# THE EFFECTIVENESS OF WEB-BASED CLIMATE CHANGE EDUCATION ON IMPROVING CLIMATE CHANGE LITERACY OF PRIMARY SCHOOL STUDENTS

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**by**

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AC | Awareness of Consequences |
| AfC | Act for Climate |
| ANCOVA | Univariate Analysis of Covariance |
| AR | Acid Rain |
| ATR | Attribute to Responsibility |
| CCE | Climate Change Education |
| CCESD | CCE for Sustainable Development |
| CCL | Climate Change Literacy |
| CCLQ | Climate Change Literacy Questionnaire |
| CCS | Climate Cool Schools |
| ECO | Ecocentric |
| EGO | Egocentric |
| GCC | Global Climate Change |
| GHE | Greenhouse Effect |
| GW | Global Warming |
| HOMO | Homocentric |
| IPCC | Intergovernmental Panel on Climate Change |
| KBSR | Kurikulum Bersepadu Sekolah Rendah |
| KSSR | Kurikulum Standard Sekolah Rendah |
| MANCOVA | Multivariate Analysis of Covariance |
| MLT | Multimedia Learning Theory |
| NEP | New Ecological Paradigm |
| NOS | Nature of Science |
| OD | Ozone Layer Depletion |
| PEB | Pro-Environmental Behaviour |

| | |
|---|---|
| PN | Personal Norms |
| QB | Questionnaire on Belief |
| QK | Questionnaire on Knowledge |
| QPEB | Questionnaire on Pro-environmental Behavior |
| QPN | Questionnaire on PN |
| QV | Questionnaire on Value |
| VBN | Value Belief Norm |
| VBNT | Value Belief Norm Theory |
| WBCCE | Web-based Climate Change Education |
| WBE | Web-based Education |

## LIST OF APPENDICES

**KEBERKESANAN PENDIDIKAN PERUBAHAN IKLIM BERASASKAN WEB TERHADAP PENINGKATAN LITERASI PERUBAHAN IKLIM DALAM KALANGAN MURID SEKOLAH RENDAH**

## ABSTRAK

Literasi perubahan iklim dilihat sebagai salah satu bahagian yang penting dalam pengajaran dan pembelajaran Sains. Pemupukan literasi perubahan iklim seiring dengan kandungan yang disampaikan dan strategi pengajaran yang digunakan dalam mata pelajaran Sains khasnya di sekolah rendah. Kajian ini diperkenalkan untuk mengkaji Keberkesanan Pendidikan Perubahan Iklim Berasaskan Web dalam meningkatkan pengetahuan (kesan rumah hijau, pemanasan global, penipisan lapisan ozon dan hujan asid), nilai (kepentingan terhadap sendiri, kepentingan terhadap orang lain dan kepentingan terhadap semua benda hidup), kepercayaan (model ekologi baharu, tanggungjawab dan kesedaran), norma peribadi dan sikap dalam kalangan murid sekolah rendah. Kajian ini menggunakan kaedah gabungan yang merangkumi pengumpulan data kuantitatif dan kualitatif dimana data kualitatif digabungkan bersama data kuantitatif. Soal selidik dan temu bual telah dijalankan bagi mengukur perubahan dalam pembolehubah bersandar. Soal selidik literasi perubahan iklim digunakan untuk mengukur keberkesanan pengetahuan, nilai, kepercayaan, norma peribadi dan sikap murid ke arah pemuliharaan iklim. Seramai 120 murid Tahun Lima dari dua buah sekolah rendah terlibat dalam penyelidikan ini yang dibahagikan kepada 60 orang murid kumpulan eksperimen dan 60 orang murid kumpulan kawalan. Sebanyak 17 aktiviti Pendidikan Perubahan Iklim Berasaskan Web digunakan dalam kajian ini untuk menyemai literasi perubahan iklim dalam kalangan murid. Analisis Kovarian Multivarian dan Analisis Kovarian dijalankan

untuk keberkesanan pembolehubah bersandar. Perubahan yang signifikan diperolehi untuk kelima-lima konstruk literasi perubahan iklim yang digunakan dalam kajian ini. Analisis Kovarian menunjukkan perubahan yang signifikan di antara kumpulan eksperimen and kumpulan kawalan. Keputusan analisis tematik daripada respon temu bual seterusnya menyokong keputusan signifikan yang diperoleh melalui dapatan kuantitatif. Sehubungan itu, Pendidikan Perubahan Iklim Berasaskan Web adalah pendekatan yang dapat digunakan untuk menyemai pengetahuan, nilai, kepercayaan, norma peribadi dan perubahan sikap terhadap pemuliharaan iklim dalam kalangan murid sekolah rendah.

