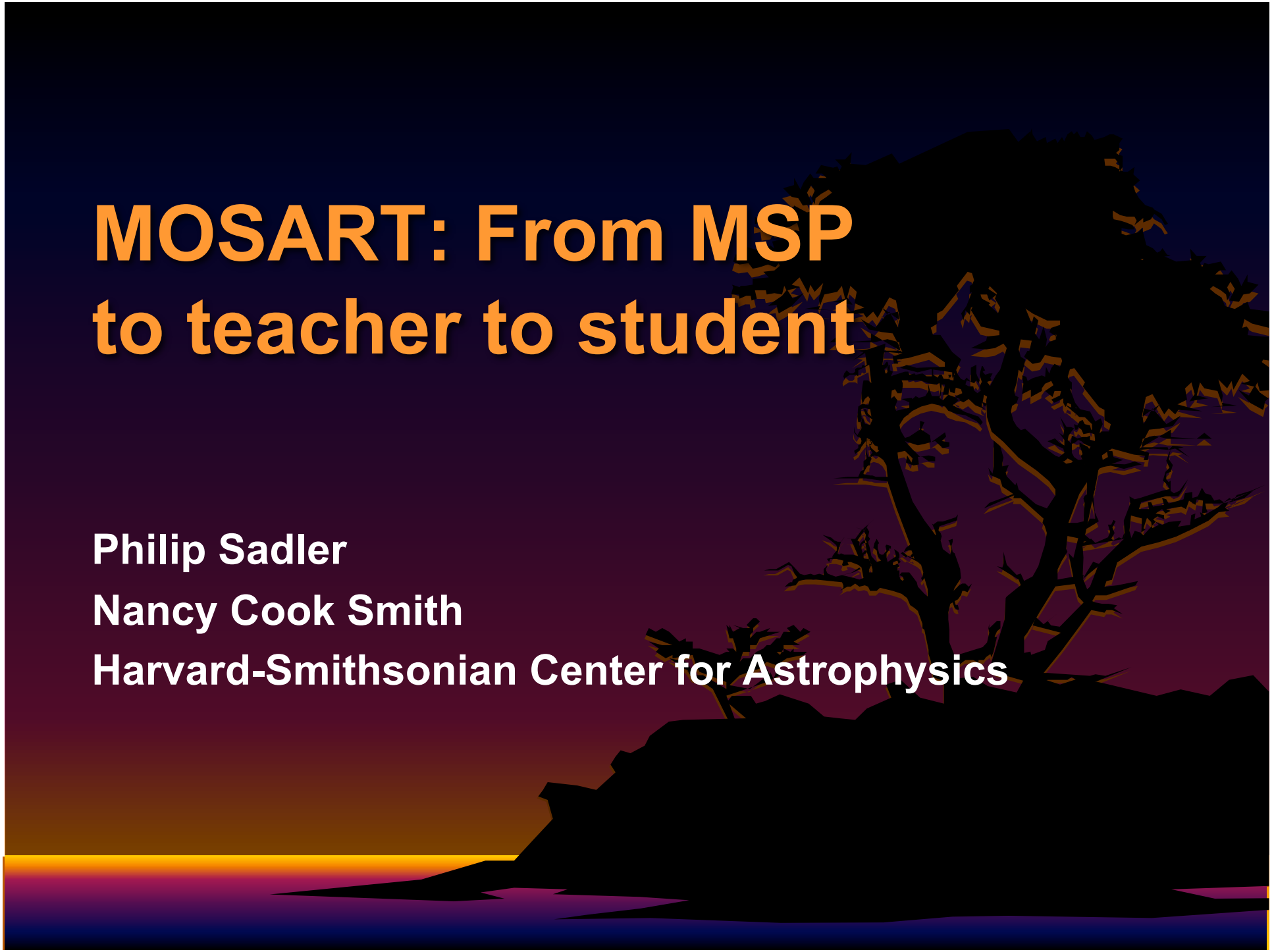
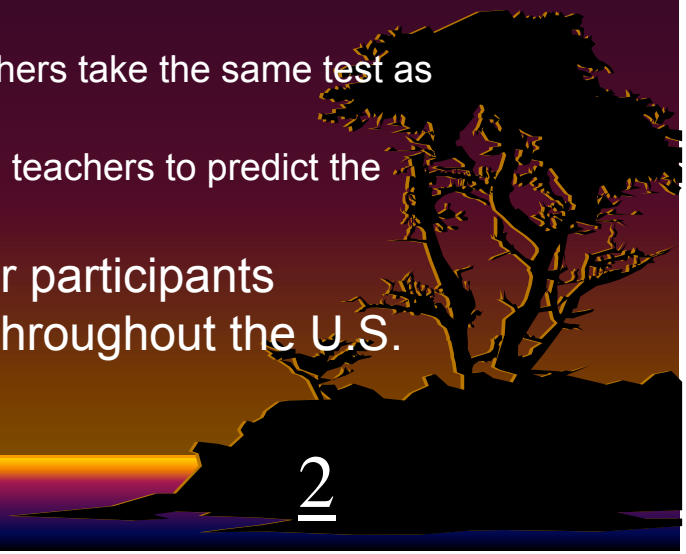
