

Exploring pedagogical content knowledge in astronomy: Impact of professional development on elementary teachers

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January 20, 2011

Overview:

Larger project on celestial motion

Details of the setting

Curriculum

Student learning

Professional development

Overview of PCK framework

Methods

Findings

Future work

Collaborators:

Cyndie Slagle – Colonial School District

Kyle Wasko – Arcadia University

Learning Progressions for Celestial Motion

Challenges:

- o Moving between earth-based and heliocentric frames of reference
- o Size and scale

Plummer, 2011

BIG IDEA - CELESTIAL MOTION: Integrated view of the motion of celestial objects in the solar system to explain phenomena from both an earth-based and a heliocentric frame of reference.

Explanatory motions

Tilt of the earth

Phenomena:
Reason for the seasons

Spherical earth*

Phenomena:
Patterns of stars' motion, seasonally and across latitudes

Orbit of the planets

Phenomena:
Apparent motion of the planets and retrograde motion

Orbit of the earth

Phenomena:
Eclipses
Phases of the Moon

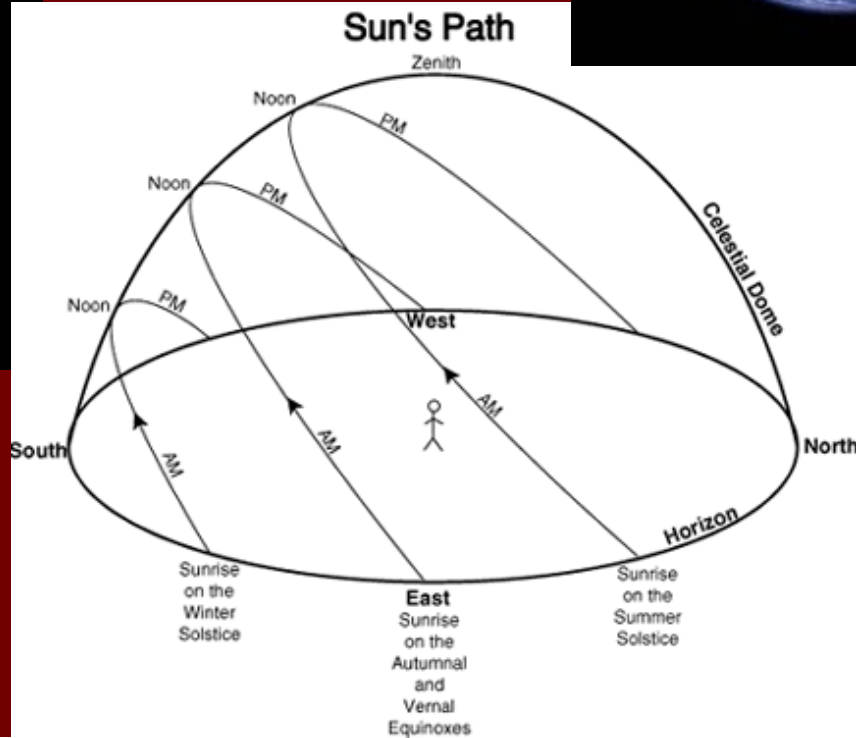
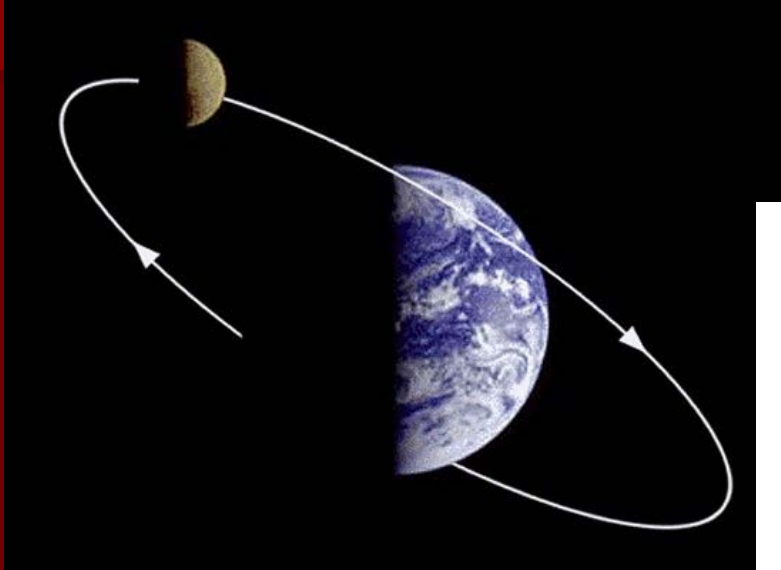
Orbit of the moon

Rotation of the earth *

Phenomena:
Daily Motion of Celestial Objects

* Students need to understand that the earth is a sphere before learning to explain with the earth's rotation. Later, students will interpret the consequences for our observations of the sky using the shape of the earth and their location on that sphere.

