.2 Respondents

Respondents of the study consisted of first-year environmental science and applied psychology students enrolled in the climate change course. The cohort had 92 students, all of whom participated in this study. They had gone through six years of academic education and taken the National Higher Education Entrance Exam, before entering colleges or universities.

Participants of the survey consisted of 37% male (N = 34) and 63% female (N = 58). They represented 100% of the students enrolled in the climate change course. Applied psychology students constituted 70.7% of the participants (N = 65), whereas environmental science students made up 29.3% of the participants (N = 27).

5.3 Survey instruments and validity

Due to the lack of a comparable questionnaire, the survey questionnaire had been developed with survey items sourced from different references that examined the beliefs and attitudes of university students in relation to climate change specifically (Leviston and Walker, 2012; Arbuckle *et al.*, 2013; Dragana and Dooel, 2014; Wei *et al.*, 2014; Hu and Chen, 2016). The questionnaire consisted of four sections. The first section collected the demographic data of the respondents, such as their programs of study, age and provinces of origin. The second section of the questionnaire examined the beliefs of the participants concerning climate change. The participants rated their degrees of agreement to the statements on a five-point scale from 1 = strongly disagree to 5 = strongly agree. Examples of the statement are climate change cannot be avoided because of the way modern society works, climate change results from a natural fluctuation of Earth's temperatures and human activities have no significant impact on global change. A mix of positive and negative statements was framed to minimize acquiescence bias. Similarly, limiting the scale to only five levels of agreement is also beneficial in reducing acquiescence bias (Adelson and McCoach, 2010). This part captures whether the course contents, particularly the definition and anthropogenic nature of climate change, the impacts of climate change and the concept of vulnerability discussed, somehow altered the beliefs of the students about climate change.

The third section of the questionnaire investigated the attitudes of the participants toward climate change and consisted of survey items related to mental predispositions such as:

- We can all do our parts to reduce the effects of climate change.
- I tend to think that climate change information is not relevant to me.
- What I do will not make any differences to climate change.

Similarly, the survey items adopted a five-point scale and were a mix of positive and negative statements. Although the course contents provided the crucial knowledge to influence the beliefs of the students about climate change, the student-centered and inquiry-based strategies adopted in the course, such as debates, discussions, interactions, videos and team research, were anticipated to reinforce their beliefs and affect their attitudes toward climate change. This part aims to capture these effects.

The fourth section of the questionnaire required the participants to rank the responsibilities of various stakeholders, namely, international organizations, national governments, local governments, business and industrial entities, environmental organizations and individuals, toward climate change from the highest to the lowest without repeating ranks. For instance, if they thought that "international organizations" have the highest responsibility among all the stakeholders, they would assign a value of 6 to it. This aimed to gauge the perception of the respondents on the levels of responsibility assumed by multiple parties in combating climate change and whether this perception changed after going through the climate change course that was designed to confer a global perspective, particularly on climate change policies, as well as its adaptation and mitigation at various levels.

As the survey sections testing the constructs of beliefs and attitudes contain items assembled from different sources instead of from established questionnaires, the questionnaire was pilot-tested for internal consistency of the items (Figure 1). During pilot testing, the digital questionnaire was distributed to 20 students who volunteered to undertake the survey and provide feedback on the survey items. They were entirely from the environmental science program. The questionnaire was also checked by four academicians of the environmental science and applied psychology programs for face validity. Improvement was subsequently made to the survey items based on the feedback gathered from both the students and academicians. The pilot test showed acceptable Cronbach's $\alpha$of 0.789 and 0.702 for survey items evaluating beliefs and attitudes toward climate change, respectively (Field, 2017). As for section 4 of the survey, which involves ranking of the responsibilities of various stakeholders from the highest to the lowest without repetition by each participant, Cronbach's α was not calculated, as the ranking could differ significantly, unlike survey items using the Likert scale where a participant could choose the same response for different survey items and there is greater probability for multiple respondents to choose the same response for the same item. The items were validated through face validity involving careful examination of the items by other academicians to ensure that they are relevant and they measure what they are intended to measure (Connell *et al.*, 2018).