# THE EFFECTIVENESS OF WEB-BASED CLIMATE CHANGE EDUCATION ON IMPROVING CLIMATE CHANGE LITERACY OF PRIMARY SCHOOL STUDENTS

## ABSTRACT

Climate Change Literacy is seen as an essential part of the teaching and learning of Science. Fostering climate change literacy is closely related to content delivery and the teaching strategy used in Science-based subject, particularly at the primary school level. This study was conducted with the aim to measure the effectiveness of Web-based Climate Change Education on improving climate change literacy among primary school students' knowledge (greenhouse effect, global warming, ozone layer depletion and acid rain), values (egocentric, homocentric and ecocentric), belief (new-ecological paradigm, attribute to responsibility and awareness of consequences), personal norms, and pro-environmental behaviour to conserve the climate. This study used a mixed method concurrent embedded research approach that incorporates both quantitative and qualitative data collection in which qualitative data was embedded within the quantitative data. Questionnaire survey and interviews were conducted to measure the changes in the dependent variables. The Climate Change Literacy Questionnaire was used to measure the effectiveness of Web-based Climate Change Education on students' knowledge, values, belief, personal norms, and pro-environmental behaviour to conserve the climate. Interviews were conducted to obtain further information to support the outcome of the quantitative analysis. The study involved a total of 120 Year Five students from two primary schools who were divided into two groups with 60 students in the experimental group and another 60 in the control group. A total of 17 Web-based

Climate Change Education activities were used in this study to infuse climate change literacy among students. Multivariate Analysis of Covariance and Analysis of Covariance tests were performed to look into the changes in the dependent variables. Significant changes were obtained for all five constructs and subconstructs towards conserving climate. Analysis of Covariance indicates that the difference between the control group and experimental group is significant. The thematic analysis performed on interview responses further support the significant result obtained in the quantitative findings. As such, Web-based Climate Change Education is an approach that can be adopted to infuse knowledge, value, belief, personal norms, and pro-environmental behaviour towards combating climate change among primary school students.

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

The term ‘climate’ can be defined as the overall pattern of weather in a selected area over a period of time. Climate has been studied over time periods ranging from decades to centuries to come to learn how long it changes (Johnson, 2016; Shepardson et al., 2013; Trocaire, 2014). Perceptions and ideas about climate change are shifting around the world. People are experiencing, first and foremost, extreme catastrophes such as flooding and snow, and persistent chronic occurrences such as drought. Climate change, on the other hand, has an impact on the unique areas where people live (Harper et al., 2017; Nicolosi & Corbet, 2018; Pachauri et al., 2014; Wigley, 2018; Wilcox et al., 2015). It is found that society and ecosystems are at risk due to climate change. Therefore, it is an essential content in Science Education and climate change topics (IPCC, 2016; McSweeney, 2015). This matter is based on the conceptual expansion of Science education's aim to reflect on scientific literacy, which emphasizes the global public to be scientifically literate on the different environmental issues associated with climate change and environmental conservation (World Economic Forum, 2019).

Global warming is a long-term warming of the Earth’s climate system that has been seen from the pre-industrial period (between 1850 and 1900) as a result of human activity, particularly fossil fuel burning which increases heat-trapping greenhouse gas levels in the atmosphere. The average increase in the Earth’s global surface temperature is the most frequent way of measuring it (NASA’s Global Climate Change Website, 2021). The Intergovernmental Panel on Climate Change

(IPCC) concluded that global warming is real, and that human activities are the cause for it (IPCC, 2016; IPCC, 2018). The IPCC notes that human activities continue to alter the landscape and the atmospheric composition, methane, carbon dioxide, and nitrous oxide composition. The gases are expected to increase the global temperature and cause changes in the Earth's climate. The IPCC (2016) as well as others such as Pauw and Petegam (2011) are urging the younger generations from primary school onward to avoid future ecological devastation.

In their survey, Shepardson et al. (2012) propose that instructional design, curriculum development, and future studies should all be examined as part of the climate change framework. Hedlund (2015) posits that since environmental issue is the biggest challenge faced by humans, upcoming generations should be forced to relate environmental problems such as climate change in their lives. As such, there is a need to prepare our students to be climate literate. Collectively, Shepardson et al. (2012), Sharma (2012), and Hedlund (2015) explain that it is critical to ensure that students understand climate change issues, and that climate change education at the school level should focus on teaching students about climate change literacy. Climate change literacy encompasses acquiring knowledge about climate change and inculcating values, beliefs, and personal norms towards conserving pro-environmental behaviour (Johnstone et al., 2020, Johnstone, 2021).

Fostering climate change literacy is closely related to content delivery and the teaching strategy used, particularly at the primary school level (Bellino & Adams, 2017; Johnstone et al., 2020). The appropriate content effectively emphasises students' knowledge of the greenhouse effect, global warming, ozone layer depletion, and acid rain (Anyanwu & Grange, 2017; Barr, 2007; Boon, 2009; Siperstein 2015). According to Stern (2000), the value orientations encompass egocentric, homocentric,

and ecocentric values, while beliefs include the world view or a new ecological paradigm, awareness of consequences and attributes to responsibility. Personal norms imply a commitment to conserve the climate, which is reflected through behaviours. The behaviours here refer to pro-environmental behaviour, which includes actions taken to protect and preserve the climate.

