Impact of Globalization on Climate Change: A Step towards Climate Change Literacy

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Abstract:

Climate change is a phenomenon of global warming and ocean acidification. In a democratic society, any non-scientist persons may be asked to render the judgment on the queries of the scientific topics such as climate change, nutrition, evolution and genetically modified organisms. Even the non-science students are studying these topics but the underlining problem is that both the students and the teachers do not apply the topical knowledge to the socio-scientific contexts. They fail to apply their knowledge to their daily life situations. In this paper attempt is made by the Chemistry teacher to integrate the Chemistry curriculum with the climate change. It provides an opportunity to motivate, enhance the class-room experience and equip the learners to use the fundamental understanding of Science, knowledge, skills and competence to address some of the challenges. Such initiation is especially important to catalyze and to enhance the climate literacy among students and teachers because our nation is in vulnerability to climate change. The present paper has dual goals: first to improve the outcome based learning of Chemistry concept and then to emancipate and to empower learners to understand and respond effectively towards climate change.

Key words: Discovery learning, collaborative learning, climate change, chemistry and curriculum.

Introduction:

"The good things about Science is that it's true whether or not you believe in it"

- *Meik deGrease Tyson*

Experiential learning activities in Chemistry at school, enriches school experiences of the learners. It fosters students learning of Chemistry, conceptual understanding, equips learners to apply their knowledge, skills and competence to real world context and march towards outcome based learning. Teaching Chemistry in such innovative methods is not much familiar with many students and educators. Even teachers who are experienced may face challenges when teaching Chemistry by using innovative methodologies to amalgamate the curriculum with the climate change. The effective and efficient teaching-learning materials are one of the essential conditions. This paper focuses on developing rich content for outcome based learning for Chemistry and to merge the content with climate change curriculum also.

"The States of Matter" of Grade Nine, covers the unit of phases and introduces the concept of vapour, pressure of gases and its temperature dependent. The Chemistry teacher makes efforts to integrate these concepts to enrich the experience of climate change. The relevance of the content in Class Ninth Science subject is significant to the challenges which are faced by the teachers and the students globally i.e., climate change. The present changes that are happening in the entire globe are well documented but our nation faces some varying climate change challenges. Most of the problems that our nation faces are resulted from the human activities. Chemistry curriculum and the teachers have a significant role in equipping the future generation learning buds.

Challenges of the climate change:

The greenhouse gases emission substantially contribute to the climate change. Our nation has a highly varied climate and the live hood of many states depend upon the climate change. The availability of water is an important variability which results from the modeled effect of climate change. Owing to climate change, by 2050 major population of our nation is at risk of increased water problem and the regional problem of climate change is that the precipitation is highly variable. Acute shortage for drinking water and changes in the rainfall pattern are expected to adversely disturb the agricultural productivity which fosters food shortage and these are the adverse effect of climate change.

Health related issues are projected and are intensified due to the climate change like heat waves- increase in the force, the occurrence and the duration. Such heat waves have adverse effect on children and induce their vulnerability to disease and raise the mobility and mortality rates.

Climate change literacy and Chemistry education: Importance:

Due to the high vulnerability of climate change, the future generation learners must be capable of understanding the challenges and know to respond to it effectively. The science of climate is built upon the fundamental knowledge of other sciences including Chemistry. It is an excellent opportunity for the students in the class-room and in the laboratory to build a connection between the climate literacy and chemistry concepts.

The integration of Chemistry curriculum with climate literacy is the objective of the present study. Researcher is a Chemistry teacher and has more than three decades of experience at Senior Secondary level. Researcher tries to establish connection between vapour, pressure which depends upon the temperature and the effect of climate change on the water resources. The teacher enables students to understand the concept about the physical properties and state of

changes and integrates it with the climate change and gives example of how it affects the students' life.

It is proved that the power of climate change is a rich content for teaching and learning the fundamental principles of Chemistry. The knowledge, skill and competence of both Chemistry concepts and climate change implication motivate the learners to consider the responsibility of responding and addressing the issue of climate change.