5.4 Research design and survey administration

The study adopts a simple longitudinal design with two surveys capturing the same variables administered at two points of time. All the students enrolled in the climate change course took part in the study, with the first survey conducted in week 2 of the course and the

second survey conducted in week 14 (Figure 1). Prior to the survey, ethical clearance was obtained from the research committee of the university. A consent page stating the purpose of the survey and its voluntary nature was attached to the online survey questionnaire. A statement was included in the consent page to inform students that their participation was entirely voluntary and that they could choose not to participate if they did not wish to do so. They were also informed that they could withdraw at any point of the survey, if they decided to participate but later changed their mind because of any reasons. If they agreed to participate in the survey, they would need to press on the "agree" button on the consent page as a gesture of consent to start the survey. The same set of survey questionnaire was used at the beginning and at the end of the course to examine if the respondents experienced changes in the constructs of interest as a result of the course. The questionnaires were administered within scheduled classes by the course instructor to facilitate the explanation of the survey items to the participants when needed without leading their responses.

5.5 Data analysis

The data collected were ordinal, comprising the degrees of agreement and ranks. Descriptive statistics of the survey items were presented. Nonparametric tests were conducted to examine whether the climate change course led to significant differences in the beliefs, attitudes and perceptions of responsibility among the participants (Field, 2017). The differences were analyzed with the Wilcoxon signed-rank test, which is the nonparametric equivalent of the paired *t*-test (Field, 2017). Differences of the responses between independent groups of participants, particularly the male and female, as well as those of different programs of study were analyzed using the Mann–Whitney *U*-test (Field, 2017). Correlations between the belief and attitude variables were probed by transforming the ratings for the survey items under each variable to a mean rating using equation (1). The mean ratings of the respective variables were tested for their normality prior to their correlations:

$$\text{Mean rating of a variable} = \frac{\sum_{i=1}^{n} S_i}{n} \tag{1}$$

where S_i is the ith survey item of the variable with $i = 1, 2, 3. . .n$, and n is the number of survey items.

6. Results

The descriptive statistics of the survey items are shown in Table 1. The mean ratings of each survey item are presented. There are two mean ratings for each survey item, namely, the rating in the first survey administered in week 2 of the course and that of the second survey administered in week 14, which was the final week of delivery of the course. Variations in the ratings indicate that the course might have an effect on the beliefs and attitudes of the students as measured by the survey items. Generally, the second survey shows variations in ratings, but some variations are slight compared with the others. For instance, when asked about whether there are too many conflicting evidences about climate change (item B9), the difference in the ratings was a mere 0.02 from the initial 3.02, indicating that the respondents generally took the middle ground after having gone through the course (Table 1). For certain items such as B12, which asks if there is agreement among experts that climate change is real, the course seemed to have reinforced the agreement among the respondents, leading to a substantial increase in the survey ratings (Table 1).

Table 1.
Descriptive statistics and Wilcoxon signed-rank test on data collected from the first and second surveys

Item	Statement	*N*	First Survey M ± SD	Second Survey M ± SD	Wilcoxon Signed-Rank (Second – First)[2] *Z*	Significance, *p*
Beliefs about climate change (B)						
B1	Climate change cannot be avoided because of the way the modern society works [1]*Remark: Climate change can be mitigated through multiple approaches*	92	3.65 ± 0.90	3.22 ± 1.11	−1.87	0.062
B2	It is already too late to do anything about climate change [1]*Remark: There is an urgent need for climate action to cap global warming and it is not too late*	92	1.91 ± 0.91	1.83 ± 0.90	−0.84	0.402
B3	Climate change is a natural fluctuation in Earth's surface temperatures [1]*Remark: Human activities have a larger role in the climate change we are experiencing now*	92	3.54 ± 0.86	3.15 ± 1.03	−1.97	**0.048**
B4	Human activities have no significant impact on global temperatures [1]*Remark: As B3*	92	1.93 ± 0.68	1.89 ± 0.92	−0.46	0.649
B5	Developing countries should take most of the blame for climate change [1]*Remark: It is crucial to understand the differentiated roles of different parties in combating climate change without putting blames*	92	2.52 ± 0.91	2.48 ± 0.84	−0.33	0.743
B6	It is still possible to reduce or mitigate climate change [1]*Remark: Mitigating climate change is possible*	92	3.96 ± 1.03	3.91 ± 0.76	−0.17	0.864
B7	The evidences for climate change are unreliable [1]*Remark: There are increasing evidences pointing to changing climate. Future predictions have uncertainties but that does not mean they are unreliable*	92	2.17 ± 0.93	2.13 ± 0.88	−0.28	0.777
B8	Claims that human activities cause climate change are overstated [1]*Remark: As B3*	92	2.85 ± 0.99	2.59 ± 0.83	−1.28	0.200
B9	There are too many conflicting evidences about climate change to know whether it is really happening [1]*Remark: As B7*	92	3.02 ± 0.77	3.00 ± 0.84	−0.10	0.919
B10	The effects of climate change are likely to be catastrophic [1]*Remark: Extreme weather events could be catastrophic*	92	3.26 ± 0.93	3.39 ± 0.83	−0.68	0.496
B11	It is too early to say whether climate change is really a problem [1]*Remark: As B7*	92	2.48 ± 0.84	2.13 ± 0.81	−1.91	0.056
B12	There is agreement among experts that climate change is real [1]*Remark: The consensus is unprecedented*	92	3.43 ± 0.78	3.72 ± 0.78	−1.59	0.124