A study by Park et al. (2020) reveals that Science Education forms an integral part of climate change education. Climate change processes include scientific principles and modalities of causation which are associated with climate change impacts (Dupigny-Giroux & Cole 2018; Liu, 2013; Sharma, 2012). The inclusion of climate change education in Science Education aligns to Sharma's (2012) claim that Science Education should be transformed to enable students to play a leading role as humans in creating a sustainable community. At the primary level, climate change has been infused in the pedagogy of Science Education either as a teaching strategy or infused in selected topics (Holthuis et al., 2014; Jin et al., 2013; Karpudewan et al., 2014; Karpudewan et al., 2015; Karpudewan & Mohd Ali Khan, 2017; Otieno et al., 2014). The issue of energy, heat and matter taught for Year 5 Science in Malaysian primary schools is closely associated with climate change concepts and principles. For instance, the greenhouse effect and global warming are the climate concepts appropriate to be integrated while teaching heat, energy, and matter topics.

Past studies have indicated the necessity of teaching and learning about global warming and climate change which is a real-world problem (Dawson, 2015; Maria & Kamisah, 2010). Some studies have shown that using web-based learning allows students to investigate and manipulate Dawson's real-world issue (Boca & Saracli, 2019). For this reason, many studies have relied on web-based learning to deliver climate change-based lesson (Duerden & Witt, 2010; Pruneau et al., 2001;

Sharma, 2012; Shepardson et al., 2013). Hence, through this study, an attempt was made to deliver climate change education during the science-based lessons on heat, energy, and matter for Year 5 students using web-based learning.

The Web-based Climate Change Education (WBCCE) performed with Year 5 students in this study enabled them to visualise videos with two-dimensional animations of 17 online activities, observing the results of the experiments in two-dimensional view, and answering the related quiz. The videos that incorporate climate change phenomena such as global warming, greenhouse effect, ozone layer depletion, and acid rain into scientific concepts such as heat, energy, and matter rely on the information on the causes, effects, and solutions to climate change. This results in WBCCE incorporating elements of climate change literacy (knowledge, values, belief, personal norms, and pro-environmental behaviour). Therefore, this study used a mixed-method approach to measure the effectiveness of WBCCE on the climate change literacy of the participating Year 5 students.

## 1.2 Background of the Study

Education is an essential component of the world response to climate change. It serves as a tool for young people to learn about global warming, encourages them to modify their attitudes and behaviours, and adapts to environmental changes (Barth, 2016; Pruneau et al., 2016; UNFCCC, 2015). According to Abdullah (2018), education has a significant impact on shaping human identity, environmental management, and future planning. For this reason, climate change forms an integral component of education in many countries (Johnstone, 2021; Karpudewan et al., 2014; Karpudewan et al., 2015, Pruneau et al., 2010; Stephanie et al., 2015; Svihla &

Linn, 2012). As stated earlier, climate-related matters affect education, and they are mostly incorporated and infused into Science Education.

A study carried out by Karpudewan et al. (2014) demonstrates the 5E learning cycle to teach the matter of climate change activities. An example of the 5E learning process is infusing the topic of energy in the primary Science curriculum to home design. The study reported that climate change introduced using the 5E learning cycle could enhance students' understanding of climate change and infuse a healthy responsibility to protect the environment. Another study conducted by Karpudewan et al. (2014) revealed that school-based education plays a vital role in improving students' attitudes and knowledge. The school plays a vital role in assisting students in their familiarity and awareness of environmental challenges which involves their attitude toward climate change issues as well as their factual knowledge and interest in the topic. Schools also have a substantial impact on their ability to persuade others to save the environment as highlighted by Karpudewan et al. (2013), Barraza and Walford (2002), Boyes and Stanisstreet (2012), Taber and Taylor (2009), Michail et al. (2006), Karpudewan and Chin (2013), and Svihla and Linn (2012).

According to UNESCO (2015, 2019), the ultimate goal of climate change education in schools should be to create climate change literacy among students in order to slow the rate of climate change. Climate change literacy is defined by Johnstone et al. (2020) as understanding of climate science, reasoning abilities about climate change, and motivation to act on climate change. Stern (2000) presents climate change literacy as understanding the impacts and engaging in deciding values, beliefs, and personal norms that influence the decision on the behaviour. Considering both Johnstone and Stern's definition, in this study, climate change literacy is

presented as a combination of knowledge, values, belief, personal norms, and pro-environmental behaviour in conserving the climate.