Conceptual understanding:

The content is important for the conceptual understanding. The delivery of the content is the second important phase. An interactive student bridges the gap between the fundamental principles of Chemistry and climate literacy. The module consists of nine units and it includes variety of topics with strong emphasis on drawing connection with the underlying principles of Chemistry (*Fig 1, Table 1*). Videos, stimulation and assessment items are included with each unit to facilitate the learning process. Every unit is followed by "overate joy (to test the knowledge) questions which the learners can employ it to reinforce their understanding. Teachers use it to test the knowledge of their students. At the end of the module, glossary is added to acquire familiarity of the terms used, which are related to climate change.

Sl.No	Lesson	Key Concepts				
		I	II	III	IV	V
1	Introduction To Earth's Climate	What is climate?	Unique Earth climate.	Earth's atmosphere	Regional climatic differences	Temperate climatic differences.
2	Is Climate Change Happening?	Ice cores	Temperature trends	Trends in atmospheric gases	Relationship between trends	Past 250 years
3	Heating it Up: The Chemistry Of Greenhouse Effects	Temperature in Earth's atmosphere.	Properties of gases	Absorption /emission of radiations	Atmospheric molecules interactions	Are all Greenhouse gases are same?
4	Climate Balancing	What is radiation balance?	Incoming solar radiations	Reflection of solar radiations	Emission of solar radiations	Greenhouse effect.
5	A global issue: Impact of Climate Change	Polar region	Coral reefs	Vector borne disease	Extreme weather	Biodiversity
6	Greenhouse gases: A closer look	Water vapour	Carbon dioxide	Methane	Nitrous oxide	CFCSE super Greenhouse gases.
7	Climate feedback: loops	What is feedback loops?	Carbon dioxide as a thermostatic	Methane feedback	Water feedback	The mountain pine battle.
8	Climate change and the oceans	The global regulations	Energy balance	Ocean acidification	Carbon specialists	Immeasurable importance
9	What next? Responding to climate change	Our children's world	Powering the future	A mosaic of solutions	The human effect	Our windows of opportunities.