(*continued*)

Table 1.

Item	Statement	*N*	First Survey M ± SD	Second Survey M ± SD	Wilcoxon Signed-Rank (Second – First)[2] *Z*	Significance, *p*
B13	Industrial pollution is the main cause of climate change [1]*Remark: Greenhouse gases specifically are the cause*	92	3.17 ± 0.82	3.15 ± 0.84	−0.23	0.822
B14	Climate change affects everyone in the world equally [1]*Remark: Vulnerability to climate change differs based on numerous factors*	92	3.85 ± 1.03	3.07 ± 1.08	−2.87	**0.004**
B15	The recent climate change is caused by the sun [1]*Remark: The recent climate change is largely anthropogenic*	92	2.67 ± 0.84	2.59 ± 0.91	−0.52	0.603
B16	Carbon dioxide is the main driver of global warming [1]*Remark: Carbon dioxide is the major greenhouse gas driving global warming*	92	3.57 ± 0.78	3.28 ± 0.91	−1.27	0.204
Attitude toward climate change (A)						
A1	We can all do our part to reduce the effects of climate change [1]*Remark: It is hoped that students would know their roles in climate action better through the course*	92	4.35 ± 0.77	3.98 ± 0.95	−1.85	0.065
A2	I tend to think that climate change information is not relevant to me [1]*Remark: It is hoped that students would give more attention to climate change*	92	1.80 ± 0.91	1.98 ± 0.88	−0.93	0.353
A3	I think fighting climate change is not my duty but the duty of the governments and industries [1]*Remark: As A1*	92	1.87 ± 0.91	2.11 ± 1.08	−1.06	0.289
A4	I am uncertain about whether climate change is really happening [1]*Remark: It is hoped that students would be more aware of the current anthropogenic climate change*	92	2.17 ± 0.88	2.11 ± 0.92	−0.23	0.818
A5	What I do will not make any differences to climate change [1]*Remark: As A1*	92	1.98 ± 0.75	2.17 ± 0.93	−1.01	0.312
A6	I would only do my part to combat climate change if everyone else did theirs [1]*Remark: It is hoped that students would know the importance of their climate actions, regardless of what other people do*	92	2.85 ± 1.17	3.04 ± 1.07	−1.25	0.213
A7	I do not think climate change is a real problem [1]*Remark: As A4*	92	2.09 ± 1.03	1.98 ± 0.98	−0.60	0.548
A8	I feel a moral duty to do something about climate change [1]*Remark: It is hoped that students would develop a sense of obligation*	92	3.98 ± 0.91	3.80 ± 0.88	−0.83	0.405

(*continued*)

Table 1.

