STUDENTS' CONCEPTUAL UNDERSTANDING AND IMAGES ON CLIMATE CHANGE

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ABSTRACT

The issue of climate change has a real impact in the students. There are noted unusual changes in rainfall patterns, increase the number of strong tropical cyclones and occurrence of extreme weather conditions. Accordingly, the students need to have a conceptual understanding and images on the different concepts concerning climate change to engage students in explaining a phenomena using their context and possibly they can suggest possible solutions to the problem. Also, it is critical to comprehend students' visual representations or images since it reflects their explanations, translations, and mental understanding of their learning. The image that students can generate is also a reflection of students' understanding. On the other hand, the developed instrument Explain and Illustrate Task Instrument (EITI) was utilized in this study through survey-method to two hundred twenty-four (224) high school students to find out students' conceptual understanding and images on climate change. The results were analyzed based on students' responses and drawings in the EITI with the corresponding rubrics. Hence, results revealed students' understanding described as partial understanding of the causes of the increase of temperature while the concepts on rainfall, cyclone, drought, extreme meteorological condition and greenhouse gases concepts were described as no understanding. However, students demonstrated specific misconceptions about the concepts of the effects of rainfall, cyclone, and drought while no understanding of the concepts temperature, extreme meteorological condition, and greenhouse gases. Nevertheless, the students' images on the selected concepts related to climate change were described as depiction. But there is a strong significant relationship that exists between students' conceptual understanding of the causes, effects and images of the concepts of cyclone, extreme meteorological condition and greenhouse gas. Yet, a very weak significant relationship exists between students' conceptual understanding on the causes and images of the concepts of temperature, rainfall, and drought.

Keywords: *climate change, students' understanding, students' images*

INTRODUCTION

The impact of climate change is reflected of the changes in rainfall, the intensity of tropical cyclones, temperature and frequency of extreme weather events, which were projected by Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) (Servando, 2011). There is more number of hot days and warm nights, and decrease of cold days and cool nights in most of the part of the country that indicate the trends of extreme daily temperatures are manifestations of climate change that is influenced by human activities which resulted to more intense and more frequent rainfall and stronger typhoon like typhoon Yolanda "Haiyan" in 2013 that resulted to 6,300 fatalities (NDRRMC, 2016). The new breed of generation is the most vulnerable to the effects of climate change as it can damage their home; affect their studies because of class suspension. Thus, it is essential for the students to understand the causes and effects of climate change for them to prepare how to face the future. Most importantly, the students will be engaged in providing solutions to the problem. Nevertheless, there is a need for the students to develop scientific knowledge because there is still insufficient knowledge about climate change which is contributed by human activities and can endanger vulnerable people (IPPC, 2014; Pitpitunge, et al., 2013). Although, there are information, guidelines and warning systems designed by concerned agencies to inform the public but it is inadequate.

It is critical to enhance students' conceptual understanding and images. There is a need for the students to realize the relationship between concepts and procedures that will also contribute their understanding in the context of the principles of learning. The existing understanding and incorporation of new information generated by the students is facilitated by their conceptual understanding. It can give opportunities for teachers to adapt to their lessons especially when students exhibit errors and teachers can address errors which can guide students towards improved understanding (Wong, et al., 2007; Rittle-Johnson, Siegler & Alibali, 2001; Anderson, 2000). The greatest challenge for teachers is teaching conceptual understanding, which is the primary goal in science education (Moran & Keeley, 2015). When students manifest conceptual understanding of the concept they can do the following: (a) think with it (b) use it in areas other than that in which learned it, (c) state in their own words, (d) find a metaphor or an analogy, for it, or (e) build a mental or physical model of it. It is emphasized that students' conceptual understanding is important to have a successful learning and teaching.