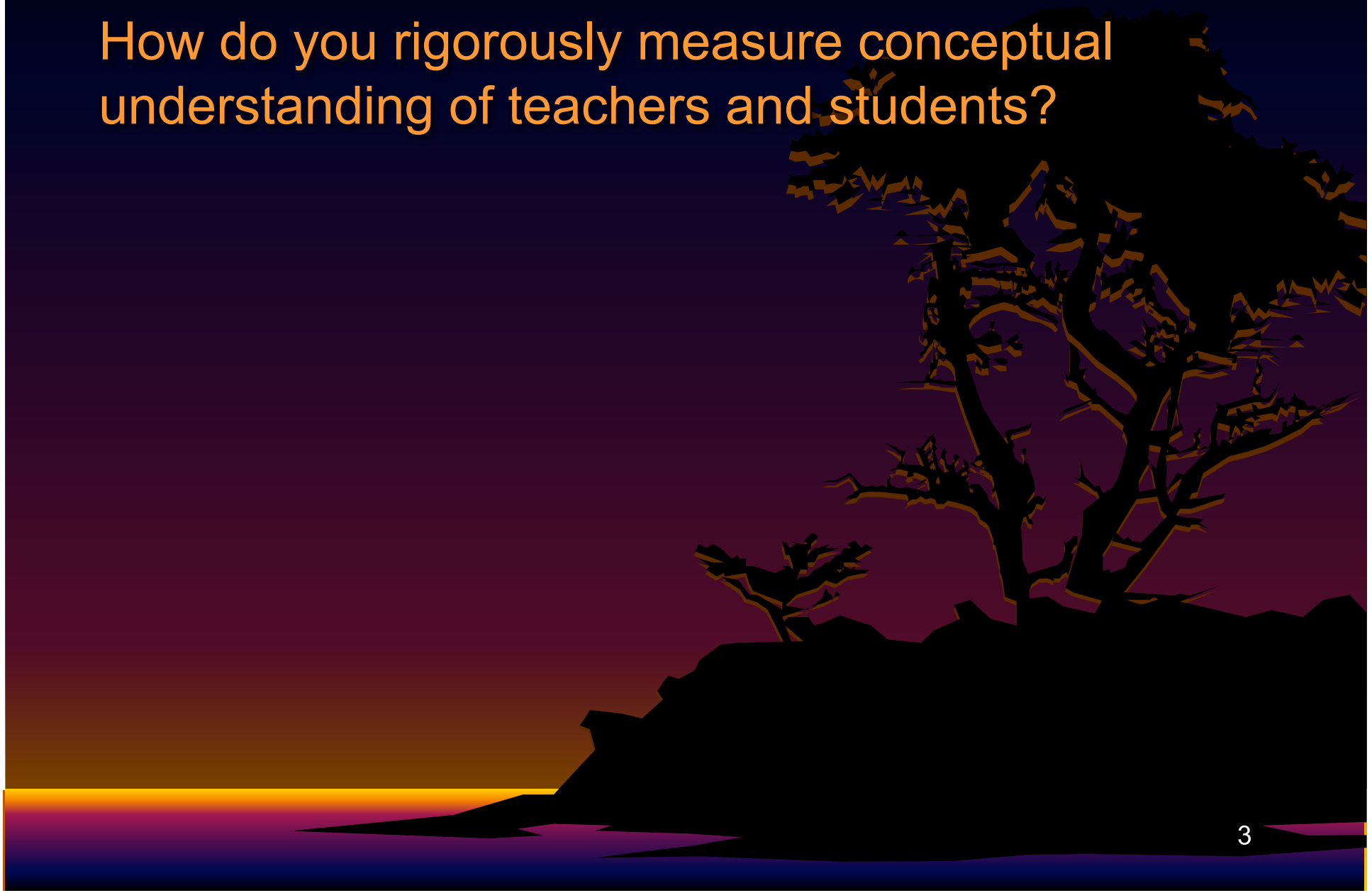