Many people leave school with persistent misconceptions and limited knowledge of elementary and middle school astronomy topics.



Investigations of children learning daily celestial motion and the phases of the moon

- Traditional astronomy curriculum
- Four 3rd grade classrooms (N=24)
 - District's 6-week curriculum focused on the moon
- Children's post-instruction knowledge:
 - Some have knowledge of sun and moon's apparent motion
 - Knowledge of earth's rotation but mostly apply to the sun, not moon or stars
 - Many continue to have common misconceptions about the phases of the moon

Research questions – present study

Goal – Understand strategies which improve students' understanding of astronomy. **What is the role of PCK in this equation?**

1. What are third grade teachers' PCK in astronomy, specifically in terms of their enactment of the district curriculum?
2. In what ways did our professional development impact their PCK in astronomy?

Professional Development – Three two-hour sessions in the district planetarium

Goals:

- Awareness of common student misconceptions and challenges
- Introduction of three new lessons focused on daily celestial motion
- Improve size/scale strategies
- Improve implementation of phases instruction

Agenda:

Day 1 –
Introduction and
the sun

Day 2 –
The seasons

Day 3 –
Moon, Stars, and
Phases of the
Moon

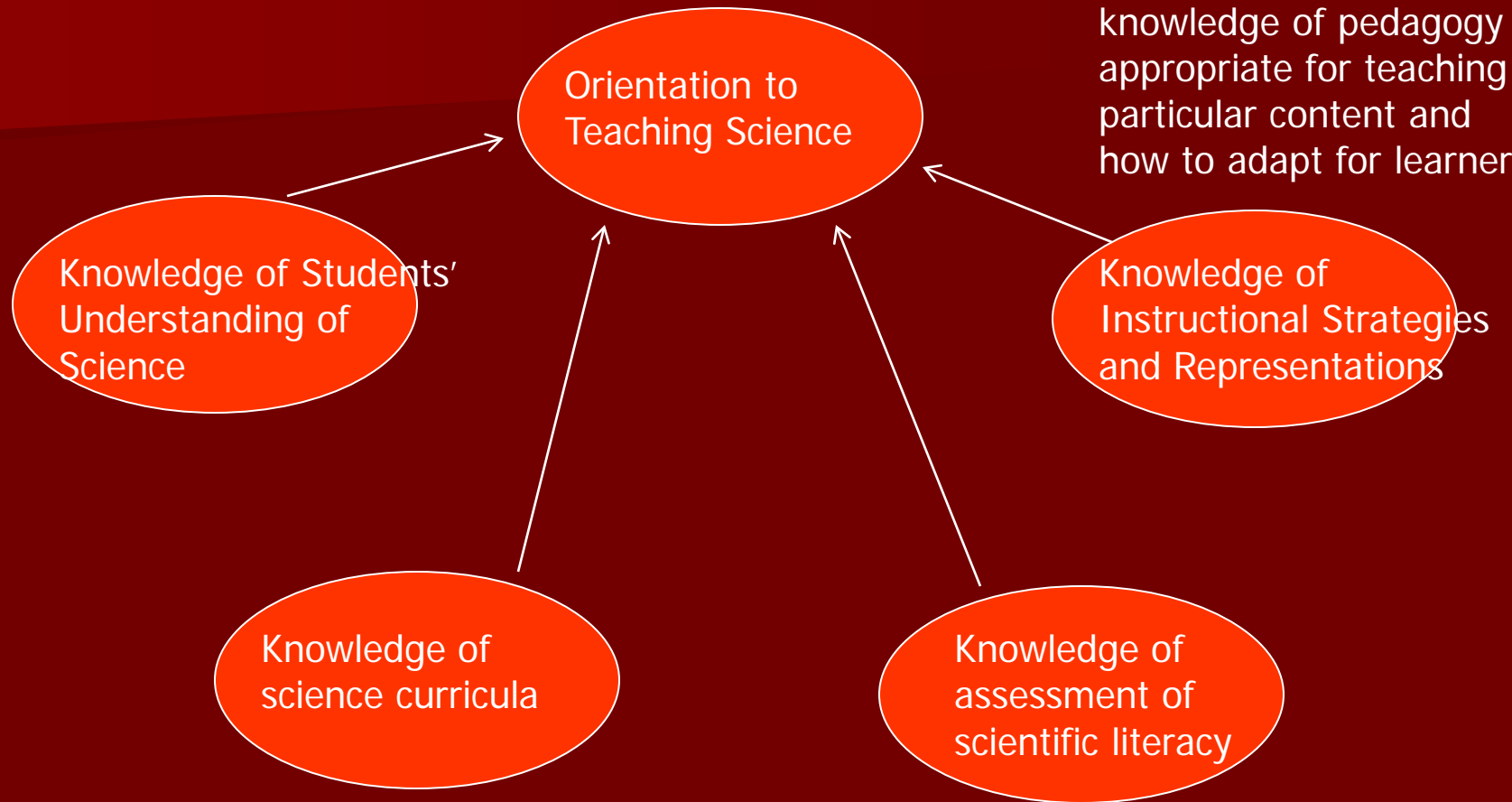
Methods

Pre-interviews before PD.