Most importantly, teachers can enhance students' conceptual understanding and images through engagement of students which is relevant to a real-life application of learning. It should be primarily on recalling of information and memorization. Also, students' visual representation or images is important because it reveals their explanations, translations, and mental understanding of their learning (Wu, et al., 2001; Kozma & Russell, 1997). In addition, Zirbel (2005) described that the representation of concepts generally in a form of image may suggest students' understanding of a science concept. Teachers' role to allow students to take part in providing solutions to environmental problems is to improve their conceptual understanding and images. Also,

there is a dearth of studies, which reveals evidences of the impact of the climate change courses on students' learning and their environmental behavior. In line with this concern, the Department of Education (DepEd) in the Philippines recommends that issues on climate change shall be included in the basic education curriculum to better educate not only the students but also the public. In response to the said need, The Disaster Readiness and Risk Reduction course was introduced in the senior high school program of the K to 12. This contains concepts of climate change and adaptation and mitigation procedures, likewise, some of the basic concepts of climate change were already included and discussed in the junior high school science subjects. With the first four years of the implementation of the Grades 7-10 science in spiral progression design, it is ample to conduct an investigation on students' understanding and images on the different concepts of science, specifically of climate change to provide empirical and baseline information for science teaching and learning.

1.1 Purpose of the Research

The aim of the study determined the students' conceptual understanding and images on the different concepts of climate change using a developed and validated "Explain and Illustrate Task Instrument." More specifically, the study answered the following questions:

1. What are the students' conceptual understanding of the causes-and effects of the following concepts of climate change, namely:

    a. temperature,
    b. rainfall,
    c. cyclone,
    d. drought,
    e. extreme meteorological condition, and
    f. greenhouse gases?

2. What are the students' images on the above-mentioned concepts of climate change?

3. Are there significant relationships existing between the following:
    a. students' conceptual understanding on the causes and effects of the different concepts of climate change,
    b. students' conceptual understanding on the causes and images of the different concepts of climate change and
    c. students' conceptual understanding on the effects and images of the different concepts of climate change?

1.2 Conceptual Framework

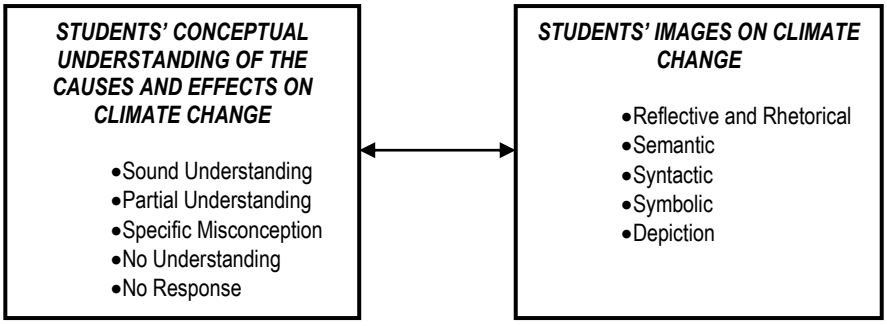

Figure 1 *Conceptual Framework*

The issues on climate change concept is both local and global problem, especially in the Philippines that the real impact on the causes and effects of climate change has threaten vulnerable countries according to Servando (2011) of PAGASA. Furthermore, climate change is given priority by the international development especially its effect but slightly felt in developing countries. A report of UNESCO (2011) mentioned that warmer countries like the Philippines are likely prone to rainfall variability.

However, there are several attempts to introduce topics of climate change in science education. Thus, the conceptual understanding of students will provide teachers opportunities to enhance their lessons and address common misconceptions (Wong, et al., 2007; Rittle-Johnson, Siegler, and Alibali, 2001; Anderson, 2000). Students' conceptual understanding on the different concepts of climate change is important because it represents the students' ability of global understanding as it identifies the cause-effect patterns over long distances, considering the earth ecosystem as a whole and perceives how climate change is affecting the entire global (Korsager, 2013; NASA, 2012). There is also a growing recognition of research undertakings on the need of students to learn how to interpret and construct representations of scientific concepts. Students' representations or images on certain science concepts provide explanations, translations, and mental understanding of their learning experiences (Zirbel, 2005; Wu et al., 2001; Kozma and Russell, 1997).