Item	Statement	*N*	First Survey M ± SD	Second Survey M ± SD	Wilcoxon Signed-Rank (Second – First)[2] *Z*	Significance, *p*
A9	I am willing to change my lifestyle to reduce climate change [1]*Remark: As A1*	92	4.07 ± 0.68	3.99 ± 0.65	−0.63	0.528
A10	I don't know what I can do to fight climate change [1]*Remark: It is hoped that students would have a better idea of the climate actions they can take*	92	2.65 ± 0.71	2.46 ± 0.94	−1.15	0.249
Ranking of levels of responsibility in combating climate change (R)						
R1	International organization (e.g., the United Nations)	92	4.20 ± 1.77	4.28 ± 1.94	−0.18	0.855
R2	National governments	92	4.39 ± 1.26	4.76 ± 1.16	−1.57	0.116
R3	Local governments	92	3.39 ± 1.16	3.87 ± 1.13	−2.00	**0.046**
R4	Businesses and industries	92	3.11 ± 1.54	3.57 ± 1.68	−1.29	0.196
R5	Environmental organizations (e.g., Worldwide Fund for Nature)	92	3.04 ± 1.75	3.30 ± 1.81	−0.57	0.569
R6	Individuals	92	2.85 ± 2.08	3.35 ± 2.00	−1.11	0.267

Notes: [1]The remarks indicate the directions of beliefs/attitudes that the students would acquire with the progression of the climate change course. It is noteworthy that the directions of beliefs could be updated with new findings in climate change. [2]*Wilcoxon signed-rank test performed on the second dataset and the first dataset, e.g., B1 from the second survey and B1 from the first survey. Bolded figure shows* $p < 0.05$ *and the difference of the first and second responses is significant*

To test whether the variations in the ratings of the first and the second surveys were statistically significant, Wilcoxon signed-rank test was conducted. Statistically significant variations imply that the course might have a significant influence on certain beliefs and attitudes of the students, and it is the primary goal of this study. The results are shown in Table 1. There are only three items showing statistical significance in Table 1, namely, B3, B14 and R3. For B3, there was a significant reduction in the belief that climate change is of natural causes. As for B14, there seems to be a stronger grasp of differential climate change impacts and that the impacts are not the same for everyone (Table 1). The participants also tended to perceive that local governments have higher responsibility in climate action, as indicated by R3 (Table 1).

To test whether demographic factors, namely, gender and program of studies, yielded significant differences in the response, Mann–Whitney U test was performed. The test revealed no significant differences in the responses of male and female participants, except for survey item A1 ($U = 245.00$, $z = -2.02$, $p = 0.04$; note: for Mann–Whitney U test, $p < 0.05$ denotes a significant difference of a data pair), ranking of responsibility for national governments ($U = 146.50$, $z = -2.37$, $p = 0.02$) and environmental organization ($U = 137.00$, $z = -2.57$, $p = 0.01$) in the first survey, as well as for survey item B1 ($U = 156.50$, $z = -2.14$, $p = 0.03$) in the second survey. For the three data pairs showing significant differences in the first survey, the female participants gave higher rating for A1 and responsibility ranking of environmental organization than the male participants in the first survey, whereas the contrary was observed for the responsibility ranking of national governments. In the second survey, the B1 rating of the female participants was higher than that of the male participants. Participants of applied psychology and environmental science programs did not provide significantly different responses, except for B9 ($U = 81.00$, $z = -2.55$, $p = 0.01$) and B15 ($U = 92.50$, $z = -2.19$, $p = 0.03$) in the first survey, where the applied psychology students had generally higher ratings than the environmental science students.

In addition, to affirm the association between belief and attitude, which forms the theoretical basis of the study, a correlational analysis was conducted. Having transformed the ratings for the survey items of each variable in the first and second surveys to the mean rating of the variable, i.e. mean rating for belief (AvgB) and mean rating for attitude (AvgA) through equation (1), the Shapiro–Wilk test for normal distribution was conducted on the mean ratings. The Shapiro–Wilk test reveals violations of normality for the mean belief ratings and mean attitude ratings of the first and the second test ($p < 0.05$, which in the case of the Shapiro–Wilk test, means a rejection of the null hypothesis that the values are normally distributed). Therefore, Spearman's correlation was conducted on the mean ratings. The results are shown in Table 2. Table 2 shows significant correlation between AvgB(First) and AvgA(First) ($r_s = 0.384$, $p < 0.01$). At $0.01 < p < 0.05$, AvgA(First) is

Variable	AvgB(First)	AvgA(First)	AvgB(Second)	AvgA(Second)
AvgB(First)	1.000			
AvgA(First)	***0.384***	1.000		
AvgB(Second)	−0.177	0.152	1.000	
AvgA(Second)	−0.005	*0.330**	*0.351**	1.000