MOSART: From MSP
to teacher to student
Philip Sadler
Nancy Cook Smith
Harvard-Smithsonian Center for Astrophysics

Summary

- This session focuses on two sets of research findings:
  - The effects of MSP institutes on teachers' subject matter knowledge and pedagogical content knowledge
  - the effects of teacher knowledge on student gains.
- Misconceptions are robust but scientifically inaccurate understandings of the world that are often consistent with everyday experience.
- We have developed a unique approach to measuring teachers' SMK and PCK in a large scale study that clarifies the relationship between teachers' knowledge of misconceptions and students' gaining better understanding.
  - To measure teachers' subject matter knowledge (SMK), teachers take the same test as their students.
  - Pedagogical content knowledge (PCK), is revealed by asking teachers to predict the most common *wrong* answer chosen by their own students.
- We have analyzed data from more than 400 teacher participants engaged in more than 20 institutes in many states throughout the U.S.



How do you rigorously measure conceptual understanding of teachers and students?



How do you rigorously measure conceptual understanding of teachers and students?

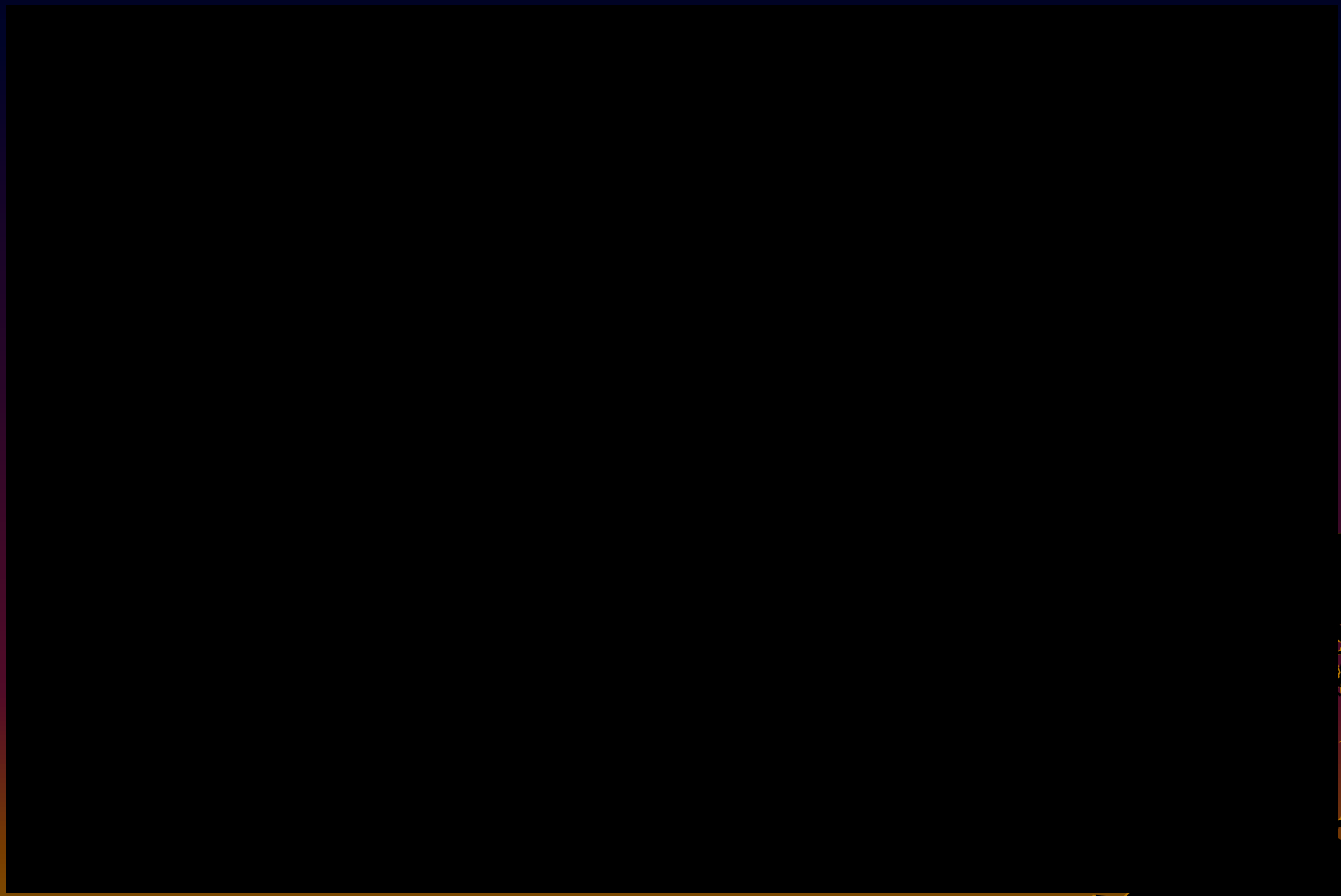
Lightman, A. & Sadler, P.M. (1993) Teacher Predictions versus Actual Student Gains. *The Physics Teacher*, 31(3), 162-167.

Sadler, P.M. (1998) Psychometric Models of Student Conceptions in Science: Reconciling Qualitative Studies and Distractor-Driven Assessment Instruments, *Journal of Research in Science Teaching*, 35(3), 265-296.

Ward, R. B., Sadler, P.M., & Shapiro, I.I. (2007). Learning Science Through Astronomy Activities: A Comparison Between Constructivist and Traditional Approaches in Grades 3-6. *Astronomy Education Review,* 6(2), 1-19.

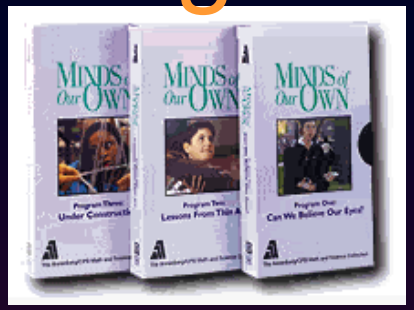
Sadler, P. Coyle, H., Miller, J. Cook-Smith, N., Dussault, M. & Gould, R (2010) The Astronomy and Space Science Concept Inventory: Development and Validation of an Assessment Instrument Aligned with the National Standards, *Astronomy Education Review.*

Scale Model of the Solar System

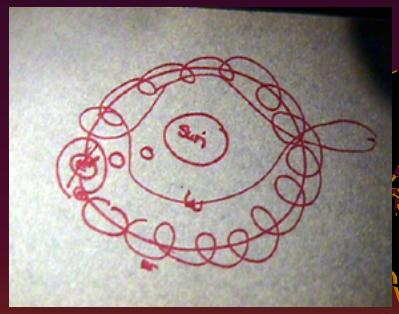


Clinical Interviews- misconceptions and change

On-on-one with students



Minds of Our Own consists of 3-one hour programs broadcast on PBS in 1997-98. It explores the ideas of students as they come to understand scientific concepts



A Private Universe documents students' ideas through their own drawings and explanations