With the above-mentioned issues on climate change and studies on students' conceptual understanding and representation, this present study aimed to describe the students' conceptual understanding and images on the different concepts in climate change. These concepts on climate change are temperature; rainfall; cyclone; drought; extreme meteorological condition and greenhouse gases. These variables were culled using the EITI then analyzed and evaluated using the adapted and modified rubric of Kozma and Russel (2005). Specifically, students' conceptual understanding on the causes and effects of the different concepts of climate change were classified as *sound understanding*, *partial understanding, specific misconception, no understanding and no response*. *Sound understanding* means that the responses of students include all components or some of the scientifically accepted response. On the other hand, students' response described as *partial understanding* means that the responses may

include at least one of the components of the acceptable scientific ideas but may also contain a kind of misconception. Moreover, students' responses described as *specific misconception* contain responses that are descriptive, incorrect or illogical information, while students' responses described as *no understanding* means that the responses are irrelevant or contain uncodable responses or a phrase like *"I don't understand."* Lastly, students who have no answer or have the following forms of responses: *"No answer," I don't know," "I have no idea"* are described as *no response*.

In addition, students' images are classified as *reflective and rhetorical, semantic, syntactic, symbolic and depiction* using the rubric mentioned above. *Reflective and rhetorical* means that the students explain the relationship between physical attributes and underlying process by using one or more images of the concept of climate change, while students' images that are presented using formal symbol to show the underlying non-observable process are described as *semantic*, and then students' images that generate images both observed and unobserved physical attributes are described as *syntactic*. Moreover, the students' images that are described as *symbolic* means that the images are based on physical attributes but include symbols thus, examples of symbolic elements are arrows that represent motion or time. Lastly, students that generate images that are based on the physical attributes are described as *depiction*.

Another important aspect of this study is determining the significant relationship existing between students' conceptual understanding on the causes-effects and images of the concepts of climate change. This counter validates the assumptions of this study and the claims of previous studies on relationship between students' conceptual understanding and visual representations or images on the different fields and topics of science.

2. Literature Review

2.1 Students' Conceptual Understanding on Climate Change

The importance of science literacy can help student understand and shape their lives. Thus, the students can have the abilities to correlate and understand which is more important behind the rote calculations and the common textbook knowledge stressed by Howard (2011) when students have conceptual understanding on a certain concept in science. In fact, sound understanding on the different concepts of climate change is more than finding the "correct" answers according to Korsager (2013). The importance of trying to grasp relations between climate and climate change issues is a way to expand a complete understanding by focusing on causalities. Hence, causalities also refer to the patterns of interaction between causes and effects (Korsager, 2013; Grotzer & Perkins, 2000; Perkins & Grotzer, 2005). A literate person on climate change needs to have knowledge on Earth's climate system and an understanding on how human-induced activities are influencing Earth's climate system (Nam, et al., 2011). The conceptual change is attained through critical evaluation of students' knowledge

(Lombardi, 2012). In fact, the advantage of learning science with understanding is the efficiency because the organization improves retention, promotes fluency, and facilitates learning material than by simply memorizing concepts.

Moreover, students' knowledge on global warming and climate change will help students realize the importance of taking care Mother Earth (Tsantakis, 2009; Cleaver, 2007; Olup & Ozalp, 2007; Mason, et al., 1998). It is essential to explore effective methods to generate changes in students' epistemic cognition to be more critically evaluative of hypotheses and theories in order to increase their plausibility perceptions of scientific claims because what students know and understand about environmental issues will ultimately influence their environmental decisions. Students' conceptions of the different concepts on climate change also help educators to understand how students make sense of what they are learning and to correct misconceptions and equip the students to successfully connect the dots from knowledge to action thus; practical application of knowledge is the most important (McNeill & Vaughnn, 2010). Likewise, students' conceptual understanding of the concept of climate change phenomenon must be deep enough to guide them into practical application. UNESCO (2011) emphasized to address the mitigation and adaptation by increasing the knowledge and understanding on the causes and impact of climate change (Alan, 2013).

Furthermore, Pitpitunge (2013) suggested that increasing the knowledge and understanding of students on the different concepts of climate change such as the basic concepts, effects and causes of climate change should involve active learning method by engaging the students in learning process because climate change education should be scientifically and socially oriented. In effect, the students are knowledgeable on the mitigation strategies and how deal with the impacts of climate change.

