Supporting The Inclusion Of Climate Change In U.S. Science Education Curricula By Use Of Learning Progressions

J. Randy McGinnis, Wayne Breslyn,
R. Christopher McDonald, Emily Hestness

University of Maryland

This material is based upon work supported by the National Science Foundation under Grant No. 1043262. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Context of Our Research in Climate Change Education: MADE CLEAR

Maryland and Delaware Climate Change Education, Assessment, and Research

www.ClimateEdResearch.org

www.madeclear.org

Our Research Focus

Our aim is to advance knowledge of how learners from diverse regional areas of Maryland and Delaware (coastal, metropolitan, and rural/suburban) learn about climate change by developing learning progressions (LPs) for three observable consequences of climate change (U.S. Global Change Research Program, 2014)

Enhanced Urban Heat Island Effect

TABLE 10.1 Hypothetical learning progression for enhanced urban heat island effect

Potential LP Indicator	*Level 1*	*Level 2*	*Level 3*	*Level 4*
Energy Association★ ★based on Jin & Anderson (2012)	Energy is associated with life, conditions, or feelings: Students state that the sunlight enables urban surfaces and air to become hot (by its presence) or cold (by its absence). Students fail to understand that the air continues to warm after the sun goes down.	Energy is associated with a physical necessity powering hidden processes or undergoing changes in hidden processes: Students state that sunlight energy is needed to heat materials in an urban environment, and that different materials absorb different amounts of this energy. Students begin to understand that energy is released from hot objects through invisible radiation.	Energy is associated with different sources: Students state that energy can come from sunlight or from hot urban surfaces that release infrared radiation. They understand that radiation from the sun can warm surfaces (differentially), and radiation from surfaces can warm the air.	Energy is associated with its transfer and transformation through different materials: Students state that sunlight is absorbed by urban surfaces (differentially), transforming into sensible or latent heat, kinetic energy, and infrared radiation. This energy can then be transferred to other surfaces, the atmosphere, or space.

Additional constructs include Energy Tracing, Role of Materials, Role of Vegetation and Water, and other Contributing Factors

Extreme Weather

TABLE 10.2 Hypothetical learning progression for extreme weather

Potential LP Indicator	*Level 1*	*Level 2*	*Level 3*	*Level 4*
Human Contribution	Students are not able to obtain, evaluate, and communicate information that human activities can contribute to the frequency and intensity of some natural hazards.	Students are able to obtain, evaluate, and communicate information that human activities can contribute to the frequency and intensity of some natural hazards.	Students are able to analyze data to evaluate claims that human activities can contribute to the frequency and intensity of some natural hazards.	Students are able to construct and evaluate scientific claims based on evidence that human activities can contribute to the frequency and intensity of some natural hazards.
Modifying Climate Systems	Students are not able to use data to identify solutions that may reduce the environmental or societal impacts of a weather-related hazard.	Students are able to use data to identify solutions that may reduce the environmental or societal impacts of a weather-related hazard.	Students are able to apply scientific knowledge to construct explanations for how humans may predict and modify their impacts on future global climate systems.	Students are able to apply scientific reasoning, theory, and models to construct explanations for how humans may predict and modify their impacts on future global climate systems.
Links between Climate Change and Extreme Weather	Students are not aware that a changing climate leads to changes in extreme weather and climate events.	Students are aware that a changing climate leads to changes in extreme weather and climate events, though students are not able to consider factors such as frequency, intensity, spatial extent, duration, and timing.	Students understand that a changing climate leads to changes in extreme weather and climate events, though students do not consistently consider factors such as frequency, intensity, spatial extent, duration, and timing.	Students understand that a changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events

Sea Level Rise

Causes and Mechanisms of Sea Level Rise

	Level 1 (Lower Anchor)	**Level 2**	**Level 3**	**Level 4** (Upper Anchor)
Causes and Mechanisms	Students identify global warming due to the enhanced greenhouse effect as a cause of sea level rise.	Students recognize that global warming causes ice melt (not distinguishing between terrestrial and sea ice) leading to rising sea levels but do not identify thermal expansion as a factor in sea level rise. Students can identify a mechanism that relies on thinking about sea level rise anthropomorphically.	Students understand that sea level rise scenarios are based on thermal expansion and ice melt (not distinguishing between terrestrial and sea ice), though they do not consistently relate these factors to atomic-molecular models.	Students understand that sea level rise scenarios are based on thermal expansion and terrestrial ice melt, and they are able to explain these factors using atomic-molecular models consistently.

Additional constructs include Scale & Representations and Impacts.

	Level 1 (Lower Ancho		Level 4 (Upper Anchor)
Causes and Mechanisms	Students identify global warming to the enhanced greenhouse effe a cause of sea le rise.		Students understand that sea level rise scenarios are based on thermal expansion and terrestrial ice melt, and they are able to explain these factors using atomic-molecular models consistently.

Level 4
(Upper Anchor)

Students understand that sea level rise scenarios are based on thermal expansion and terrestrial ice melt, and they are able to explain these factors using atomic-molecular models consistently.

MADE CLEAR

Maryland and Delaware Climate Change Education, Assessment, and Research

www.ClimateEdResearch.org

www.madeclear.org