Knowledge is one of the important subject matters in climate change education. According to Fang and Chen (2012), knowledge of climate change causes is a very powerful source of behavioural change as it can build more pro-environmental actions to fight against climate change. Leiserowitz et al. (2010) refer to the appropriate knowledge of global warming, greenhouse effect, ozone layer depletion, and acid rain. The components of knowledge integral to climate change commensurate the Year 5 Science curriculum on heat, energy and matter, emphasizing learning about energy in connection with real-world phenomena (Curriculum Development Division, 2016). Web-based learning permits students to visualise the real-world phenomena. The realistic viewing of the phenomena, as indicated in earlier studies, enables students to comprehend the scientific principles behind global warming, greenhouse effect, ozone layer depletion, and acid rain (Alexandru et al., 2013; Feldman et al., 2018; Porter et al., 2012; Svihla & Linn, 2012).

A study by Gheith (2013) claims that values are the main driving force in both personal and social endeavour. De Groot and Steg (2007, 2008) speculate on three value orientations: egocentric and homocentric, and ecocentric. Nordfjaern (2015) and Onur et al. (2011) state that people who have egocentric value weigh the costs and benefits of their environmentally-friendly behaviour and the only thing that they do is things that will make them profitable. According to Judith et al. (2008) and De Boer et al. (2013), individuals with strong homocentric values will consider their cost and benefits to experience by society and humans around them and that they do not value or care for nature. Finally, individuals who possess the ecocentric value

make decisions based on perceived costs and benefits to the ecosystem as a whole, and expand on the concept of eco-centrism as the view that defines a man as a member of a whole (De Groot et al., 2012; Schultz et al., 2005). The three value orientations are significant while students investigate the real-world phenomena of global warming, greenhouse effect, ozone layer depletion, and acid rain during the lessons on heat, energy, and matter using WBCCE.

Stern et al. (1999), Stern (2000), and Dunlap et al. (2000) describe 'belief' as the combination of a new ecological paradigm, attribute to responsibility, and awareness of consequences. The new ecological paradigm about climate change includes the way humans conserve the Earth, the result of human's bad behaviour towards climate, and disaster in the future while investigating the real-world phenomena of global warming, greenhouse effect, ozone layer depletion, and acid rain. According to Eriksson et al. (2008) as well as Thor and Karlsudd (2020), awareness of consequences relates to activities that have to be expanded which may include many additional beliefs about specific conditions concerning climate change. This may further involve the awareness that humans have to save the Earth from disasters and reduce climate change issues. On the other hand, attribute to responsibility is to be responsible for other consequences of one's action and refers to man's responsibility and contribution towards conserving the climate, as stated by Karpudewan (2019).

Personal norm is described as an obligation to act environmentally in order to promote change in one's feeling of environmental responsibility and that humans have to keep the environment clean and the way to save our nature and Earth (Doran & Larsen, 2016). Stern (2000) proposes personal norms as one of the constructs closely associated with behaviour development on environment issues, denoting that

students' personal norms are enhanced when they are provided with the experience of manipulating real-world environmental issues. Stern's assertion parallels to exposing students to real-world climate change issues during the lessons on heat, energy, and matter using WBCCE. Additionally, Stern (2000) also explains pro-environmental behaviour as a set behaviour influenced by values, beliefs, and personal norms. Krajhanzl (2010) provides another meaning and defines pro-environmental behaviour as a protective way towards a healthy environment. In lieu of both Stern's and Krajhanzl's definition, in the context of protecting the climate, pro-environmental behaviour includes the action performed to conserve the climate. In these WBCCE online activities, students use web-based learning to investigate the four climate change phenomena of global warming, greenhouse effect, ozone layer depletion, and acid rain during science lessons on the topic of heat, energy, and matter.

The effective teaching and learning of climate change materialises when students are provided with the opportunity to visualise the four climate change phenomena for real (Svihla & Linn, 2012). Studies have documented that web-based learning allows students to experience real phenomena (Alexandru et al., 2013; Fieldman et al., 2018; Makrakis et al., 2012; Schupbach et al., 2003; Uherek & Schüpbach, 2013). Svihla and Linn (2012) tested a team of Year 6 students through five online inquiry lessons to introduce them to the climate change phenomena through a Web-based Inquiry Science Environment (WISE) project. Through these lessons, students learned about the disciplinary context of global climate change in a virtual context, such as greenhouse effect and global warming, ozone layer depletion and acid rain. In the research, students were engaged in virtual experiments to visualise the greenhouse effect and global warming through video. It was discovered

that students' knowledge about greenhouse effect and global warming were increased, and thus allowed students to explore meaningful information about greenhouse effect and global warming.