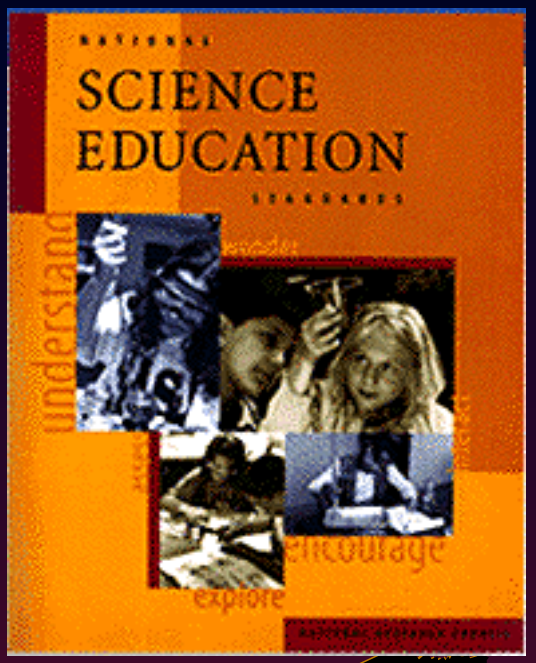
www.learner.org

Both students and teachers have (or had) preconceptions

- Exist prior to formal instruction
- At odds with accepted scientific thought, "misconceptions"
- Commonly held, not idiosyncratic
- Embedded in larger knowledge structures, not just a simple "error" (that is easy to correct)
- Resistant to change, overestimation of Δ
- Originally catalogued as "math bugs"
- Preconceptions forgotten as knowledge is restructured

Steps in instrument development based on student ideas

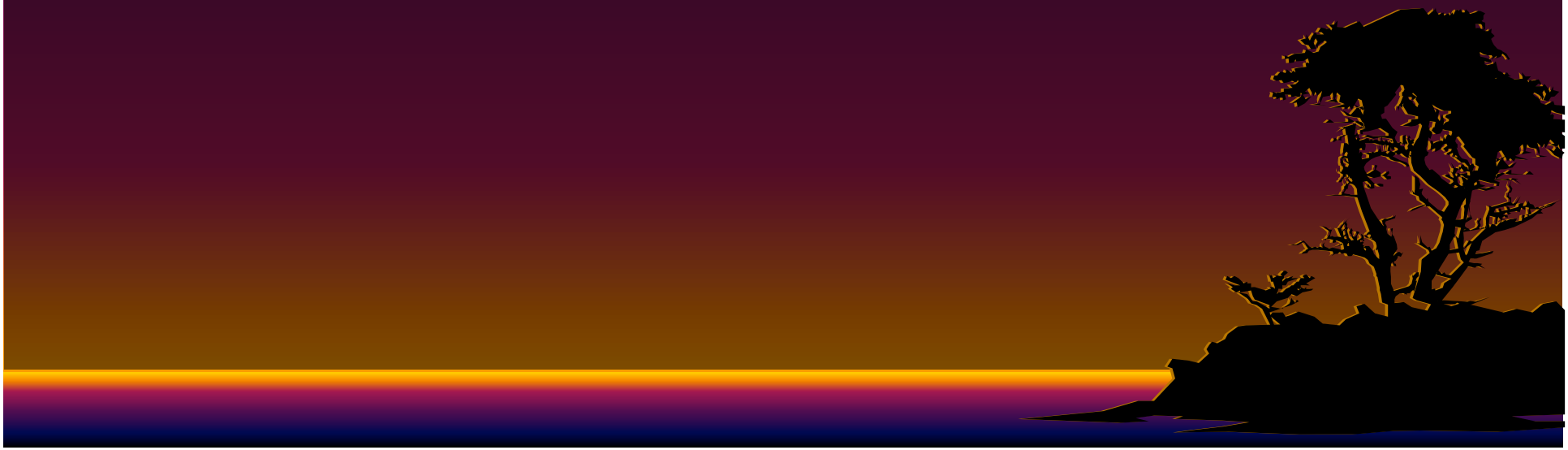
- Employ NRC standards, the root of state standards
- Construct assessment instruments based on misconceptions
  - Research literature
- Validation with both students and teachers
  - Pilot and field tests
  - Final instruments
- Measure both SMK and PCK



What is the cause of day and night?

NAEP 3rd grade

SED 8-12th grade



What is the cause of day and night?

NAEP 3rd grade

a. Earth turns.
b. Sun turns.
c. Moon turns.
d. Sun gets dark at night.

e. I don’t know.

SED 8-12th grade

What is the cause of day and night?

NAEP 3rd grade

a. Earth turns. (81%)
b. Sun turns. (8%)
c. Moon turns. (4%)
d. Sun gets dark at night. (6%)
e. I don't know. (1%)

SED 8-12th grade

What is the cause of day and night?

NAEP 3rd grade

a. Earth turns. (81%)
b. Sun turns. (8%)
c. Moon turns. (4%)
d. Sun gets dark at night. (6%)
e. I don't know. (1%)

SED 8-12th grade

a. The earth spins on its axis.
b. Clouds block the sun's light
c. The earth moves into and out of the sun's shadow.
d. The sun goes around the earth.
e. The earth moves around the sun.

What is the cause of day and night?

NAEP 3rd grade

a. Earth turns. (81%)
b. Sun turns. (8%)
c. Moon turns. (4%)
d. Sun gets dark at night. (6%)
e. I don't know. (1%)

SED 8-12th grade

a. The earth spins on its axis. 68%
b. Clouds block the sun's light
c. The earth moves into and out of the sun's shadow.
d. The sun goes around the earth.
e. The earth moves around the sun.

What is the cause of day and night?

