Establishing a Learning Progression for the Science and Engineering Practice of Developing and Using Models for Middle School STEM Students

MONTANA STATE UNIVERSITY
Master of Science in Science Education

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Background

Middle school STEM students at an international school in Ho Chi Minh City, Vietnam.

The NGSS framework groups together all middle school students in one single grade band.

Seeking to develop a learning progression for the science and engineering practices for each individual grade level.

Sample – ISHCMC-AA

STEM 6 *N*=30
STEM 7 *N*=30
STEM 8 *N*=23

Treatment and Research Design

1. **CAT – Misconception Probe**
   Establishes baseline for student readiness.
2. **Short Performance Assessment**
   2-Dimensional NGSS aligned assessment for developing and using models of a novel phenomenon.
   Data anlysis of student proficiencies in performance.
3. **Student Survey**
   Determines student perceptions of strengths and weaknesses at each grade level.
4. **Small Group Interview**
   Provides feedback from students.

Research Questions

Main Question: "How does a leveled learning progression of the science and engineering practice of developing and using models increase science literacy skills through performance expectations in middle school STEM students?"

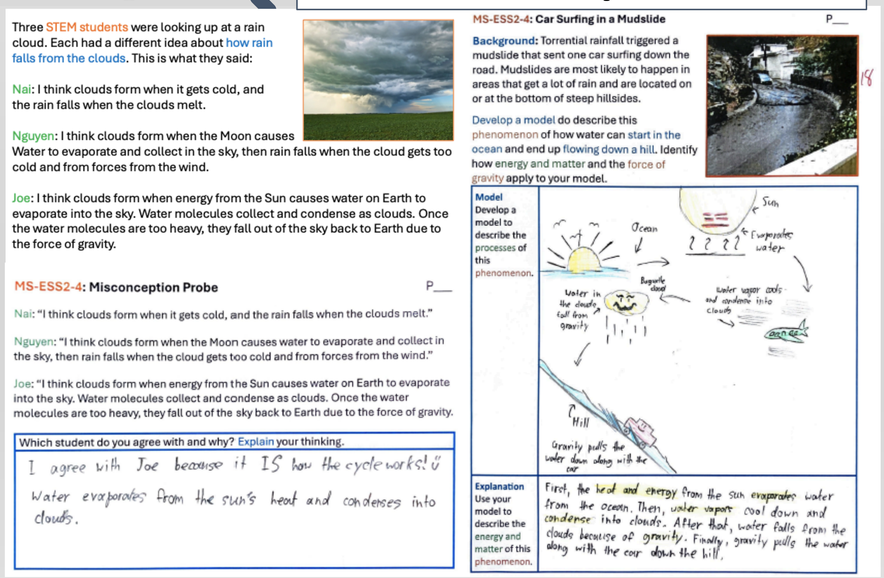
Sub-Question 1: To what extent does providing a leveled learning progression for developing and using models impact student performances for grades 6, 7, and 8?

Sub-Question 2: How do student perceptions of strengths and weaknesses differ for developing and using models for grades 6, 7, and 8?

Sub-Question 3: How does a learning progression for developing and using models impact middle school STEM teachers at ISHCMC-AA?

Findings

Student Exemplar STEM 6



Three STEM students were looking up at a rain cloud. Each had a different idea about how rain falls from the clouds. This is what they said:

Nai: I think clouds form when it gets cold, and the rain falls when the clouds melt.

Nguyen: I think clouds form when the Moon causes Water to evaporate and collect in the sky, then rain falls when the cloud gets too cold and from forces from the wind.

Joe: I think clouds form when energy from the Sun causes water on Earth to evaporate into the sky. Water molecules collect and condense as clouds. Once the water molecules are too heavy, they fall out of the sky back to Earth due to the force of gravity.

MS-ESS2-4: Misconception Probe P___

Nai: "I think clouds form when it gets cold, and the rain falls when the clouds melt."

Nguyen: "I think clouds form when the Moon causes water to evaporate and collect in the sky, then rain falls when the cloud gets too cold and from forces from the wind."

Joe: "I think clouds form when energy from the Sun causes water on Earth to evaporate into the sky. Water molecules collect and condense as clouds. Once the water molecules are too heavy, they fall out of the sky back to Earth due to the force of gravity.

Which student do you agree with and why? Explain your thinking.

I agree with Joe because it IS how the cycle works! Water evaporates from the sun's heat and condenses into clouds.

MS-ESS2-4: Car Surfing in a Mudslide P___

Background: Torrential rainfall triggered a mudslide that sent one car surfing down the road. Mudslides are most likely to happen in areas that get a lot of rain and are located on or at the bottom of steep hillsides.

Develop a model do describe this phenomenon of how water can start in the ocean and end up flowing down a hill. Identify how energy and matter and the force of gravity apply to your model.

Model Develop a model to describe the processes of this phenomenon.

Explanation Use your model to describe the energy and matter of this phenomenon.

First, the heat and energy from the Sun evaporates water from the ocean. Then, water vapor cool down and condense into clouds. After that, water falls from the clouds because of gravity. Finally, gravity pulls the water along with the car down the hill.

Data Analysis

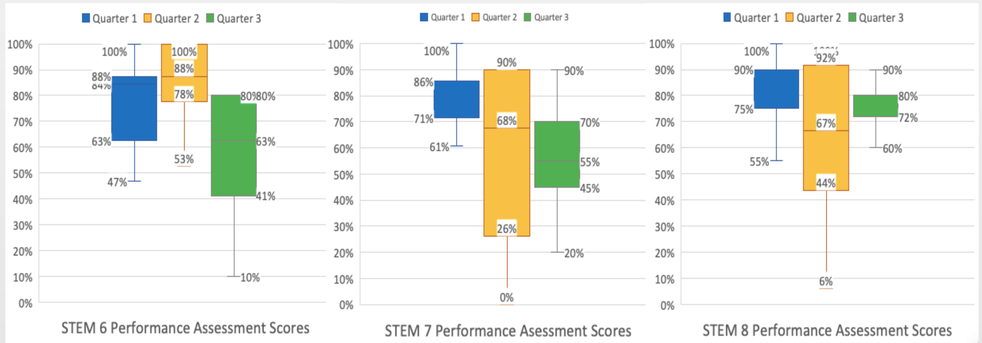


Figure 1. Student performance scores by grade level at the ends of quarters 1, 2, and 3.

How this impacts my teaching:

The following learning progression will be used by the MS STEM department at ISHCMC-AA in the 2024-2025 school year.

Table 1. Learning Progression of Performance Expectations for grades 6, 7, and 8.

Grade	Performance Expectations
6	☐ Develop a model to describe phenomena. ☐ Identify and label components of the model using a word bank. ☐ Describe connections between components of the model. ☐ Models developed include drawings and 3D constructed.
7	☐ Develop and/or use a model to predict and/or describe phenomena. ☐ Identify and label *correct* components of the model using a word bank. ☐ Describe connections between components of the model. ☐ Evaluate limitations of a model. ☐ Models developed include drawings, 3D constructed, and digitally produced.
8	☐ Develop and/or use a model to predict and/or describe phenomena. ☐ Identify and label components of the model. ☐ Describe connections between components of the model. ☐ Use connections to describe, explain and predict changes to the model. ☐ Develop a model to describe unobservable mechanisms, or causal accounts for the phenomenon. ☐ Connect the model to the phenomenon using the relevant crosscutting concept. ☐ Models developed include drawings, 3D constructed, digitally produced, and computer simulations.

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