Table 1: Module

Module		
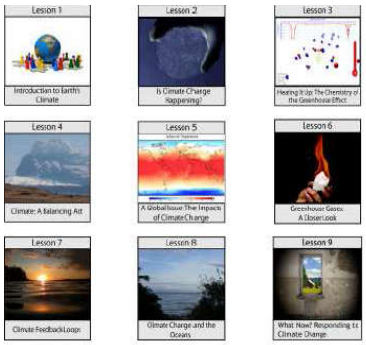	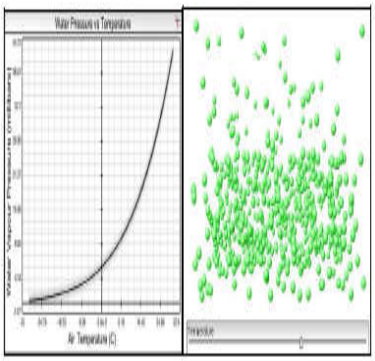	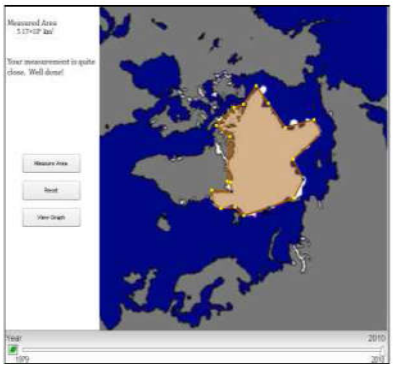
Fig 1	Fig 2	Fig 3
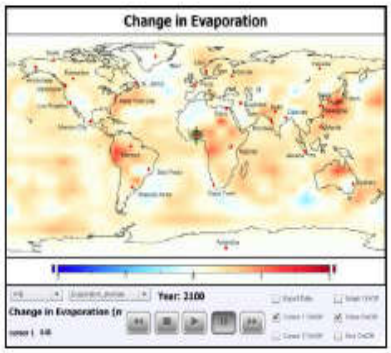		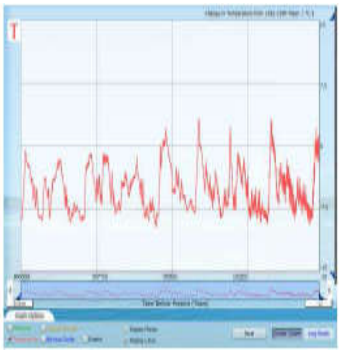
Fig 4	Fig 5	Fig 6
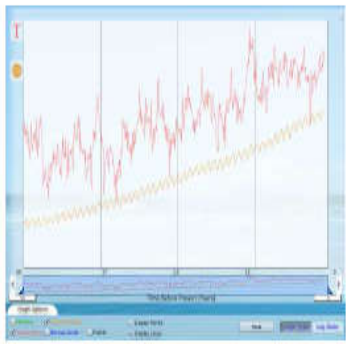	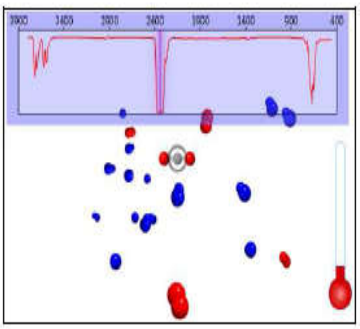	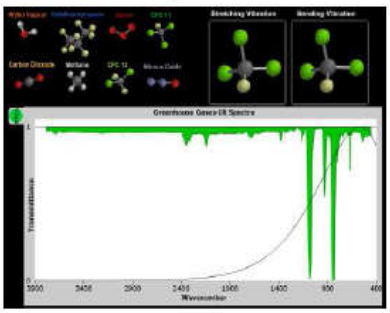
Fig 7	Fig 8	Fig 9
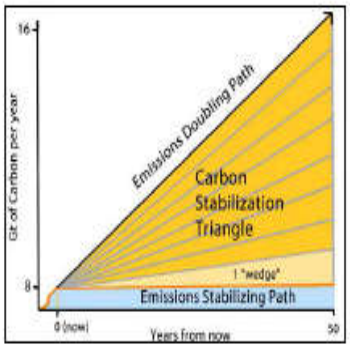	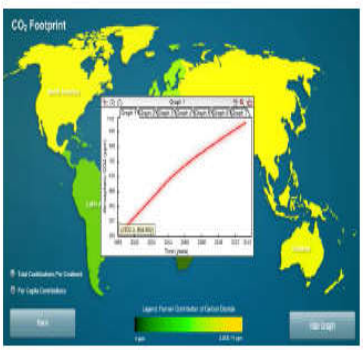	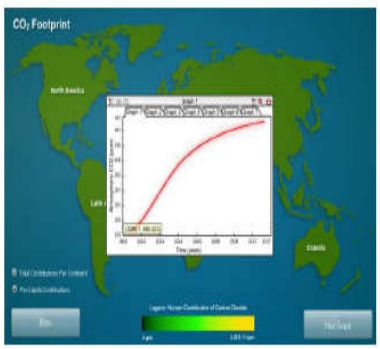
Fig 10	Fig 11	Fig 12

Principles of Designs:

The pedagogical design of the module is fundamental to its effectiveness in improving climate literacy and its underlying principles of Chemistry. Interactive session, guided inquiry and self-assessment are incorporated in the module. The content is highly interactive, contains numerous simulations where students are able to adjust to the conditions of systems and witness the results. High degree of interactions is effective in facilitating the learning process. Module is planned to learn through the inquiry process than simply memorizing the concepts. Directive questions are employed to motivate the students to interrogate the data and derive to an appropriate conclusion independently. Contents are integrated into number of formative and summative assessment which helps to reinforce the topic, content, concepts which have been presented and to allow the users to ensure that the students have understood the key concepts. The self-check focuses on time of the task and prevents students from clicking rapidly through the content.

Water and Climate Change:

The various sections of the module address the connection between the water cycle and the climate change like the unit-6 "Greenhouse gases: A closer look"

The students envisage the outcome of increased temperature on evaporation of water through interactive graph and animations. The warming trend is linked with the climate change which results in the increased concentration of atmospheric water vapour through high rate of evaporation. The students learn that the water vapours are the Greenhouse gases. Questions guide the learners to consider how evaporation of water result in positive feedback loop that compounds climate change. The increase in atmospheric moisture increases the local cloud cover, which contributes to the increasing Earth's albedo. It is an example of negative feedback loop. These opposing feedbacks are complex and operate on different time and geographical scales.