2.2 Students' Images on Science and on Climate Change

It is significant for the students to learn how to create representations on the different scientific concepts, processes and findings (Tytler, et al., 2014). He also added that before the students can have a chance to verbally explain a particular concept it is possible for the students to demonstrate understanding with a representation. For instance, physics teachers used the representation approach that can provide teacher a better reasoning and ability and conceptual understanding according to Sutopo, et al., 2011. Furthermore, Evagorou, et al., 2015 and Pauwels (2006) asserted that visual representations or images in science refers to the objects that are believed to some kind of material or physical existence which also refer to purely mental, conceptual, and abstract constructs which is considered a complex process. Images can also help in understanding problems, guiding problems, solving methods and how it affects mental structures (Gursel, 2011; Owens & Clements, 1998).

Moreover, the use of visual representation in science concepts communication has an important role (Cook, 2011; Ametller & Pinto, 2002). Thus, there are students who can obtain knowledge that may not be getting from verbal explanations alone

(Cook, 2011; Patrick, Carter & Wiebe, 2005). There was also an advantage of using arrows for instance, to display the flow of events, mixing of real and symbolic entities, highlighting of certain words or images, wording of verbal explanations, and integrating several images into one all have been effective to students' understanding of images (Cook, 2011; Styliaiduo & Ormerod, 2002). In addition, students have different manner of interpreting, understanding and recalling information according to Olmanson (2012). When learners form these ideas and beliefs, they usually create images and mental models, visual representations and drawing to provide glimpse of students perceptions of scientist were commented on by many researchers such as Picker and Berry (2000, 2001-2002) as cited by Avilla, (2009). It facilitates people to understand the things around them even if they have not yet experienced or can only hear or read about it when constructing mental models or a representation of a certain concept. Kozma and Russel (2005) discussed and categorized the representational competence of students' images such as reflective and rhetorical, semantic, syntactic, symbolic and depiction.

Images are used in teaching climate change concepts to the students. Nowadays there are many issues on climate change and imagery or representation has an important role in increasing the sense of importance and even encouraging the feelings of being able to do something of the issue about climate change (O'Neil, 2013). The students' written words and drawings are conceptual visualizations or representations of their understandings of global warming and climate change. Global warming and climate change concepts that are embodied with meaning (Kress, et al., 2001; Alerby, 2000), thus, students' conceptions may be constructed from their graphic representations (Shepardson, 2012; Vosniadou & Brewer, 1992). There are recent findings that a certain visual or mental imagery can provoke counter-productive responses and so it is important to understand how student construct and represent the concepts on climate change (Moloney, et al., 2014; Cole, 2005). The climate change education is also considered as a mitigation strategy and it is dependent on the effectiveness of the curriculum. Thus, the design and implementation of the curriculum is described as successful if we understand where students are in terms of their knowledge and disposition about the issue on climate change (Hung, 2014).

Furthermore, students in the Philippines are one of the most affected of heavy rainfall, strong typhoons and other extreme weather conditions. Students' conceptual understanding and images of students on the different concepts on climate change can help them realize the importance of taking care of their environment. Thus, imagery is important in increasing climate change awareness with the use of a representation also, effective in promoting the importance and showing concern towards climate change (Salinger, 2016; Smith & Joffe, 2009).

3. Methodology

3.1 Research Design

This research utilized the descriptive correlation design in attaining the objectives of this study. The study focused on determining the students' conceptual understanding and images on the different concepts of climate change, as well as, the significant relationship existing with students' conceptual understanding on the causes-effects and images of the different concepts on climate change. Moreover, Figure 2 illustrates the research process undertaken in this study, which is observed into three phases such as Phase 1: Design, development and validation of the task instruments; Phase 2: Administration of the task instrument; and Phase 3: Data analysis.

