Space, Scale, and Scope (S^3): Enhancing Understanding and Decreasing Misconceptions in STEM Education

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Introduction:

- This project aims to identify scientific misconceptions surrounding space, scale, and scope, pursuant to NGSS standard ESS1.B: Earth and the Solar System
- Misconceptions can be rooted in a variety of disciplines, ranging from how the earth experiences seasons to the composition of clouds (Driver et al., 1985)[1]
- Research has demonstrated that science educators may be fostering misconceptions similar to their students, therefore further perpetuating the cycle of misinformation within their classroom (Sadler et. al., 2010)[2]

Objectives:

Objective 1: Identify misconceptions that Nevadan preservice elementary science educators may hold about space, scale, and scope.

Objective 2: Create research-based activities in order to address these common misconceptions.

Methods:

This was a mixed methods study conducted at a large southwestern university. Our methods included surveys, research-based classroom interventions, and data analysis in order to assess and address misconceptions surrounding space, scale, and scope.

MEASURMENT TOOLS

A Pre-test and a Post-test were administered to students to determine if any of their previous misconceptions were addressed by the interventions.

POPULATION

This study was conducted within a population of preservice elementary science students. Three classes, totaling about 50 students, participated in the complete study.

MOSART Tests:

The research based surveys we employed in this study were the Misconceptions-Oriented Standards-Based Assessment Resources for Teachers (MOSART). MOSART was developed by the Science Education Department of the Harvard-Smithsonian Center for Astrophysics as an assessment tool to identify common misconceptions within various scientific disciplines (Sadler et al., 2010)[2].

ASSESSMENTS USED:

- Modified Astronomy/ Space K-4 & 5-8 Test Form A/B
- Modified Geoscience K-4 & 5-8 Test Form A/B

These four forms were modified and combined to generate two Pre and Post-tests containing questions pertaining to space, scale, and scope. The most commonly missed questions by students are detailed in **Table 1.**

TABLE 1. FREQUENTLY MISSED QUESTIONS

Multiple Choice Question	Percentage Answered Correctly by Students
An eclipse of the moon can only occur if:	28% correct
Which answer shows the most accurate pattern of the three objects in order from closest to Earth to farthest from Earth?	30% correct
How far away is the closest star to us beyond our Sun?	36% correct
How many stars does our solar system contain?	38% correct
Scientists think Earth's moon formed when:	42% correct
If the Sun stopped shining right now, the soonest it could be noticed on Earth would be:	34% correct
If you could look down from space at Earth from far above its north pole, the Sun and Moon would be in the directions shown by the arrows in the picture below. What would the Moon look like to a person on Earth facing the Moon?	14% correct
According to scientists, the tall mountains in the western U.S. are younger than the low mountains in the eastern U.S. How can the younger mountains be taller?	50% correct

Research-Based Interventions:

We structured our lesson plans around the specific topics that students had the most difficulty with answering correctly. This yielded several lessons regarding space, scale, and scope in both astronomy and geology. Three lessons are outlined in **Figures 1-3.**

Figure 1. Students participate in modeling moon phases.

LESSON 1: Modeling Moon Phases

Students will be introduced to different conceptual models to understand how moon phases and eclipses occur.

Figure 2. Students learn about comparing different celestial bodies and ratios.

LESSON 2: Cosmic Comparisons

Students will interact with a computer model of various cosmic bodies to understand scale and proportions.

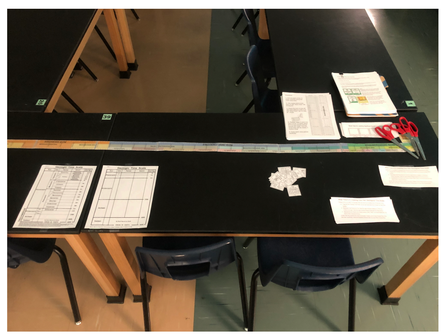

Figure 3. A complete geologic time scale is laid out for students to visualize.

LESSON 3: What Time Is It: Creating Your Own Geological Time Scale

Students are given a geologic time scale and are tasked with locating and recording noteworthy time periods and events.

Data Analysis:

- Our preliminary data demonstrate that this population of preservice teachers had several misconceptions regarding both elementary geology and astronomy concepts.
- These misconceptions ranged from misunderstanding the lunar cycle as well as the size and distance of the moon. Additionally, many students struggled with understanding the structure of our solar system and how quickly light travels.
- With regard to the geology survey, some students reported misconceptions regarding weathering processes and conceptualizing the deep time scale.

Preliminary Findings:

- Our preliminary findings suggest that the students have responded well to these interventions.
- If these interventions assist in decreasing the rate of misconceptions prevalent within this population of preservice elementary science teachers, the lessons will be combined and written up to be shared on an open-source lesson plan database.

Bite-Size Activities:

Short summaries of the activities in Lessons 1-3 have been made public and can be found here:

References

1. Driver, R., Guesne, E., & Tiberghien, A. (Eds.). (1985). Children's ideas in science. Milton Keynes, UK: Open University Press.

2. Sadler, Philip M., H. Coyle, J. Miller, N. Cook-Smith, M. Dussault, & R. Gould. (2010). The Astronomy and Space Science Concept Inventory: Development and validation of assessment instruments aligned with the K-12 National Science Standards. *Astronomy Education Review, 8* (1).

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