Unit seven explores the concept of water feedback (climate feedback loop). The increase in global temperature lowers the earth albedo through melting polar, snow and ice. Polar ice caps measurement learning tool is applied to measure the area of polar ice of different years, observe and quantify the polar ice cover over the past three decades. The students do not consider the shrinking of polar ice to be the part of a great regional relevance. The unit 'Climate Balancing' explains the loss of polar ice lowers the Earth albedo which leads to the captivation of solar radiation and increases global warming. Our nation is vulnerable to climate and any process that intensifies the climate change holds importance, including the melting of polar snow and ice.

Substantial population of our nation, living in the coastal areas will be affected by the moderate sea level rise (e.g., Chennai, Mumbai etc.,).

The unit five 'A Global Issue: Impact of Climate Change', coves the issues of water availability, soil moisture and the frequency of extreme weather conditions such as drought and heavy rainfall. The students are able to examine the simple models for these predictions using the visualization of global climate change learning tool. The instrument is used by the students to observe the modeled evaporation differences in various cities across the globe (from 1960-1990) as projected by IPCC (Inter- Governmental Panel on Climate Change). The instrument projects that in future i.e., by the year 2100, the cities may experience faster and higher level of evaporation than the past 30 years of average for the relevance period of almost 0.5mm/day under moderate Air Emission Condition, (*Fig 2*) The higher the rate of evaporation, the soil moisture decreases consistently and ultimately it affects the agricultural production. These models are developed from IPCC Scenario by using Educational Global Climate Modeling (EGCM) software. It is extensively designed for climate modeling instrument.

Climate Change: Evidences

Learners may not have experience in evaluating the scientific claims, discriminating the scientific evidence for climate change and claims by few constrain, who openly disputes that the temperature increases since the industrial revolution and it has human signature. Data do not exhibit our earth experiencing numerous regular and natural fluctuations throughout our history of planetary. Interrogation of the evidences helps students to see and understand the connection between human activities and current surface air temperature rise.

Unit two – "Is climate change happening?" The students are introduced to the ice-core. The climate change scientist use to re-structure the average temperature of the earth surface of Earth hundreds and thousands year ago. The Isotope Radio Mass Spectroscope (IRMS) learning tool *(Fig 3)* instrument explains the low isotopic ratio of oxygen and hydrogen in specific ice core layers and is analyzed to provide proxy measurement of Earth's temperature over time. Analysis of proxy temperature measurement from isotopes ratios of water in ice term cores clearly indicates that earth temperature has dramatically fluctuated in the past. Through the climate trends learning instrument, the students are able to interact with and ask questions on the graphical presentation of the history of the temperature and the greenhouse gases trends. The instrument *(Fig 4)* displays the average temperature of the Earth for the previous 800Ka, on the basis of the ration of heavy to light water in core ice samples.

The temperature fluctuation in mean global temperature over 800Ka span clearly shows that there are many intra-glacial and glacial period. The difference in the average terms of the surface from one of these episodes is in the order of 8-10^{o}c. unsurprisingly, students ask question about scientists claim that the present increase in temperature of earth is caused by human activities rather than natural factors. The significant key factor is to make sense about the difference since industrial revolution and to analyze the change in temperature. The content of the study material reveals that there is a rapid increase in temperature over a period of 8,00,000 years and the slope measuring instrument reveals that in the past, the change in temperature took place very slowly and nearly at the rate of 0.001^{o}C per year. When the same analysis is done for the past 100 years, the rate of change has a greater magnitude and is around 0.01^{o}C per year. The difference in the slopes reveals that the profound transformation is happening at the present and it points out an anthropogenic signature in the recent data set.

The climate trends learning instrument is used to show the current rapid increase in temperature and is strongly correlated with raise in numerous green-house gases such as carbon (IV) oxide in the atmosphere. *(Fig 5).*

The illustration correlates that the swift increase in Carbon (IV) oxide in the atmosphere is aligned with the increase in temperature. The learning instrument suggests that the climate change is strongly associated with anthropogenic emission of green-house gases. The unit two illustrates the correlation between the atmospheric greenhouse gases concentration and Earth's average temperature. Students derive to the conclusion that change in the human activity induces the natural phenomena. Students are cautioned and they clearly understand about the cause and effect link and the significant co-relation.