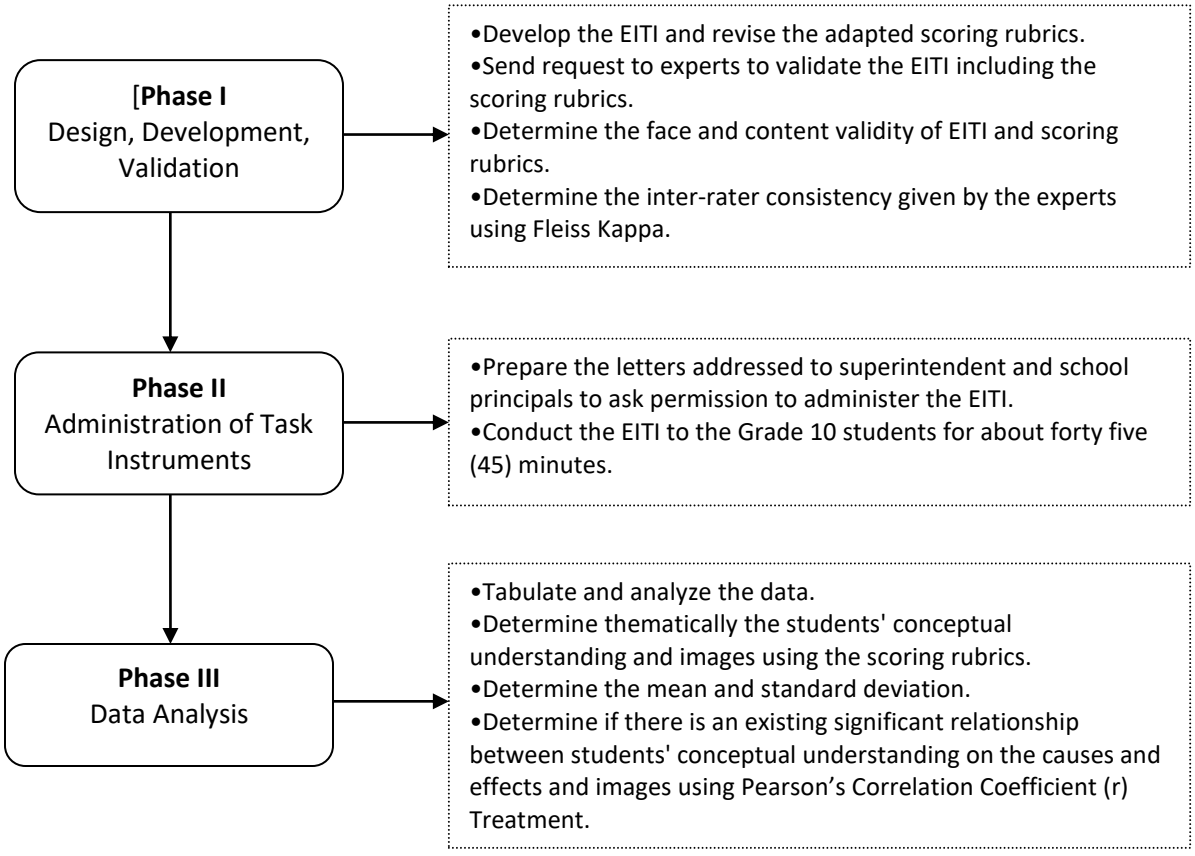

Figure 2 *Research Process*

3.2 Participants of the Study

The respondents chosen were based on the list of flood prone areas provided by PAGASA and MMDA in 2015. Moreover, two hundred twenty-four (224) Grade 10 students from three public schools are involved in the study. The EITI was administered to the participants with the endorsement of the Schools Division Office and with the recommendation and approval of the school principal.

3.3 Research Instrument

The EITI and the scoring rubric are the instruments used to probe students' conceptual understating and images of the different concepts on climate change and were validated by the experts. Part I aimed to determine the students' conceptual understanding where the respondents provided answers on the causes and effects on each concept of climate change. On the other hand, Part II aimed to determine the students' images by creating an illustration or image for each concept of climate change. Moreover, the excerpts of the six-item task instrument were based on news articles and literature from PAGASA, DENR and Climate Change Commission.

3.4 Data Analysis

The developed EITI and revised scoring rubrics were validated by experts to determine the face and content validities of the instrument followed by determining the inter-rater consistency given by the experts using Fleiss Kappa. For Phase II, the responses of the students on the EITI were tallied and analyzed to determine frequency and percentage to determine the number of participants in each variable such as a) students' conceptual understanding on the causes and effects of the concepts of climate change and b) students' conceptual images of the concepts of climate change. Also, the mean and standard deviation were computed for the levels of acceptability of EITI and the overall students' conceptual understanding and images of students. Lastly, Pearson's Correlation Coefficient (r) Treatment was used to determine the existing relationships between students' conceptual understanding and images.