Post-interviews after teachers taught the unit with revised lessons.

Pseudonym	Years teaching	Teaching 3 rd grade	College science coursework
Abby	8 years	4 years	Earth science for elementary teachers
Melanie	2 years	0 years	Sci for el teachers; physics; 3 bio classes
Sarah	5 years	4 years	General science H.S. astronomy
Jennifer	6 years	4 years	Science for el teachers 2 gen science
Trish	9 years	4 years	None

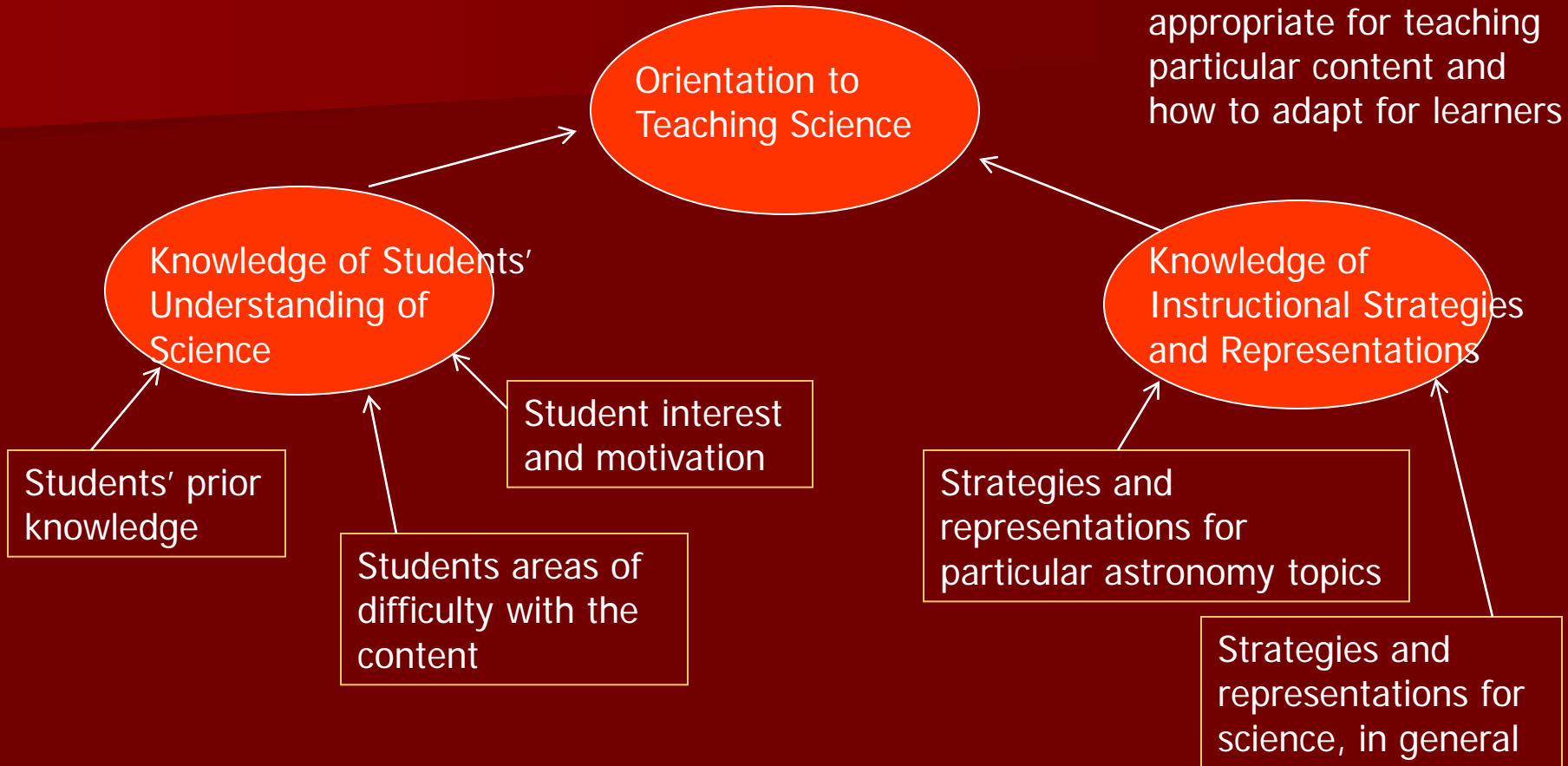
Integration of goals with pedagogical content knowledge (PCK) framework