Align absorption of electromagnetic radiation by molecules and climate change:

The unit three "Heating it Up: The Chemistry of Greenhouse Effect", illustrates that there is a significant relationship in rising global temperature and greenhouse gases. The students must be able to understand the mechanism by which the greenhouse warms the temperature of the atmosphere and how they establish relationship between climate change and human activities.

Through the Collisional Heating Learning Tool, students interact with a visual model of how greenhouse gas molecules absorb infrared (IR) radiations at wavelength required for vibrational excitation of molecules *(Fig 6).* The process of collisional de-excitation results in an increase in temperature as the excited greenhouse gas molecules transfer energy into atmospheric

gases as N_2 (g) and O_2 (g) are unable to directly absorb IR radiations. This provides an important content and encourages in understanding the concept of kinetic molecules theory.

Unit three motivates the students to learn why greenhouse gases differ in making their impact on atmospheric temperature for analyzing various factors that significantly contributes to the radioactive forcing gas. The instrument Infrared Spectral Window Learning facilitates the analysis to display laboratory 7R spectra of several green-house gases that absorbs strongly. The students are able to understand the importance of greenhouse gases and greenhouse gases are potential for global warming and it is an important conceptual understanding of climate literacy *(Fig 7)*

The future of the climate change:

The climate change and its underlying principles are essential for the basic understanding of the issues and the common man is mostly concerned with contentious and mitigation of the problem. The unit nine "what Next? Responding to the Climate Change" covers how human decision affects climate change. Students and teachers must understand how easy choices alleviate or exacerbate anthropogenic climate change. Unit nine makes use of two interactive learning instrument like CO_2 footprint learning and Carbon stabilization wedges instrument.

The Carbon Stabilization Wedges Learning instrument allows learners to explore various statistics and presents exciting technologies with potential to stabilize annual carbon dioxide emission at the current level and prevents an additional 200 gy of carbon inflow into the atmosphere for next 50 years *(Fig 8)*. Based on the Princeton Carbon Mitigation Initiation, the instrument breaks down the challenge of removing eight smaller "wedges" of carbon from the projected emission graph. Each wedge represents 25 gy anthropogenic carbons that prevent from inflowing the atmosphere over the duration of 50 years. In this framework, the tool enables the learners to make condition adjustment which are related to various mitigation strategies and observe the resulting effect on projected carbon emission.

By exploring the instrument the students quickly learn the key concept that even single mitigation strategies are not suitable for stabilizing the emission rate but mosaic solutions are effective such as decarbonisation of power within the category of efficiency, decarbonisation of fuel, forest and agricultural soil are simultaneously implemented. "Wedges" are removed from the projected emission graph and stabilize the emission at the present level. Thus the students learn that by scaling many technologies and by employing new practices, stabilization of the carbon emission is the most feasible goal. It is relevant to our context that the energy efficiency

measures and the reduction of carbon emission are possible only through reducing the tillage of land for agriculture.

The CO_2 Foot Print Learning Instrument is relevant in understanding the potential effect of future human action in the national level. The instrument allows students to build various carbon dioxide emission scenarios and observes the impact of atmospheric CO_2 levels. This is done by complex numerical solving, several compartmental model that traces the exchange of CO_2 with planetary sinks and sources. The elements that are included rise directly to population growth model and per capita CO_2 emission defined over a regional level. Unit nine initiates and motivates students to utilize the tool to understand the relative magnitude of per capita Carbon dioxide emission for each continent and the total carbon dioxide emission. It clearly indicates that the average carbon dioxide emission of a person is much lower than the average emission of an individual living in any other continent. The CO_2 footprint learning instrument for the students is not a fortunate reality although India is believed to be the most vulnerable nation to the climate change and has contributed less to intensify the problems.

By using this model, a student adjusts the emission rate and observes the resultant atmospheric concentration of carbon dioxide up to 2140 years. Students run the model in which each continent continues to emit at the present rate and demonstrate that the atmospheric carbon dioxide concentration is expected to grow from recent milestones of 400 pm to 600 pm and above by the year 2100. Students may stimulate the impact of different scenarios to decrease the emission rate. Through this unit, the students explore the consequences of growing emission in the Asian continent, due to rapid industrialization and increase energy requirement. In this model of linear growth, even if 10% of emission rate is estimated in the Asian continent, the concentration of atmospheric carbon (IV) oxide is expected to drastically increase, reaching the value of above 90ppm by 2110, even if other continents maintain the same emission level.