4. Results and Discussion

The scoring rubric by Kozma and Russel (2005) was adapted and modified in order to describe both the responses and illustrations of the participants to the EITI. These responses and illustrations represent the students' conceptual understanding and images of the different concepts on climate change. Table 1 shows the unit weight given to each response and illustration together with the weighted mean intervals and their corresponding interpretation on students' conceptual understanding and images.

Table 1
Mean Interval and Interpretation of Students' Responses and Illustrations on EITI

Unit Weight (Assigned Values)	Weighted Mean Interval	Interpretation on Students' Conceptual Understanding	Interpretation on Students' Images
5	4.20 – 5.00	Sound Understanding	Reflective and Rhetorical
4	3.40 – 4.19	Partial Understanding	Semantic
3	2.60 – 3.39	Specific Misconception	Syntactic
2	1.80 – 2.59	No Understanding	Symbolic
1	1.00 – 1.79	No Response	Depiction

4.1 Students' Conceptual Understanding on Climate Change

Table 2
Overall Students' Conceptual Understanding on the Causes on the Different Concepts of Climate Change

Climate Change Concepts	$\bar{X}$	*SD*	Interpretation
Temperature	3.48	0.993	Partial Understanding
Rainfall	2.33	0.979	No Understanding
Cyclone	2.27	1.167	No Understanding
Drought	2.06	0.998	No Understanding
Extreme Meteorological Condition	2.28	1.445	No Understanding
Greenhouse Gases	2.29	1.359	No Understanding

The results revealed that the students' conceptual understanding of the causes of the concept of temperature is described as partial understanding as attributed to its mean value of 3.48. On the other hand, no understanding is the interpretation to the mean values on the other concepts of climate change. It may suggest that students may have understanding of the concepts but did not able to explain further and in details the causes behind the different phenomena of climate change. The challenges experiences by the students affected their understanding between their everyday experiences and scientific knowledge (Furberg, 2016). For example, the concept of rainfall abnormalities, the students were not aware on the causes of excessive rainfall but were aware of the effects of abnormal rainfall.

Table 3
Overall Students' Conceptual Understanding on the Effects of the Different Concepts of Climate Change

Climate Change Concepts	$\bar{X}$	*SD*	Interpretation
Temperature	2.05	0.550	No Understanding
Rainfall	2.68	0.724	Specific Misconception
Cyclone	2.61	0.996	Specific Misconception
Drought	2.79	1.425	Specific Misconception
Extreme Meteorological Condition	2.20	1.129	No Understanding
Greenhouse Gases	2.55	1.194	No Understanding

On the other hand, the students' conceptual understanding on the effects on the different concepts of climate change demonstrates specific misconception specifically on rainfall, cyclone and drought with mean values of 2.68, 2.61 and 2.79, respectively. For instance, the students presumed that the effects of rainfall is flood but according to Asian Development Bank (ADB) (2012) one cause of flood in urban areas is due to poor management of storm and surface runoff. The Metro Manila Development Authority (MMDA) (2010), the volume of rainwater was not enough to accommodate due to poor drainage system in urban areas (Lagmay, et al., 2015). The common students' misconception on the effect of drought is no rain and dry soil, but the students should also remember that El Nino which resulted to drought happened naturally and can even cause heavy rainfall in some areas or even stronger typhoons according to Malano (2015). However, there are concepts that students demonstrate no understanding particularly on the effect-concepts of temperature, extreme meteorological condition and greenhouse gases. The students should not disregard that greenhouse gases make life possible but its reverse effect is enhanced due to human activities.

4.2 Students' Images on Climate Change

Notably, the students' images were described as depiction. It is when students generate image or representation based on the physical attribute on the different concepts of climate change. For the science teachers, it is essential for the educators to determine how the students are learning the science concepts. Nevertheless, students must understand the different representations of science concepts and processes, to be able to translate a representation into one another and understand their coordinated use in representing scientific knowledge to learn science effectively (Sutopo, 2011; Hubber, et al., 2014).