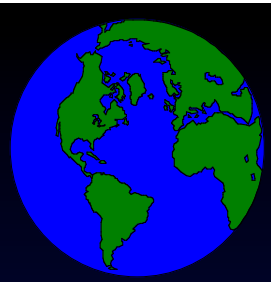
NAEP 3rd grade

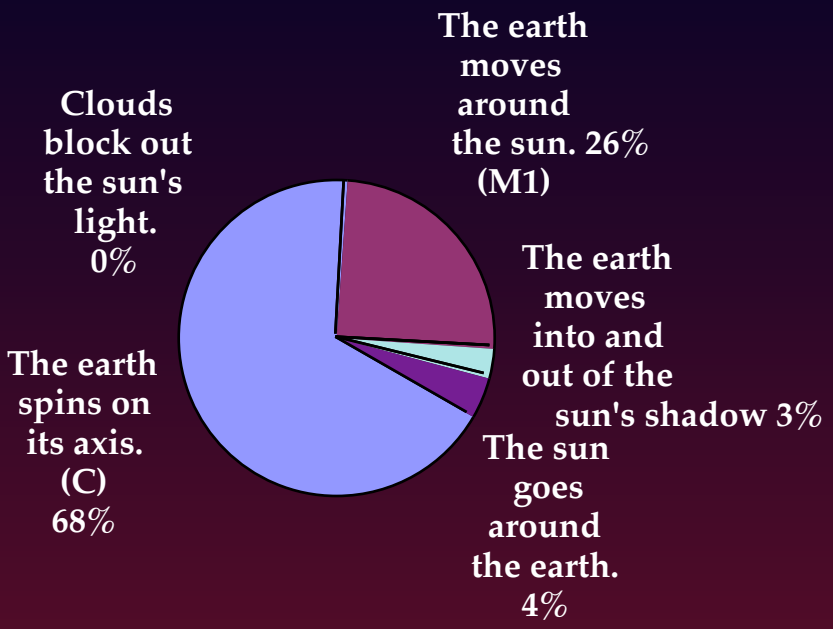
a. Earth turns. (81%)
b. Sun turns. (8%)
c. Moon turns. (4%)
d. Sun gets dark at night. (6%)
e. I don't know. (1%)

SED 8-12th grade

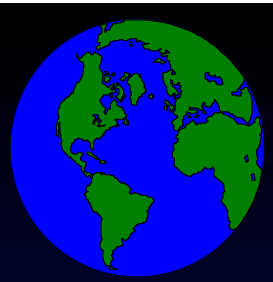
a. The earth spins on its axis. 68%
b. Clouds block the sun's light 0%
c. The earth moves into and out of the sun's shadow. 3%
d. The sun goes around the earth. 4%
e. The earth moves around the sun. 26%