Magnusson, Krajcik, & Borko, 1999

Integration of goals with pedagogical content knowledge (PCK) framework

PCK – teachers' knowledge of pedagogy appropriate for teaching particular content and how to adapt for learners



Knowledge of Students Understanding of Science

Knowledge of students' prior knowledge of astronomy

Before

- Abby – most descriptive
- Description of day/night prior knowledge close to actual
- Limited on prior knowledge of moon, stars apparent daily motion
- Did not know common misconceptions about the phases

- Melanie – limited due to lack of experience

After

- Increased detail in descriptions
- Details of students' challenges with describing apparent motion of sun
- Lunar phases misconceptions
- Size/scale difficulties

Knowledge of Students Understanding of Science

Knowledge of students' difficulty with the content

Before

- Abby – detailed knowledge of students' difficulty with the content
 - Relative motions
- Trish – difficulty visualizing distances to stars
- Others – no mentions

After

- All described specific challenges
 - Transferring concepts from physical modeling to other contexts
 - Measuring with assessments
 - Abstract nature of the stars

Knowledge of Students Understanding of Science

Knowledge of students' interest and motivation

Before

- Abby – discussed her own personal interest in the topics and her students' interest
- Sarah – students interested in going to the planetarium but not the unit

After

- All of the teachers focused on the students' interest, engagement, and motivation for the content
 - Sarah, Jennifer, Trish – student interest was noted as improved from previous years
- Particular topics: students' personal observations of the moon; size/scale of stars

Knowledge of instructional strategies and representations for astronomy

Prior to the intervention

■ Abby

- Modeling activities for earth and moon's motions
- Demonstrating lunar phases with models
- Believes in using video clips to aid in visualization
- Limitations: students do not engage in constructing explanations of their observations; limited strategies for teaching about the stars

■ Melanie

- No prior astronomy teaching

■ Sarah, Jennifer, Trish

- More closely followed curriculum
- Use demonstration strategies
- Use video clips
- Rely on planetarium to teach stars concepts
- Expressed limited knowledge of these concepts

Knowledge of instructional strategies and representations for astronomy

After the intervention

- Increased focus on providing students' with opportunities to physically model motions
 - Increased focus on teaching earth-based observations
 - Increased discussion of size/scale strategies
 - Increased enthusiasm and confidence
- Areas needed continued growth:
 - Only Trish engaged students in physically modeling why stars appear to move
 - Phases instruction needs improvement based on post-instruction interviews with children

Recommendations for future PD work in this area:

- Knowledge of student misconceptions, prior knowledge
- Increase awareness of areas of particular student difficulty
- Develop teacher confidence and student interest
- Goals for the curriculum will be built on in later grades
- Need for additional modeling, drawing, and writing exercises to improve explanations
- Develop strategies to integrate video content

Future work

- Intervention was limited – three 2-hour interventions
- What would happen with a more extensive and detailed revision to the teachers' curriculum?
- Future research – open-ended interviews yielded several interesting themes, observations
 - Target specific concepts for these PCK facets across more teachers

Thank you

Questions?

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3rd graders understanding of daily celestial motion

Compared kids in traditional curriculum (N=24) with revised curriculum (Abby, Trish, and Sarah's students; N = 32)

o Groups have same distribution (Mann-Whitney test, $Z = -0.661$, $p = .508$).

After instruction

- Both conditions improved knowledge of Daily Celestial Motion (Wilcoxon signed ranks test; $p < 0.001$).
- Experimental group significantly more advanced ($Z = -3.571$, $p < 0.001$).

3rd graders understanding of phases of the moon

Before instruction:

- Not significantly different ($p = .058$)

After instruction:

- Not significantly different ($p = .681$) but both improved (trad: $p < 0.01$; revised: $p = 0.001$)

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Levels	Traditional Curriculum (N=24)		Revised curriculum (N=32)	
	Pre	Post	Pre	Post
Level 1 – Naïve	50%	13%	50%	0%
Level 2 – Accurate mental model of sun's apparent motion	38%	50%	16%	22%
Level 3 – Accurate mental model of sun's app motion & moon or stars' app motion	13%	38%	32%	59%
Level 4 – Scientific understanding of daily celestial motion	0%	0%	3%	16%

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	Traditional (N=24)		Revised curriculum (N=32)	
	Pre	Post	Pre	Post
Levels				
Non-normative	96%	32%	78%	41%
Alternative fragments	4%	13%	13%	25%
Fragments of the scientific	0%	38%	9%	31%
Scientific explanation	0%	17%	0%	3%