Table 4
Overall Students' Images on the Different Concepts of Climate Change

Climate Change Concepts	$\bar{X}$	*SD*	Interpretation
Temperature	1.49	0.501	Depiction
Rainfall	1.17	0.432	Depiction
Cyclone	1.34	0.476	Depiction
Drought	1.13	0.413	Depiction
Extreme Meteorological Condition	1.44	0.497	Depiction
Greenhouse Gases	1.43	0.659	Depiction

4.3 Relationships Existing Between Students' Conceptual Understanding and Images

The study also revealed different levels of significant relationships existing between students' conceptual understanding on the causes-effects and images of the different concepts on climate change. Strong and positive relationships exist on students' conceptual understanding on the causes and effects of cyclone, extreme metrological condition and greenhouse gases with Pearson r values of 0.610, 0.746 and 0.792, respectively. These suggest that the students' conceptual understanding on the causes and effects were strongly related. Like for instance, if a student has partial understanding on the causes, it also has partial understanding on the effects and if a student has no understanding on the causes it is most likely a student has no understanding on its effect. On the other hand, very weak to moderate positive relationship exist to the rest of conceptual understanding on the causes-effects and images of the different concepts on climate change. More particularly, very weak positive relationships exist between students' conceptual understanding on the effects and images of rainfall and drought concepts of climate change.

Table 5

Significant Relationship between Students' Conceptual Understanding and Images on the Different Concepts of Climate Change

Climate Change Concepts	Variables	*R*	Interpretation
Temperature	Conceptual Understanding on the Causes and Effects	0.240	weak and positive relationship
	Conceptual Understanding on the Causes and Images	0.112	very weak and positive relationship
	Conceptual Understanding on the Effects and Images	0.279	weak and positive relationship
Rainfall	Conceptual Understanding on the Causes and Effects	0.349	weak and positive relationship
	Conceptual Understanding on the Causes and Images	0.141	very weak and positive relationship
	Conceptual Understanding on the Effects and Images	0.032	very weak and significant positive relationship
Cyclone	Conceptual Understanding on the Causes and Effects	0.610	strong and positive relationship
	Conceptual Understanding on the Causes and Images	0.310	weak and positive relationship
	Conceptual Understanding on the Effects and Images	0.194	very weak and positive relationship
Drought	Conceptual Understanding on the Causes and Effects	0.552	moderate and positive relationship
	Conceptual Understanding on the Causes and Images	0.145	very weak and positive relationship
	Conceptual Understanding on the Effects and Images	0.109	very weak and positive relationship
Extreme Meteorological Condition	Conceptual Understanding on the Causes and Effects	0.746	strong and positive relationship
	Conceptual Understanding on the Causes and Images	0.532	moderate and positive relationship
	Conceptual Understanding on the Effects and Images	0.452	moderate and positive relationship
Greenhouse Gases	Conceptual Understanding on the Causes and Effects	0.792	strong and positive relationship
	Conceptual Understanding on the Causes and Images	0.441	moderate and positive relationship
	Conceptual Understanding on the Effects and Images	0.496	moderate and positive relationship

5. Conclusions and Recommendations

The results of this study revealed that the students' conceptual understanding on the causes of rainfall, cyclone, drought, extreme meteorological condition, and greenhouse gases concepts were described as no understanding, while the partial understanding is the description for the students' conceptual understanding on the cause of temperature concept. On the other hand, the students' conceptual understanding on the effects of temperature, extreme meteorological condition and greenhouse gases concepts were described as no understanding while students' conceptual understanding on effects rainfall, cyclone and drought concepts were revealed with specific misconception. Moreover, students' images of the different concepts on climate changes were all described as depiction. Lastly, a range from very weak to strong significant positive relationships exists between students' conceptual understanding on the causes-effects and images of the different concepts on climate change were established.

Results further suggested that it is necessary to provide more and repetitive meaningful learning experiences to enhance students' understanding on the basic scientific concepts incorporated on climate change, in which will be the basis for their understanding on adaptation and risk management (Barros, et al., 2012; IPCC, 2012). In addition, it is also important to consider what and how students' generate images or representations on the different scientific concepts that vary from symbolic to physical attributes. These are conceptual visualizations used students mutually in constituting their understanding (Coppola, et al., 2008).

For the further improvement of this study and to check the results' veracity, it is advised to use another group of independent participants, as well as, have a translated version of the EITI in the vernacular familiar to the participants to have an easy understanding on the context of the task. It also advised to conduct interview on selected respondents to further triangulate their responses and illustrations on the task instrument. Moreover, it is also recommended to cover other related concepts of climate change concepts, which are not included in this study.

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