In a study by Alexandru et al. (2013) entitled *Changing with the Climate Network*, the programme linked schools across Europe to enhance the teaching and learning of climate change through networking. This study proved that web-based education was different from teacher-cantered learning in terms of great advantages, differentiation, collective feedback, and collaborative problem solving. It encouraged responses to cut greenhouse gas emissions in a constructive manner as well as actions to deal with climate change. The researchers recommended that a technology-based method with students would be better for such issues as greenhouse effect, global warming, ozone layer depletion and acid rain. In another study, Makrakis et al. (2012) investigated the ICT-enabled Climate Change Education that examined the web-approach to the critically named ExConTra's which integrated critical construction theory using ICT combined with ESD. For the first time, this study was open to all primary schools. A student was able to learn and gain new knowledge by participating in discussions and simulations, playing games, exploring simulations, and watching videos and slides on the information while getting personal rewards for doing so and helping to change the environment. The study's findings imply that to the behaviour of pro-environmental students, they must engage in and keep on learning to see that their active involvement and understanding of climate change which is transferred into action will sustain pro-environmental action on the web-based learning environment. The initiative above has been proven to effectively improve primary schools students' learning about climate change. The web-based learning conducted by Uherek and Schüpbach (2013),

Svihla and Linn (2012), and Makrakis et al. (2012) matches with the assertion that many web learning applications are now designed in such a way that information presented online on the website is integrated with multimedia features and follows certain core ideas (Svensson & Ostluand, 2007).

The above definition of climate change literacy corresponds to the Science curriculum in Malaysian primary schools. The objective of climate change literacy is to foster enthusiasm and creativity while fostering scientific and logical thinking, respect and attitudes, as well as instilling environmental knowledge (Curriculum Development Division, 2016). The concept, in particular, aligns to the meaning of climate change literacy which helps children understand the ideas of the primary school Science curriculum. The project's eighth purpose is to make people aware of their actions' environmental consequences. In order to achieve this goal, environmental challenges, like climate change, should be introduced into the Year 5 primary Science curriculum, along with concepts like heat, energy, and matter (Curriculum Development Division, 2016). This is because the learning outcomes of these topics correspond with knowledge students acquire from understanding global warming, greenhouse effect, ozone layer depletion, and acid rain. This is the main reason why Year 5 primary school students were selected as the respondents of this study.

The topics of heat, energy, and matter in Year 5 primary school Science curriculum provide the concrete base to integrate and infuse climate change phenomena such as global warming, greenhouse effect, ozone layer depletion, and acid rain. The topics' learning outcome corroborate the scientific explanation embraced within the four climate change phenomena (Curriculum Development Division, 2016). For instance, in the lesson on energy, students are assigned to

research and generate ideas on the usage of non-renewable energy and the implications if the supply of renewable resources decreases. The lessons on temperature and heat require students to generalise how temperature increases as it gets warmer and decreases when it loses heat. The lessons on renewable energy and temperature changes are associated with global warming and greenhouse effect. While it is standard practice to expand and contract materials in order to obtain and release heat, students must also describe how this occurs. In learning about matter, students must observe the changes in the formation of clouds and rainfall as the result of changing states of water. Students also have to discuss the importance of the natural water cycles to maintain water resources as well as factors that cause contamination and methods to counterbalance its impact to living things. This relates to acid rain and ozone layer depletion.

The WBCCE introduced in this study adapts the content-specific features found in web-based learning in the studies by Uherek and Schupbach (2013), Svihla and Linn (2012), McNeill and Vaughn (2012), and Masruri (2017). In this study, WBCCE refers to 17 online activities that incorporate climate change causes, effects and solutions which are integrated with web-based learning and infused in Year 5 Science topics of energy, heat, and matter. WBCCE entails students to read the introductory section of an experiment and to view the audio-visual experiments related to scientific concepts on the topic of energy, heat, and matter. This is followed by a discussion session about the experiments related to heat, energy, and matter which integrate the four climate change phenomena. Then, students are engaged with answering four quiz questions posted online based on their understanding from the audio-visual experiments and group discussion. The questions require students to review and recap the information obtained from the

audio-visual experiments. After that, students are required to provide feedback about the audio-visual experiments. Finally, students type in their understanding about the four climate change phenomena at the comment dialogue box before continuing with the next activity with the same approach. Students are tasked with three activities in each lesson during the intervention phase of six weeks at school.

## 1.3 Problem Statement

The most threatening and environmentally-urgent issue of the 21st century is climate change (Alexandru et al., 2015; Mahdi Amirabadizadeh, 2015). Climate change is a serious hazard to individuals from all walks of life. According to a study by Lay (2019), the only way to slow environmental degradation is to teach future citizens about climate conservation, particularly among primary school students. According to Stern (2000), values, beliefs, and personal norms are the root of pro-environmental behaviour. Knowledge is another important factor that informs behaviour formation (Azevedo and Marques, 2017; Karpudewan et al., 2009). However, efforts undertaken at the primary level to teach students on climate change locally have been scarce, and studies employing the value belief norm theory perspective in researching about climate change in Malaysia have been limited (Karpudewan et al., 2014; 2015; 2019).