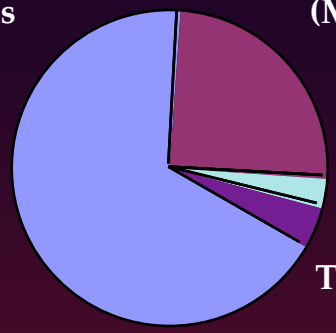
Reason for Day and Night

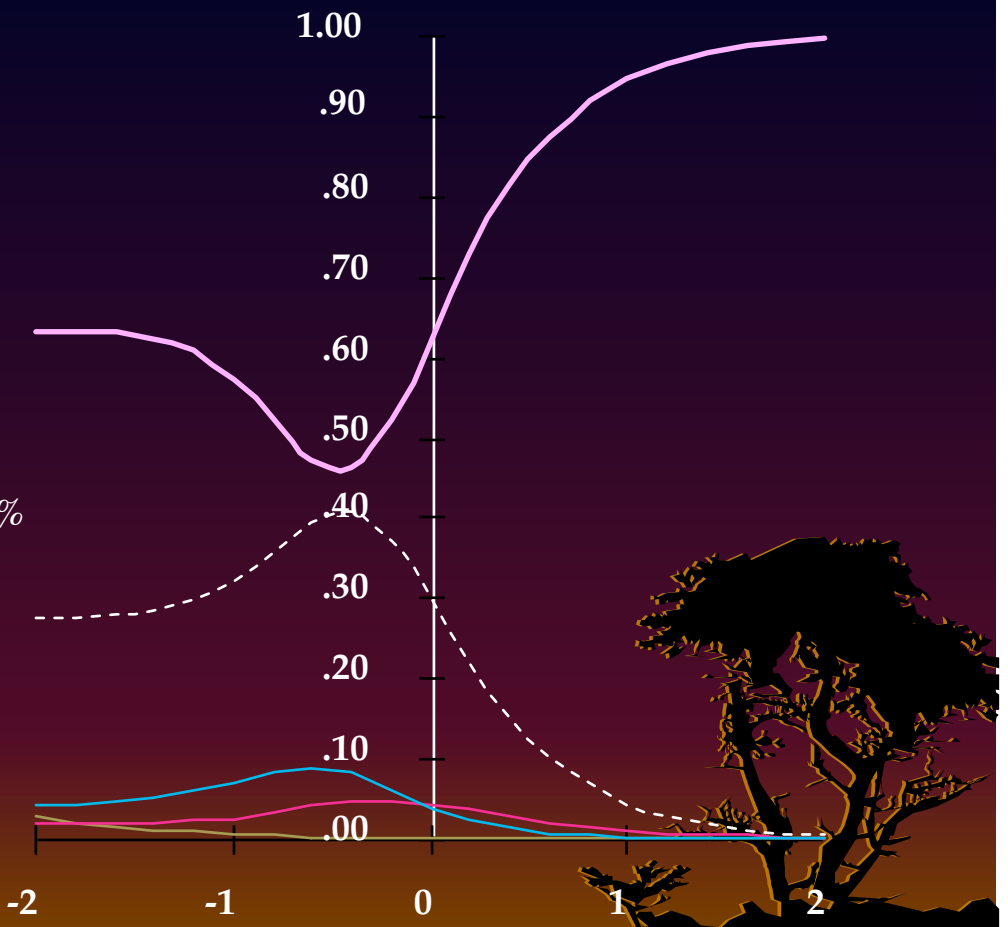




Reason for Day and Night



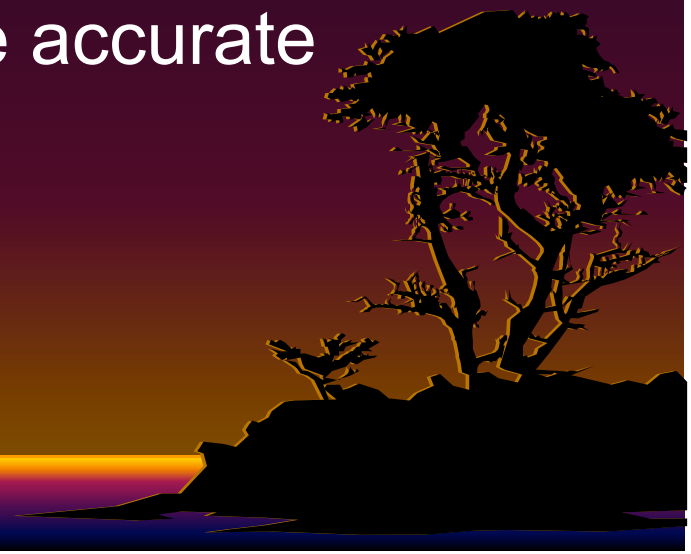




Our Criteria for Conceptual Understanding

Students and teachers must:

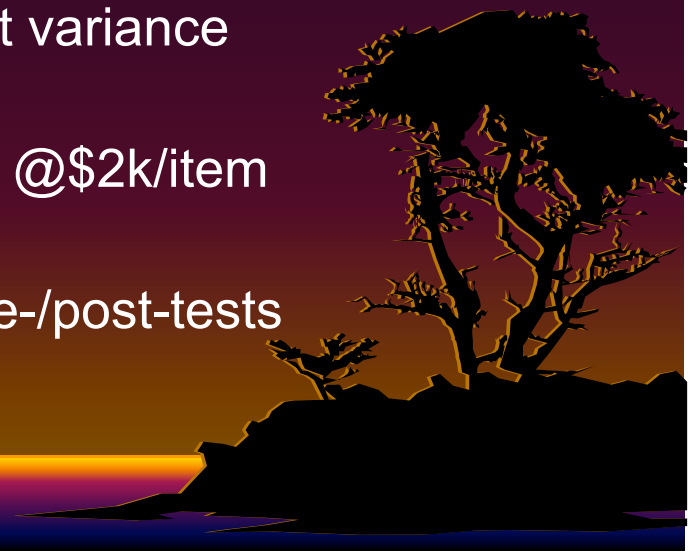
- Prefer accepted scientific explanations over widely-held misconceptions
  - Item must contain both
- Apply their knowledge to make accurate predictions
  - Can concept be used?



Test Construction

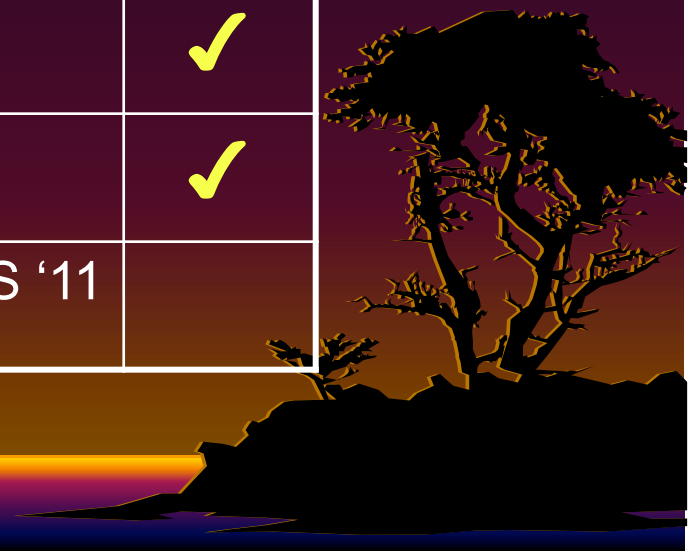
How do you move from clinical interviews to distractor-driven, multiple-choice items?

- Breakdown of Standards into component concepts
  - Identify all relevant misconceptions reported in the literature
  - Interview in areas for which the literature is sparse
- Item Construction
  - Write stem, correct answer, misconceptions,
- Validation
  - Are the questions accurate in terms of the science? Readable?
- Pilot Testing (N=100/item)
  - selection of core items that represent the most variance
- Large scale sample (N=1000/item)
  - Item characteristics for 100-200 items/domain @$2k/item
- Finalization of Instruments
  - Made available for evaluation of programs, pre-/post-tests