Notes: Bold = **Correlation is significant at the 0.01 level (two-tailed). Italic = *Correlation is significant at the 0.05 level (two-tailed). AvgB(First) = Mean rating for belief in the first survey. AvgA(First) = Mean rating for attitude in the first survey. AvgB(Second) = Mean rating for belief in the second survey. AvgA (Second) = Mean rating for attitude in the second survey

Table 2. Spearman's correlations (r_s) of the mean ratings for belief and attitude

significantly correlated to AvgA(Second) with $r_s = 0.33$ and AvgB(Second) is significantly correlated to AvgA(Second) with $r_s = 0.351$. Despite being significant, the magnitudes of correlation (r_s) are considered moderate.

7. Discussion

7.1 Changes in beliefs and attitudes toward climate change

The responses collected in the first and second surveys did not show significant differences (Table 1), except for items B3 stating that climate change is a natural fluctuation in the Earth's surface temperature ($p = 0.048$), B14 stating that climate change affects everyone in the world equally ($p = 0.004$) and R3 indicating the responsibility level of local governments in combating climate change ($p = 0.046$). These significant differences address few major arguments about climate change, which the course had aimed to achieve. The first was the causes of climate change. There was a significant reduction in the mean ratings of B3 in the first and second surveys (from 3.54 in the first survey to a significantly lower agreement level of 3.15 in the second survey, also see Table 1), indicating that more participants had begun to understand the anthropogenic nature of climate change, although some still held on to climate change as a natural phenomenon. The second centered on the vulnerability to climate change. Significant decrease in the ratings of B14 was observed, and this could imply that the participants had begun to grasp the concept of vulnerability to climate change. Vulnerability to climate change is affected by a multitude of factors such as income, access to resources and even geographical locations (Thornton *et al.*, 2014; Tang, 2021). Due to the differences in vulnerability, it is unlikely that climate change would have equal impacts on everyone on Earth. Understanding that different individuals and communities are affected differently by climate change might have contributed to a significant decrease in the level of agreement among the respondents to item B14, which states that climate change affects everyone equally (Table 1).

Reciprocally, a significant reduction in the mean agreement for B3 (climate change is a natural phenomenon) would lead to an increase in disagreement for B4 (with the rating changing from 1.93 to a more disagreeing 1.89, also see Table 1), which states that human activities do not significantly impact global temperatures, and B8 (with the rating changing from 2.85 to a more disagreeing 2.59, also see Table 1), which says that the anthropogenic causes of climate change are overstated. However, the differences in the ratings for B4 and B8 are not statistically significant (Table 1). Despite agreeing on the inevitability of climate change in this modern society (item B1 of Table 1), the participants seemed to have a positive outlook on acting against climate change, which was captured by their self-perceived attitudes. For instance, the participants generally agreed that they could do their parts to reduce the effects of climate change and perceived that they have a duty in the combat against climate change (Table 1). This seems to align with the cross-sectional study of Wei *et al.* (2014) in that their respondents generally believed climate change had taken place locally and globally, and they expressed their willingness to change their behaviors to combat climate change, regardless of whether they actually changed their behaviors. A good proportion of the participants opined that industrial pollution is the main cause of climate change (item B13, Table 1). Although pollution is a more specific environmental problem than climate change, the participants perceived them as linked probably because many air pollutants are greenhouse gases that fuel climate change. Albeit statistically insignificant, a more disagreeing rating for item A4 (Table 1) in the second survey might implicate a decrease in uncertain attitude among the participants toward climate change. This is in line with the findings of Hu and Chen (2016), who reported a decline in uncertainty about climate

change among their participants after intergenerational communication on local climate change as part of CCE.