Climate change has been recognised as one of the most urgent issues impacting our education system at present, as research shows that both middle and high school students are uncertain about its current patterns and future directions (Choi et al., 2010; Feldman et al., 2010; Özdem et al., 2014). A worldwide survey performed by the OECD (2009) and UNICEF (2009) with young children revealed that most children had very poor knowledge of climate change. According to Ajzen

(2012), global warming, greenhouse effect, ozone layer depletion and acid rain remain inadequately illustrated, as textbooks do not show the real-world phenomena. A similar scenario is also prevalent among Malaysian primary school students. Karpudewan et al. (2014) reported that primary school students possess a low level of knowledge about the environment and climate change. Particularly, the study discovered widespread knowledge gaps among Malaysian primary school children about global warming, greenhouse gas emissions, ozone layer depletion, and acid rain. A different study involving primary school students documented that the participating students possessed superficial knowledge about the environment (Karpudewan & Chin, 2013). A study by Lim et al. (2005) in two schools at Selangor agrees that the students' knowledge of environmental issues such as climate change was at surface level in Malaysia.

Furthermore, very few studies investigated and documented the Malaysian primary school students' environmental values, beliefs, and personal norms in general and climate change in particular. In an attempt to document a model to describe the climate change behaviour of primary school students, Karpudewan (2019) identified the values, beliefs, and personal norms of Malaysian primary school students. The study documents that Malaysian primary school students' values, beliefs, and personal norms are literately poor. In a different study, Karpudewan et al. (2014) investigated Malaysian primary school students' level of belief. In this study, the authors conducted a new ecological paradigm scale investigation to explore the belief variable in the subjects. The findings depict the lower level of Malaysian primary school students' belief as measured by the new ecological paradigm. There are other studies which have reported on Malaysian secondary and primary students' awareness and attitude towards the environment

(Azlinawati et al., 2018; Nurul Hidayah et al., 2012). The studies' findings revealed that generally, Malaysian students lack awareness and attitude despite at times the students exhibited a considerable good level of knowledge (Aini et al., 2011; Karpudewan & Chin, 2013; Karpudewan et al., 2014). These findings offer strong evidence that students may lack a clear sense of self-awareness, as well as any interest in values, beliefs, and norms to be poor. This is because values, belief, norm and awareness are interrelated in a linear manner (Anderson, 2012; Brownlee et al., 2013).

There are limited studies available in the literature that report on behaviours towards conserving the climate in terms of pro-environmental behaviour. However, many available studies focus on general pro-environmental behaviour and behaviours towards specific environmental issues. For instance, Erdogan et al. (2012), in their study, reported that children exhibit minimal pro-environmental behaviour. Based on the Programme for International Students Assessment (PISA) 2015 data in Coertjens et al. (2010) article, there is evidence to show that students who participate in environmental activities in schools have a higher pro-environmental behaviour. Based on their concept of awareness of consequences, Boyes and Stanisstreet (2012) attempted to build some models on encouraging pro-environmental behaviour as there was a lack of effort in linking general potential behaviour patterns and building models to develop among students. The local study involving undergraduate students indicated that students possessed minimal self-reported pro-environmental behaviour (Karpudewan et al., 2012). Prior to the intervention on project-based energy education, secondary students were also deemed to possess minimal behaviour towards conserving energy (Karpudewan et al., 2016).

Past studies on informed teaching and learning emphasise relating knowledge of climate change to the students, working on the primary reason in which students have low values, beliefs, norms, and behaviour (Chen et al., 2015; Doost et al., 2011; Fielding & Head, 2012; Foo, 2013; Gifford & Nillson, 2014; Lee et al., 2015; Levine & Strube, 2013; Marcinkowski et al., 2011; Ntona et al., 2015; Stern, 2000; Theobald et al.,2015). Some studies recommend the gap in climate change literacy can be addressed using web-based learning (Bliwise, 2005; Bolliger & Supanakorn, 2011; Das, 2015; Hedlund, 2015; Porter et al., 2012; Smith et al., 2018). A study by Mower (2012) documented web-based learning effectively improved students learning about climate change. However, this is not the scenario in Malaysian primary schools. According to Balakrishnan (2022), examinations have a significant impact on what happens in the classroom. Teachers are continuing to "teach to the test." Environmental education, including climate change, is generally taught using a teacher-centred approach which emphasises students acquiring the knowledge to answer the exam questions only. Mustam and Danial (2018) argue that the education in Malaysia entirely neglects the emphasis on inculcating the affective dimensions of environmental awareness, which are values, beliefs, and personal norms to develop good behaviours in students to conserve the climate. Therefore, in this study, WBCCE refers to 17 online activities that incorporate climate change causes, effects, and solutions, which are integrated with web-based learning and infused in Year 5 Science topics of energy, heat, and matter.

## 1.4 Purpose of the Study

The main purpose of this study is to measure the effectiveness of WBCCE on students' knowledge (i.e., greenhouse effect, global warming, ozone layer depletion, and acid rain), values (egocentric, homocentric, and ecocentric), belief (new ecological paradigm, attribute of responsibility, and awareness of consequences), personal norms, and pro-environmental behaviour.