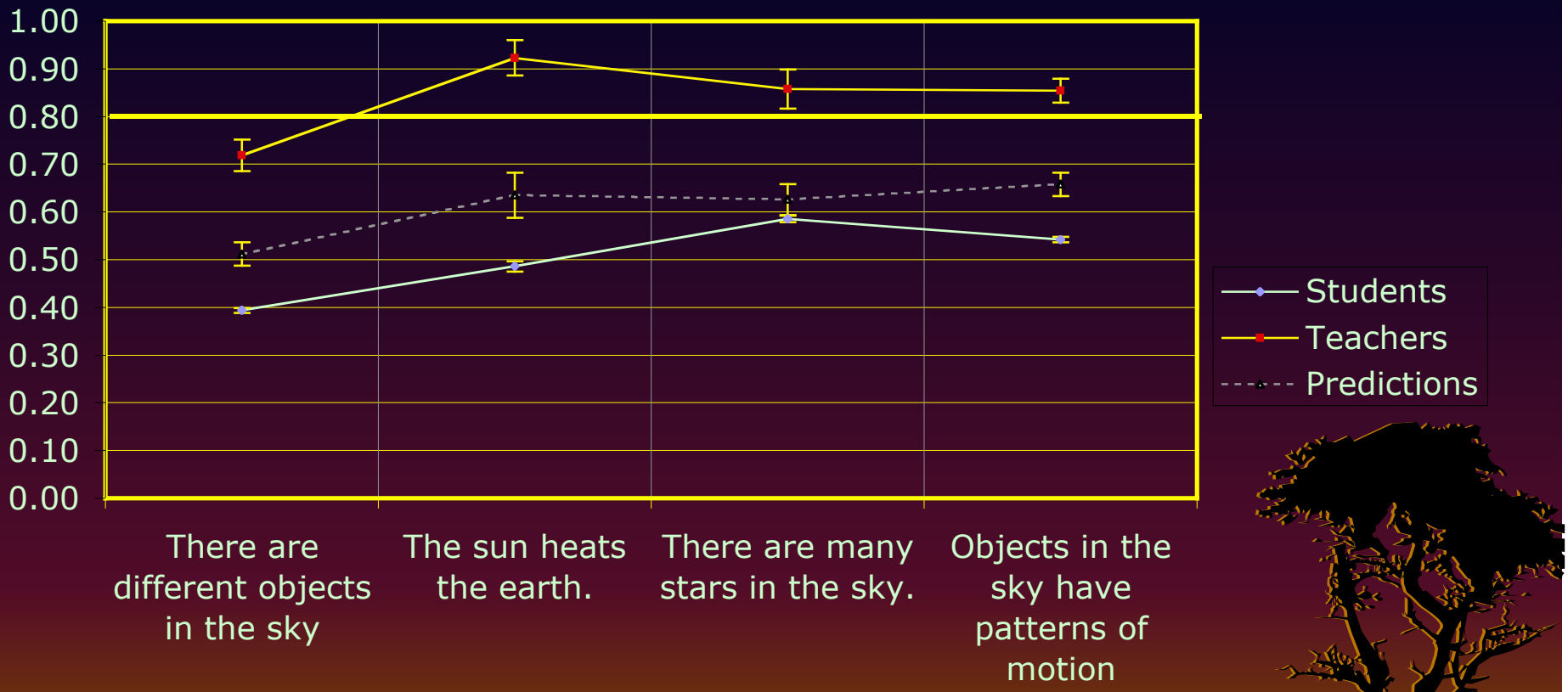
Test Instruments Available at the MOSART Website

	K-4	5-8	9-12
Astronomy	✓	✓	✓
Earth & Space Science	✓	✓	✓
Physical Science	✓	✓	
Chemistry			✓
Physics			✓
Life Science	S ‘11	S ‘11	