The instrument demonstrates the positive effect of lower emission. The per capital emission rate is applied to the rest of the world, the prediction is that the concentration of the atmospheric carbon attitude will rise from 410 to 460 ppm by 2100 *(Fig 9).* The value is lower than the projected values of CO_2 levels based on the present emission rate. The challenge is to maintain low emission at the period of greater industrialization and economic growth.

The human emission of carbon dioxide and consequences of increased atmospheric concentration of oxides of carbon can be explained by the various concepts and principles in Chemistry. The combustion reaction is a major source of anthropogenic carbon (IV) oxide emission. Carbon dioxide produces chemical reaction which is used to introduce stoichiometric

principles and ideas of atoms, economy and efficiency based on the principles of sustainable development and green Chemistry. Green Chemistry strongly gains its foothold in Chemistry curriculum. Thermochemistry is mapped with human energy requirement and emission of carbon dioxide. This is creatively used by the Chemistry teacher to minimize the impact on Earth.

Symbiosis:

Sl.No	Climate Change Topics	Related Chemistry Topics
1	Burning of fossil fuels CO_2 Production/emission	Chemical Reaction • Conservation of Masses. • Combustion reaction. • Balancing Equation. • Stereochemistry/molecules • Exothermic reaction
2	Extreme weather Condition	Gas Laws → Pressure, Temperature • Density • Conversion • Enthalpy • Kinetic Theory of gases → Status of Matter → Phase Changes → Latent heat
3	Declining Artic Sea Level Decrease Snow Cover Glacial Retreat Sea Level Rise	• Kinetic theory of gases → States of matter → Phase Changes • Conservation of Masses.
4	Ocean Acidification	• Solutions → Dissolved gases • Acids and bases
5	Global Temperature Ocean Temperature	• Kinetic theory of gases → Molecular Motion → Temperature • Enthalpy
6	Greenhouse effect	• Covalent bond

Table 2: Symbiosis: Climate Change and Chemistry Curriculum

The symbiotic approach is developed to build the module to explain the climate change on the basis of the principles of Chemistry. The visualization of Chemistry on the Climate change module is designed. Phase concepts of climate change are integrated into teaching of Isotopes, atomic structure, gases, acid base Chemistry solution and equilibrium. It fosters the conceptual understanding of Chemistry and enhances literacy in climate change among senior secondary school students. The isotopes are related to measure the proxy temperature from the

core of ice data, determine gas in greenhouse gases, ocean acidification to infer acid-base solution, chemical equilibrium and precipitation, questions and numerical design to integrate the approach and to develop high order thinking (HOTS), problem solving attitude as part of life skill education.