In addition, the climate change course introduced the concept of ethics, which got the students to ponder on whether it was ethical and fair that countries, particularly the Pacific Island ones, took the greatest blow of climate change despite not being the major emitters of greenhouse gases (Barnett, 2011). This had in fact deepened their understanding of the inequality revolving around climate change. There was a significant increase in the perceived responsibility of local governments in combating climate change in line with a better understanding of the concept of vulnerability among the participants on completing the course. The idea of differentiated vulnerability is particularly important in the adaptation to climate change, which often requires local considerations. Unlike the mitigation of climate change, which can benefit from setting common goals of carbon reduction, adaptation to climate change involves managing problems stemming from the changing climate, which are often geographically, demographically and sector specific, to reduce their impacts. The involvement of local governments in facilitating the adaptation to climate change is especially crucial to formulate adaptation strategies that address local susceptibility and improve local resilience to climate change (Mees *et al.*, 2019).

7.2 Preconceptions and demographic factors affecting beliefs and attitudes

Generally, the participants' beliefs about climate change showed that they had certain preconceptions about climate change that align with the contents of the course such as human activities have a role in global temperatures (item B4, Table 1), it is possible to mitigate climate change (item B6, Table 1), the effects of climate change could be catastrophic (item B10, Table 1) and there is agreement among experts that climate change is real (item B12, Table 1). Therefore, these preconceptions did not change significantly after having gone through the course (Table 1). This could be a result of embedding CCE in China's education curriculum in response to ESD. The Chinese Ministry of Education had issued a guideline on execution of environmental education in schools, which facilitated the inclusion of environmental education and topics of climate change in its primary and secondary school curricula nowadays (Han, 2015).

Although the demographic factors did not significantly influence the responses of the survey, it is noteworthy that the students of applied psychology tended to believe that there were many conflicting evidences about climate change, which casted doubts on whether climate change is really happening, whereas the environmental science students were less skeptical. Even though the results pointed to an inclination to disagree that the recent climate change is caused by the Sun (Table 1), environmental science students tended to disagree with the statement more. Besides, the female participants demonstrated a stronger perceived willingness to do their parts to reduce the effects of climate change than the male participants. This resonates partially with the findings of Hu and Chen (2016) that gender predicted changes in attitude and behavioral intention to mitigate climate change to a certain extent. Unlike the study of Hu and Chen (2016), this study only showed a significant difference in intention to combat climate change between the male and female participants.

7.3 Belief–attitude correlation

The correlation analysis affirms the belief–attitude relationship that forms the basis of many agent-based models of social psychology [see Table 2 for the significant correlations between AvgB(First) and AvgA(First) as well as between AvgB(Second) and AvgA (Second)]. Ajzen (1991) advocated that beliefs related to certain features of an item or concept, together with evaluations of these features, shape one's attitude toward the item or

concept. This is portrayed in the significant positive Spearman's correlations between the mean ratings for belief and attitude in the first and second surveys, although the magnitude of correlation was only moderate. Interestingly, a significantly positive correlation was also reported between the mean ratings for attitude in both the surveys [see Table 2 for the significant correlation between AvgA(First) and AvgA(Second)], which might shed light into the potential positive influence of the students' existing attitude on their later attitude toward climate change at the end of the course.

7.4 Potential effects of course design on beliefs and attitudes, and further course improvement

This study shows that the current design of the course was effective in addressing certain complex arguments revolving around climate change, particularly the vulnerability to and ethics of climate change, as well as the natural and anthropogenic causes of climate change (refer to B3 and B14 in Table 1). However, it was not effective in bringing about significant attitudinal reinforcement among the respondents. Table 1 shows that the participants had already possessed certain desirable attitudes toward climate change in the first survey, such as their disagreement on the irrelevance of climate change information to them and their perception of a moral duty to do something about climate change, but this course had not reinforced the desirable attitudes substantial enough to yield significant differences in the ratings of the second survey. This is in fact in agreement with few studies revealing a lack of relation between students' knowledge of environmental issues and their attitudes (Legault and Pelletier, 2000; Pauw and Petegem, 2013). Although students' knowledge about climate change had not been tested in this study, it was assumed that their knowledge would have grown after following through the course, and this might have resulted in significant changes in certain beliefs about climate change. The relationship between environmental knowledge, beliefs and attitudes was demonstrated by a survey conducted by Higuchi *et al.* (2018), which showed that environmental knowledge correlated to environmental beliefs and attitudes of the participants. However, in contrast to the findings of Higuchi *et al.* (2018), although the course significantly changed certain beliefs of the participants, it did not lead to any significant attitudinal changes (Table 1).

