PENNSTATE

Solar System Learning Progression: Overview

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Research Purpose and Rationale

We have determined that astronomy is often taught as a set of disparate concepts (e.g,. phases of the Moon, seasons, tides, facts about the planets) without any focus on an underlying causal model. In an effort to inform the implementation of the NGSS, we have organized these concepts from the point of view of Big Ideas.

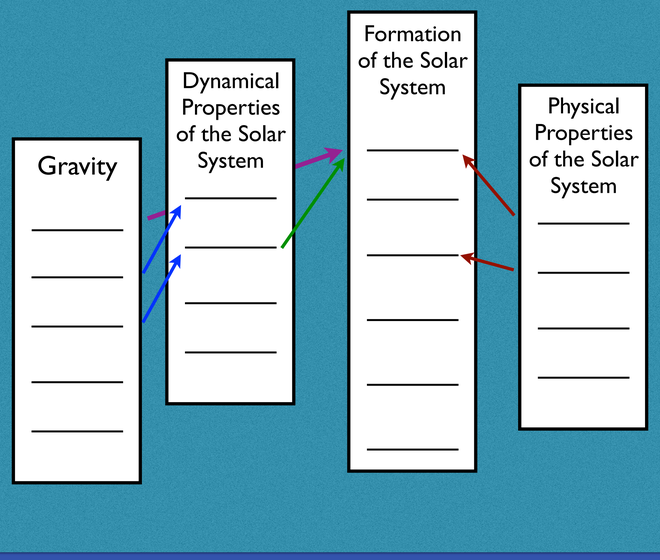
We constructed a hypothetical learning progression in astronomy focused on *Solar System formation*, because it is a predictive model that can tie together these concepts in a coherent way. Students at the highest level of sophistication are able to explain how Solar System objects were imprinted with observable patterns from their formation.

Upper Anchor Statement

This upper anchor statement describes our goal for student learning as they move up the learning progression:

Observable patterns in the locations, motion, and physical properties of the objects in the Solar System reveal that the Sun, planets, moons, and smaller bodies formed at roughly the same time from the same initial pool of material, which was a slowly rotating cloud of gas.

Figure 1: Connecting multiple construct maps to create the learning progression



The Learning Progression is built upon four construct maps

- The theoretical framework builds upon the work of Wilson (2005, 2009), who proposed building learning progressions by connecting construct maps that focus on smaller goals within a big idea
- We have created multiple construct maps: each has an upper anchor (describing a scientific understanding of that construct), a lower anchor (reflecting novice understanding), and levels of increasing sophistication that connect the two
- Using our data (described on the right), we have begun the work to build the learning progression by studying how these students make connections across the individual construct maps as they grapple with the Big Idea of Solar System formation
- This idea is illustrated schematically in Figure 1, in the center

Year 1: Developed the hypothetical learning progression

- Interview protocol developed to elicit students' ideas about the Solar System and its formation
- Semi-structured interviews conducted with students in grades: 6th through college (N=44)
- The range of student ideas and our understanding of the discipline was used to develop hypothetical construct maps
- Students were randomly selected without regards to their astronomy curriculum, instructional methods

Year 2: We revised everything based on pre / post instruction interviews of students and instructional video of their teachers

- From the Year 1 data, hypothetical construct maps were created to feed into the overall LP on the formation of the Solar System
- Year 2 data includes:

Summary of data collection in Year 2		
Grade level & class	6th science	11th & 12th physics
Pre- / post-instruction interviews for N students	24	12
Construct maps addressed	physical properties, dynamical properties, gravity, Solar System formation	dynamical properties, gravity
Video of instruction collected	yes	yes

- During analysis of the Year 2 data, modest revisions were made to the codes and to the levels in the hypothetical construct maps to represent the full breadth of student responses
- To represent all of the results from the Year 1 and 2 data, additional posters are presented in this symposium.
  - Solar System formation: Flarend et al.
  - Physical Properties of Solar System Objects: Rubin et al.
  - Gravity and Dynamical Properties: Ong et al.

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15
Size / scale of Earth Sun system	Reasons for the seasons		Phases, eclipses, & tides	Tides	Meteors, comets, & asteroids		Planet and asteroid orbits		Relative mass of Solar System objects Planet properties	Spring Break	Grouping planets by their properties	Planetary orbits Exoplanets	Gravity, mass, & density	Astronomical Technology
Modeling phenomena with Earth's rotation	Earth's motion in the Solar System	Sun Earth Moon system					Size / scale of the Solar System					Solar system formation – accretion theory		Solar System formation – Solar nebula theory

This is a timeline of the astronomy instruction of our sixth grade partner teacher. Text in grey are concepts that do not align with our upper anchor, while those in black are the ones we recorded and analyzed during our Year 2 data collection. This same timeline is reproduced on the other posters in our series, but on each of those the concepts particular to that poster are bolded.

Use this QR code for a copy of all of our posters.

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