## 1.5 Research Objectives

1. To measure the effect of WBCCE on students' knowledge of climate conservation.
    a) To measure the effect of WBCCE on students' knowledge about greenhouse effect.
    b) To measure the effect of WBCCE on students' knowledge about global warming.
    c) To measure the effect of WBCCE on students' knowledge about ozone layer depletion.
    d) To measure the effect of WBCCE on students' knowledge about acid rain.
    e) To explore students' climate conserving knowledge among experimental group and control group in the pre- and post-interviews.

2. To measure the effect of WBCCE on students' values of climate conservation.
    a) To measure the effect of WBCCE on students' egocentric values of conserving the climate.
    b) To measure the effect of WBCCE on students' homocentric values of conserving the climate.

c) To measure the effect of WBCCE on students' ecocentric values of conserving the climate.

d) To explore students' climate conserving values among experimental group and control group in the pre- and post-interviews.

3. To measure the effect of WBCCE on students' beliefs of climate conservation.

a) To measure the effect of WBCCE on students' new ecological paradigm of conserving the climate.

b) To measure the effect of WBCCE on students' attribute of responsibility of conserving the climate.

c) To measure the effect of WBCCE on students' awareness of consequences of conserving the climate.

d) To explore students' climate conserving belief among experimental group and control group in the pre- and post-interviews.

4. a) To measure the effect of WBCCE on students' personal norms of climate conservation.

b) To explore students' climate conserving personal norms among experimental group and control group in the pre- and post-interviews.

5. a) To measure the effect of WBCCE on students' pro-environmental behaviour of climate conservation.

b) To explore students' climate conserving pro-environmental behaviour among experimental group and control group in the pre- and post-interviews.

## 1.6 Research Questions

In line with the objectives of the study, the following research questions are formulated:

1. Is there any statistically significant difference in the linear combination of the experimental and control groups' climate change knowledge post-test mean score after controlling the pre-test scores?
    a) Is there any statistically significant difference between the experimental and control groups' knowledge about greenhouse effect post-test mean score after controlling the pre-test scores?
    b) Is there any statistically significant difference between the experimental and control groups' knowledge about global warming post-test mean score after controlling the pre-test scores?
    c) Is there any statistically significant difference between the experimental and control groups' knowledge about ozone layer depletion post-test mean score after controlling the pre-test scores?
    d) Is there any statistically significant difference between the experimental and control groups' knowledge about acid rain post-test mean score after controlling the pre-test scores?
    e) How do students' knowledge about climate change differ in the pre-test and post-test interviews between the experimental group and control group students?
2. Is there any statistically significant difference in the linear combination of the experimental and control groups' environmental values post-test mean score after controlling the pre-test scores?

a) Is there any statistically significant difference between the experimental and control groups' egocentric values post-test mean score after controlling the pre-test scores?

b) Is there any statistically significant difference between the experimental and control groups' homocentric values post-test mean score after controlling the pre-test scores?

c) Is there any statistically significant difference between the experimental and control groups' eco-centric values post-test mean score after controlling the pre-test scores?

d) How do students' values towards climate change differ in the pre-test and post-test interviews between the experimental group and control group students?

3. Is there any statistically significant difference in the linear combination of the experimental and control groups' environmental belief post-test mean score after controlling the pre-test scores?

a) Is there any statistically significant difference between the experimental and control groups' new ecological paradigm post-test mean score after controlling the pre-test scores?

b) Is there any statistically significant difference between the experimental and control groups' attribute of responsibility post-test mean score after controlling the pre-test scores?

c) Is there any statistically significant difference between the experimental and control groups' awareness of consequences post-test mean score after controlling the pre-test scores?

d) How do students' belief towards climate change differ in the pre-test and post-test interviews between the experimental group and control group students?

4. a) Is there any statistically significant difference between the experimental and control groups' personal norms post-test mean score after controlling the pre-test scores?

   b) How do students' personal norms towards climate change differ in the pre-test and post-test interviews between the experimental group and control group students?

5. a) Is there any statistically significant difference between the experimental and control groups' pro-environmental behaviour post-test mean score after controlling the pre-test scores?

   b) How do students' climate conserving pro-environmental behaviours differ in the pre-test and post-test interviews between the experimental group and control group students?

## 1.7 Hypothesis

$H_{01}$: There is no significant difference in the linear combination between the experimental and control groups' environmental knowledge towards WBCCE post-test mean scores after controlling the pre-test scores.

$H_{01a}$: There is no statistically significant difference in the knowledge about greenhouse effect between the experimental and control groups towards WBCCE post-test mean score after controlling the pre-test scores.

$H_{01b}$: There is no statistically significant difference in the knowledge about global warming between the experimental and control groups towards WBCCE post-test mean score after controlling the pre-test scores.

$H_{01c}$: There is no statistically significant difference in the knowledge about ozone layer depletion between the experimental and control groups towards WBCCE post-test mean score after controlling the pre-test scores.

$H_{01d}$: There is no statistically significant difference in the knowledge about acid rain between the experimental and control groups towards WBCCE post-test mean score after controlling the pre-test scores.

