

PENNSTATE Solar System Formation Hypothetical Construct Map



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LP Upper Anchor: Observable patterns in the locations, motion, and physical properties of the objects in the Solar System at the current time reveal that the Sun, planets, moons, and smaller bodies formed roughly 4.6 billion years ago from the same initial pool of material, which was a slowly rotating cloud of gas.

Research Question: How does instruction informed by our hypothetical LP alter student understanding for Solar System formation?

Classroom Sample: 6th grade students (n=24)

Data: pre/post interviews and daily classroom recordings

Post instruction changes:

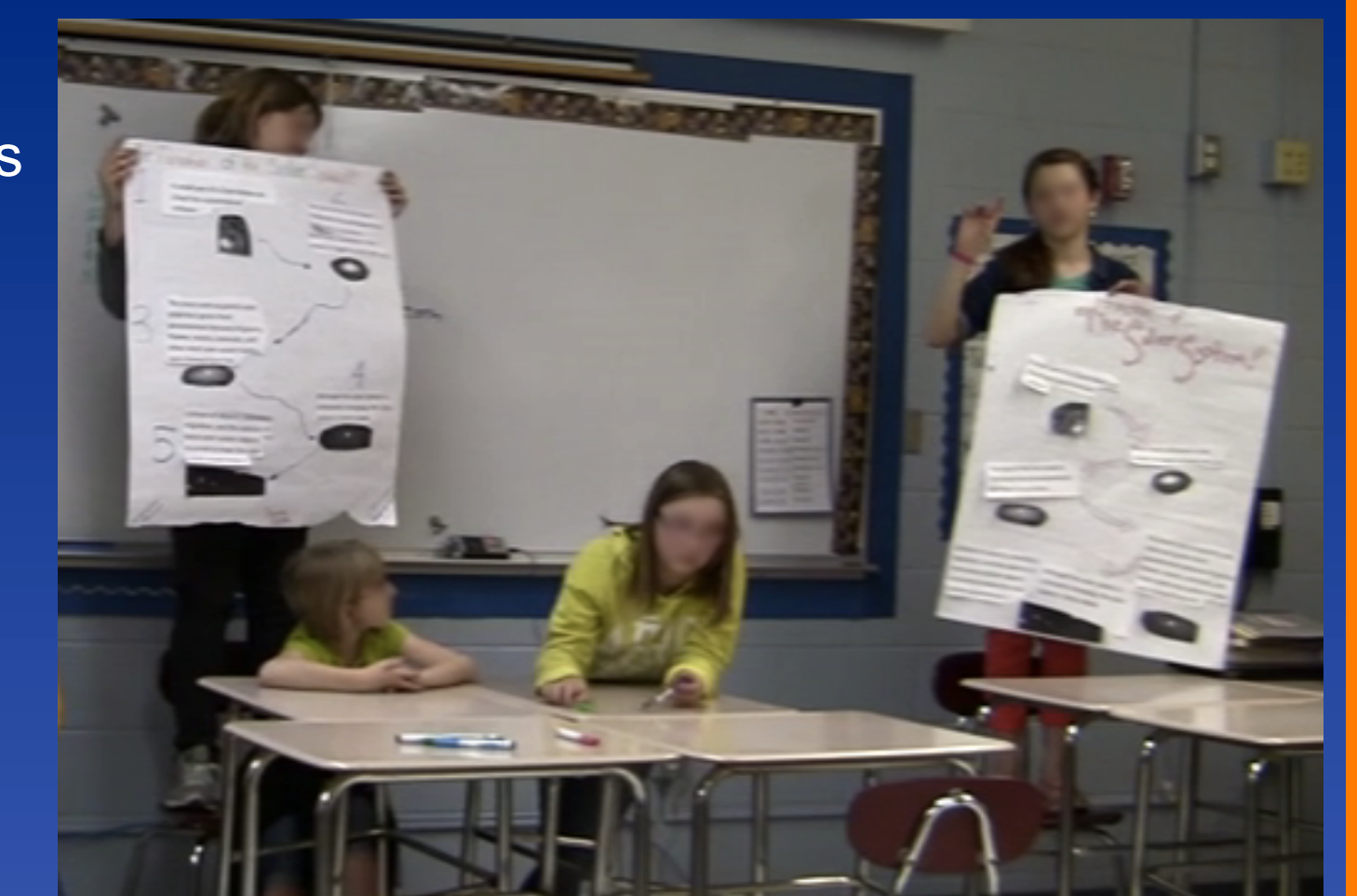
- All students had a formation model and included some type of accretion
- Largest gains were in understanding of contributions by micro accretion process (level 5A)
- Limited conception of gravity hindered student understanding of macro accretion at levels 5B and 6

Classroom instructional activities contributed to changes in understanding of microscopic accretion, but not macroscopic

- Kinesthetic activity** -Students role played different microscopic particles which accreted by electrostatic attraction if they were the same material meeting at the same station. When they has gathered enough particles (people), they accreted all particle types via gravitational attraction and become even larger objects.
 - Teacher demonstrated electrostatic attraction with balloon and hair/ paper bits but no kinesthetic/ visual demonstration for gravity.
 - Resulting group size emphasized micro accretion process, not macro because few groups were large enough to be eligible for gravitational attraction.



- Sorting activity** – Students ordered pictures and sentence representing various stages of the formation process.
 - Pictures included microscopic materials available for accretion, but no macroscopic materials.
 - Verbal description of microscopic accretion of gas and dust.
 - No verbal description of macroscopic accretion .