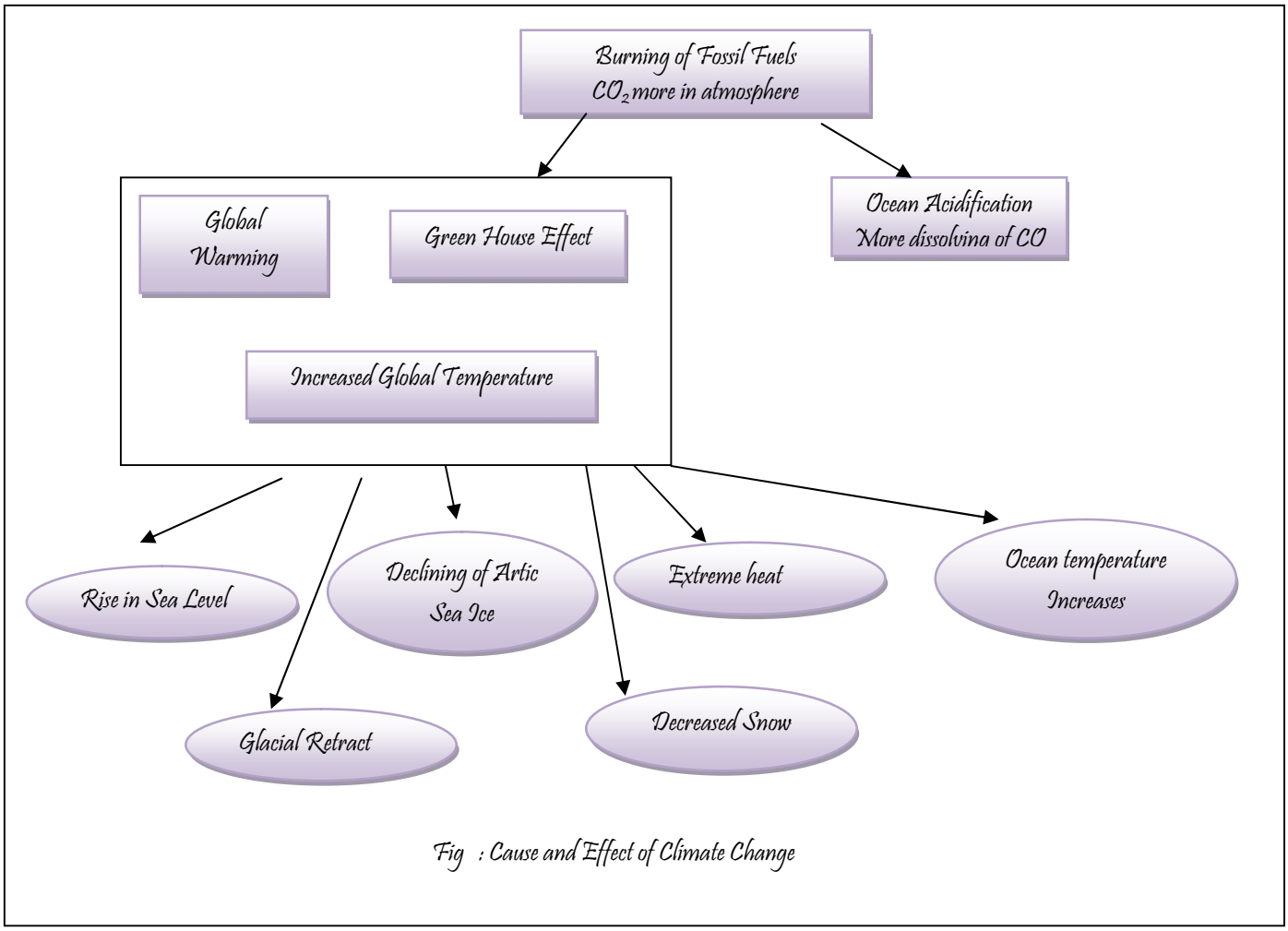

Fig : Cause and Effect of Climate Change

Conclusion:

The module is developed to integrate climate change in the school curriculum. It is highly useful to enhance literacy in climate change and conceptual understanding of Chemistry among students of Senior Secondary Schools. Students and teachers are able to establish strong connection between water cycle and climate change. It helps to use the resources effectively, to teach the concept such as "Change of States of Matter" (grade nine), vapour phase (grade eleven and twelve) and Chemistry of water (grade eleven) in the real world framework. The module motivates and encourages students to acquire class-room experiences by replacing the fundamental principles of Chemistry in real world challenges. It emancipates and empowers students with climate change awareness.

References:

1. Barreda, A.B. (2018). Assessing the Level of Awareness on Climate Change and Sustainable Development among Students of Partido State University, Camarines Sur, Philippines.The Journal of Sustainability Education. Retrieved December 13, 2018 from www.susted.com/.../assessing-the-level-ofawareness-on-climate-change-and-sustainab

2. Houghton, J.T. (2004). Global Warming-The Complete Briefing. Cambridge University Press. 216-241

3. Parant, A.; Pascual, A.; Jugel, M.; Kerroume, M.; Felonneau, M.L.; Guéguen, N. Raising Students Awareness to Climate Change: An Illustration with Binding Communication. Environ. Behav. 2017, 49, 339–353. [CrossRef].

4. Prashant Thote and Gowri. S, "Climate Change Inclusive Education School Curriculum", Review of Research, Volume 8, Issue 3, Dec 2018.

5. Prashant Thote and Gowri. S, "School Principal: A Catalyst for Sustainable Development", Review of Research, Volume 8, Issue 9, June 2019.