A reflection of the course revealed that videos showing how climate change impacts different regions and people differently were effective in conveying the concept of vulnerability. Debate on the causes of climate change permitted students to delve into the depth of the argument and examine the evidences. It also provided an avenue for the course instructor to correct misconceptions about the modern climate change (Perkins *et al.*, 2018). Brainstorming at the early stage of the course on how students defined climate change and what they thought about climate change was useful to identify the preconceptions, including misconceptions, they had about climate change. Debate and discussions on the differences between climate change and other environmental problems were observed to help the students in knowing what climate change really is and how it is different but linked to other environmental problems. Contents on adaptation and mitigation of climate change and the associated discussions on the responsibilities of different stakeholders in adaptation and mitigation actions helped students to understand the complexity and shared responsibilities in climate action, as well as the importance of policymaking and actions at different levels (Stubbs *et al.*, 2018). Arguments and discussions about the ethics and justice surrounding climate change helped to enforce the understanding of vulnerability and global responsibility in climate action. However, contents related to climate change modeling and impacts of climate change on ecosystem might be challenging to students without certain science knowledge such as biology. Although a group project and a presentation built the

students' research and communication skills, students expressed their preference for more practical projects.

Therefore, future improvement of the course can target to achieve these through more intensive use of multimedia to cultivate autonomous learning and students' interest (Perkins *et al.*, 2018). This includes the use of carbon footprint calculators to quantify students' own carbon footprints and assess the impacts of their lifestyles on climate change. Students could also be introduced to regional databases that show the spatial and temporal changes in the distribution and phenology of plants and animals. They could be asked to evaluate if these changes were related to climate change. Videos on the efforts taken to address regional impacts of climate change are also helpful. Students should be encouraged to apply the knowledge learned from CCE in various extracurricular settings and to raise environmental awareness of the public. These could be incorporated in the CCE curriculum to make CCE more personally meaningful among the learners. By making CCE more personally relevant and meaningful, it is more likely for learners to exhibit changes in attitude (Monroe *et al.*, 2019; Perkins *et al.*, 2018). Application of climate change knowledge was also promulgated by Karpudewan and Mohd Ali Khan (2017), who reported that experiential-based CCE helped to meet the needs for competence, autonomy and relatedness among the learners. This permits the learners to appreciate the knowledge of climate change and its practical aspects to make it relevant (Rooney-Varga *et al.*, 2014). Besides, giving autonomy to students by encouraging them to communicate information to other audiences was reported to motivate them to take action (Rooney-Varga *et al.*, 2014). Furthermore, Wibeck (2014) emphasized the importance of making the impacts of climate change personally relevant, which this study resonated. Rumore *et al.* (2016) suggested role-play simulations specifically for adaptation part of CCE. Besides, this study suggests the incorporation of carefully designed CCE at earlier stages of education with the employment of appropriate pedagogy to shape desirable attitudes toward climate change. This echoes the finding that earlier attitude of students toward climate change potentially influences their later attitude.

Content-wise, it is deemed that a more systematic presentation of evidences in relation to the anthropogenic and natural causes of climate change would enable the learners to appreciate and comprehend the arguments better (Han, 2015). The learners could be given the autonomy to evaluate the evidences to draw the conclusions for themselves. As to whether climate change is really happening, which the survey participants tended to be neutral about (Table 1), the course could similarly benefit from a systematic presentation and an evaluation of the evidences, and this could be delegated to the learners. It is necessary to clarify industrial pollution and climate change for learners to understand the links and nuances (Sandra *et al.*, 2014). It would also be advantageous to clearly convey the roles and responsibilities of combating climate change at different levels, so that the learners know what they could do individually and how they could contribute to the larger efforts to combat climate change.