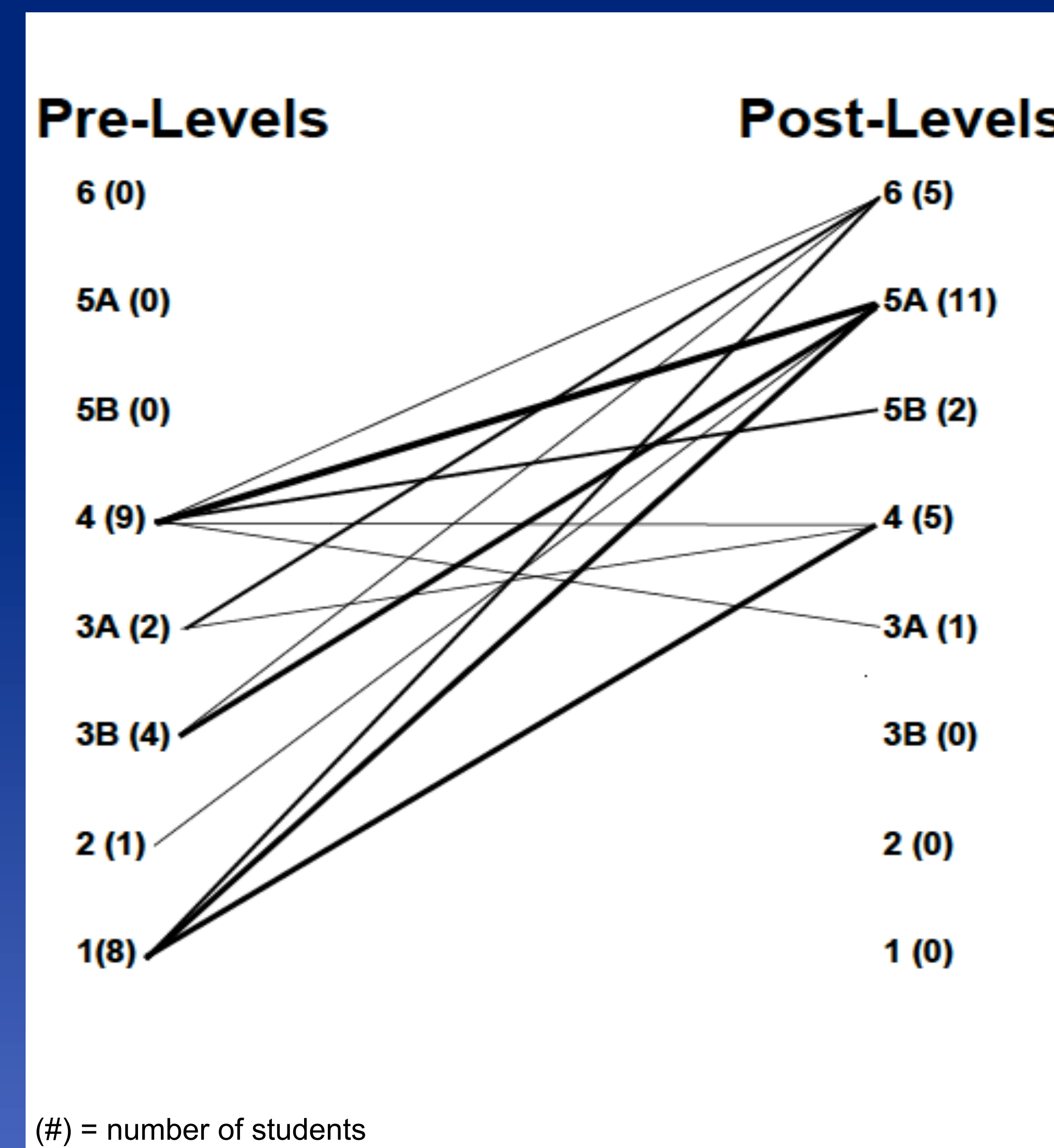


Next Steps in Classroom Instruction – focus on gravity

- Repeat kinesthetic activity starting with larger groups to enhance presence of gravity
- Need visual or kinesthetic representation of gravity
 - Universality of gravity – any objects with mass attract each other
 - Behavior of force with distance

Level	Formation Hypothetical Construct Map Level Description of Student Understanding
6	Objects in the Solar System formed from the from the same cloud of gas, rock and/or dust by the accretion of microscopic materials that built up until they were massive enough for gravity to continue accretion at the macroscopic level . Gravity caused the collapse of this material into the Sun and planets.
5A	Objects in the Solar System formed from the accretion of microscopic materials such as gas, rock, and/or dust. Objects formed from the same cloud of gas and dust and may have occurred after an explosion. Gravity caused the collapse of this material but not necessarily in the formation of the individual planets.
5B	Objects in the Solar System formed from the accretion of macroscopic materials such as gas, dust, rocks, meteors, etc. and gravity played a role in this process. Objects formed from the same cloud of gas and dust and may have occurred after an explosion. Gravity caused the collapse of this material but not necessarily in the formation of the individual planets.
4	The Solar System formed from an accretion-like process involving materials such as gas, rock and/or dust of any size, which may have occurred after an explosion. Gravity plays a role in the formation or maintenance of the whole system, but not in forming the planets.
3A	The Solar System formed from some type of accretion-like mechanism and may have occurred after an explosion. Gravity played no role in the formation or maintenance of the Solar System.
3B	The Solar System may have occurred after an explosion but there is no understanding of a mechanism for how planets formed from pre-existing materials. Gravity plays a role in the formation or maintenance of the whole system, but not in forming the planets
2	The Solar System began as an explosion but there is no understanding of a mechanism for how planets formed. Gravity plays no role in the formation or maintenance of the Solar System.
1	The Solar System has always existed , so no formation process occurred.

Change in Students' Understanding of Solar System Formation



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