$H_{02}$: There is no significant difference in the linear combination between the experimental and control groups' environmental values towards WBCCE post-test mean score after controlling the pre-test scores.

$H_{02a}$: There is no statistically significant difference in egocentric values between the experimental and control groups towards WBCCE post-test mean score after controlling the pre-test scores.

$H_{02b}$: There is no statistically significant difference in homocentric values between the experimental and control groups towards WBCCE post-test mean score after controlling the pre-test scores.

$H_{02c}$: There is no statistically significant difference in eco-centric values between the experimental and control groups towards WBCCE post-test mean score after controlling the pre-test scores.

$H_{03}$: There is no significant difference in the linear combination between the experimental and control groups' environmental belief towards WBCCE post-test mean score after controlling the pre-test scores.

$H_{03a}$: There is no statistically significant difference in new ecological paradigm between the experimental and control groups' post-test mean score after controlling the pre-test scores.

$H_{03b}$: There is no statistically significant difference in attribute of responsibility between the experimental and control groups' post-test mean score after controlling the pre-test scores.

$H_{03c}$: There is no statistically significant difference in awareness of consequences between the experimental and control groups' post-test mean score after controlling the pre-test scores.

$H_{04}$: There is no statistically significant difference in personal norms between the experimental and control groups' post-test mean score after controlling the pre-test scores.

$H_{05}$: There is no statistically significant difference in pro-environmental behaviour between the experimental and control groups' post-test mean score after controlling the pre-test scores

## 1.8 Significance of Study

The WBCCE activities promote student-centred and real-life learning which allow students to watch the audio-visualised online activities, discuss them with friends, answer quizzes based on the online activities, leave feedback in the comment box, and have their marks appear immediately after each activity. These WBCCE activities promote the child's behavioural changes to conserve the climate and to compare them to the non-web-based climate change learning and education approach (Buchanan et al., 2019; Klosterman & Sadler, 2010; Kubiatko, 2010; Pruneau et al., 2003). Hence, WBCCE is one of the 21$^{st}$ century learning approach tools which

serves to equip the future generation of students with a better understanding of the current ecosystem by aiding them in the development of a comprehensive environmental climate Science curriculum.

Teachers become facilitators while conducting WBCCE, providing the social context for student's understanding of climate change literacy and research methods (McNeill & Vaughn, 2012; Porter et al., 2012; Svihla & Linn, 2012). The activity manual for this mode of study will assist the teacher in guiding, motivating, and encouraging students' active participation in WBCCE activities. A better understanding of climate change can lead to more informed decisions, more effective policies, and increased public safety. It will indirectly contribute to economic growth. Another reason to increase the number of these projects is that they help to reduce negative environmental impacts and risks.

The study can be useful for Science Education policymakers and curriculum developers. Several studies have shown the effectiveness of WBCCE in enhancing climate change literacy (Gottlieb et al., 2013; Ohman, & Ohman, 2012), yet studies on WBCCE in the Malaysian context are still lacking. As a result, this study can be used as a practical guide for future studies looking into ways to improve climate change literacy through WBCCE. Climate change literacy among students has been shown to improve as a result of WBCCE activities. Therefore, it seeks to assist Science teachers, curriculum developers, and policymakers in improving Malaysian students' skills on the Programmed for International Student Assessment (PISA) and Trends in Mathematics and Science Studies (TIMSS) assessments.

WBCCE activities add value to the Value Belief Norm Theory and Multimedia Learning Theory and the quasi-experimental research design method used in this study. The activities are consistent with value belief norms and multimedia learning expectations, which enable students to incorporate learning into their daily lives by engaging in real-world situations. WBCCE activities in this study also enhance knowledge, values, belief, personal norms, and pro-environmental behaviour toward climate conservation. Thus, this study is capable to function as a source of reference embodying experimental research in the curriculum development for Science Education on climate change using the Value Belief Norm Theory and Multimedia Learning Theory.

WBCCE can be a good example for the model development of web-based learning since there are limited web-based learning studies and model available in the literature that report on behaviour changes towards conserving the climate in Malaysia. Past studies have identified lack of teaching and learning that emphasise the four climate change phenomena among students as the primary reason students have low values, beliefs, norms, and behaviour (Chen et al., 2015; Doost et al., 2011; Fielding & Head, 2012; Foo, 2013; Gifford & Nillson, 2014; Karpudewan et al., 2014, 2015; Levine & Strube, 2013; Ntona et al., 2015). The WBCCE activities can be a good example for model development to encourage the younger and future generations to conserve the climate as a responsible citizen.

An overall increase in students' perception of climate change can have a greater impact on such issues like global warming, greenhouse effect, ozone layer depletion and acid rain due to low learning performance in schools (Feldman et al., 2010; Özdem et al., 2014). The Ministry of Education can develop some web-based learning climate change programmes to help students gain the knowledge, value,