7.5 Significance and implications

This study has important implications to CCE in China. China is currently the largest emitter of carbon dioxide, a major greenhouse gas driving climate change. To reduce carbon emission and promote sustainable development, ESD has been incorporated into the national policies and programs. However, according to Wang (2015) and Han (2015), there are apparent gaps in the actual implementation of ESD, particularly a lack of awareness for ESD among local practitioners and stakeholders. This limits the effectiveness of ESD in bringing about attitudinal changes, which are crucial to propel sustainable development nationally. In particular to CCE, it has been reported to have conventionally been integrated

into biology and geography classes and the contents might suffer inconsistency and insufficiency (Witoszek, 2018). This study has an important regional significance in the sense that students often have different beliefs and attitudes toward climate change due to the differences in the levels of information about climate change they receive. These differences are often regional, affected by how and what climate change information is conveyed through the regional educational system (Niu *et al.*, 2010). This is in line with the concepts of vulnerability and resilience, which are often regional and require specific adaptations. Therefore, it is likely that high school students in China would enter universities with certain beliefs and conceptions about climate change that are different from those in other countries. Even within China, due to a lack of standardization of climate change syllabi, nuances in students' beliefs and conceptions about climate change are not uncommon (Han, 2015). It is therefore instrumental to have a climate change course that could serve as a regional model to address the unique challenges in relation to beliefs and attitudes toward climate change. The conception of this course marks the beginning of developing a model regional climate change course at the university level, and it is hoped to be perfected through continuous improvement. It is expected to contribute to the development and implementation of CCE in the higher learning institutions in China, particularly to bring about positive attitudinal changes that are crucial to the combat against climate change. Besides, it could serve as a platform of experience exchange to address the unique challenges of CCE in other regions of the world.

7.6 Limitations

This study was subject to a few limitations. The first was related to the quality of responses. Although the participants had been briefed about the survey, it was difficult to ensure that they responded to each of the survey items carefully without any biases. A common bias is acquiescence bias, where the respondents felt an urge to provide positive responses out of politeness instead of basing their responses on what they really believed. Acquiescence bias could also result from survey fatigue, where the respondents provided responses for the sake of completing the survey without giving much thoughts to the survey items (Tellis and Chandrasekaran, 2010). The respondents could fall for conformity bias, prompting them to provide socially desirable answers. Question order bias could affect responses through priming, where the respondents tended to give inconsistent answers to a cluster of questions bearing certain similarity (Tellis and Chandrasekaran, 2010). In this study, question order bias had been reduced through a mix of positive and negative statements and avoidance of clustering questions, which were seemingly similar. In addition, the clarity of the survey items might limit the ability of the respondents in providing reliable responses. The pilot test had aimed to improve the clarity of the questionnaire. Furthermore, this study only tracked the changes in the responses to the survey items among the same group of participants at two points of time, i.e. at the beginning and at the end of the course. These changes may not sufficiently reflect the progressive changes in the beliefs and attitudes of the participants toward climate change. A more extensive longitudinal approach to track such changes at multiple points of time throughout the course could be useful, particularly in identifying which part of the course leads to a certain change observed. To more directly capture its effectiveness in influencing beliefs and attitudes, an intervention type of study design can be adopted in which the experimental group taking the course can be compared with the control group not taking the course, in terms of their beliefs and attitudes concerning climate change. With more CCE courses introduced in the future, studies can be conducted to examine and compare their effectiveness in influencing students' beliefs and attitudes toward climate change.

8. Conclusion

The participants of this study consisting of the first-year science students enrolled in a newly developed CCE course came with certain preconceptions about climate change, which were in agreement with the contents of the course. The course was designed with the aims to provide scientific evidences, global perspectives and social context to the major themes of climate change encompassing its causes, impacts, adaptation and mitigation. A mix of pedagogy including discussions and sharing, video learning, quizzes and interactive games was adopted. Besides, misconceptions were addressed. The course was found to be effective in conveying the anthropogenic nature of climate change, vulnerability to climate change and the importance of localized strategies in combating climate change, but it did not yield significant reinforcement of desirable attitudes or deterrence of undesirable ones. Correlation analysis of this study affirms the established belief–attitude relationship and implied that existing attitudes toward climate change correlate to later attitudes. This study highlights a deficiency of the course and the pedagogy adopted in effecting significant attitudinal changes or reinforcements. It is recommended that the use of multimedia in the course can be extended from conventional audiovisual to interactive CCE platforms, and students can be involved in community projects that allow them to apply the knowledge learned. Role-play for topics such as adaptation and mitigation could be incorporated to increase autonomous learning. This study is instrumental to the regional implementation of CCE in tertiary education, which is currently lacking in China. It is an important milestone in the mainstreaming of ESD and specifically CCE in China.

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