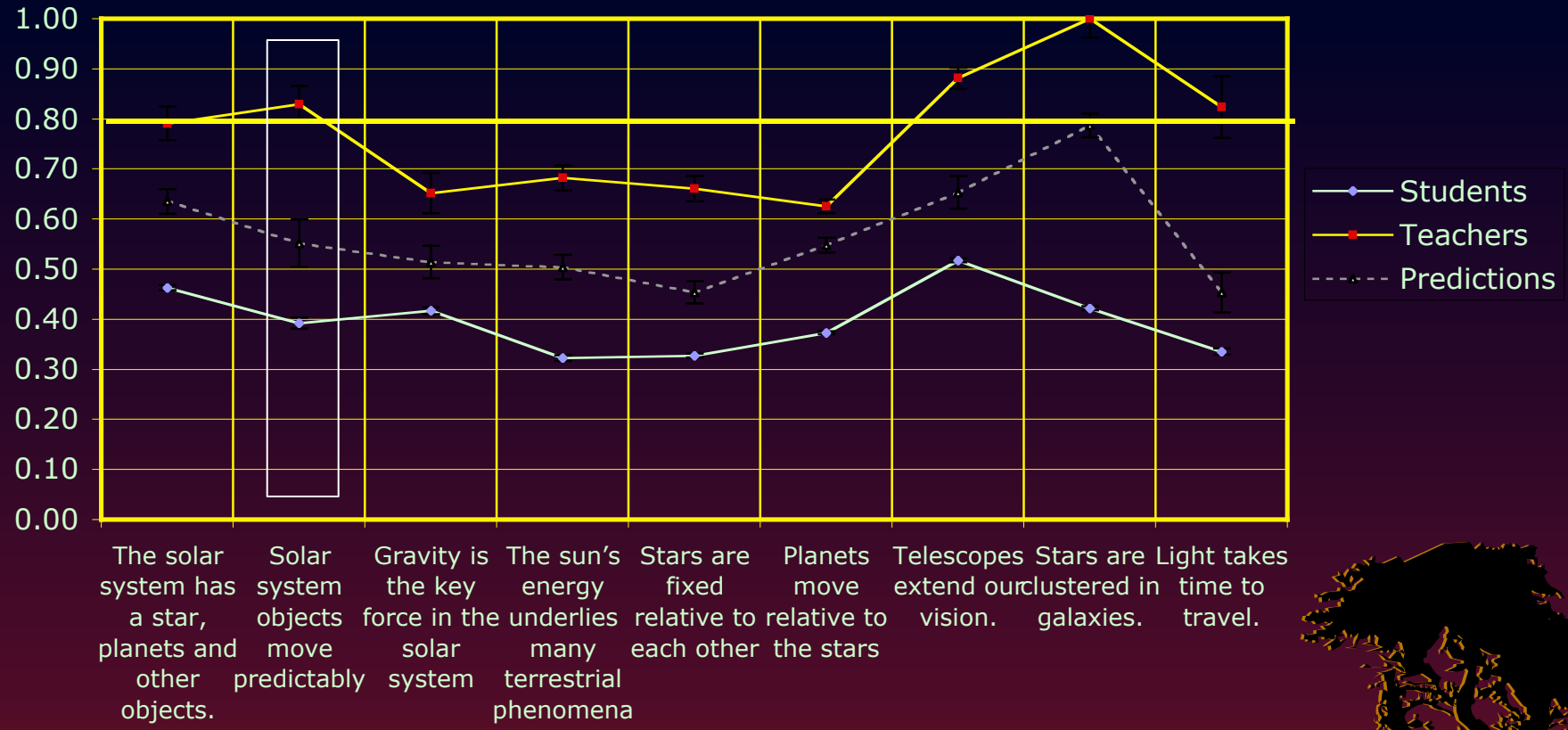


What is the State of Teacher and Student Knowledge?

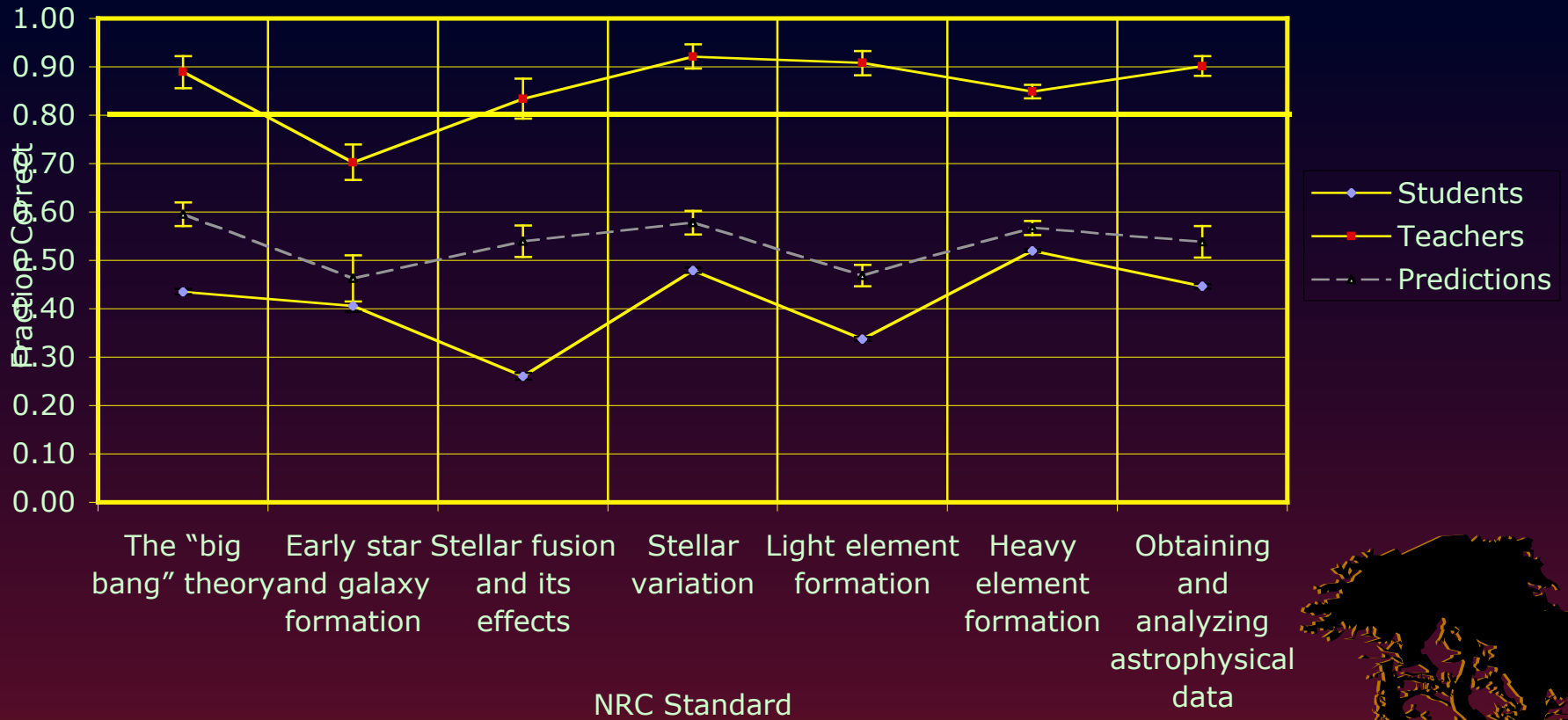
Elementary Standards: Astronomy



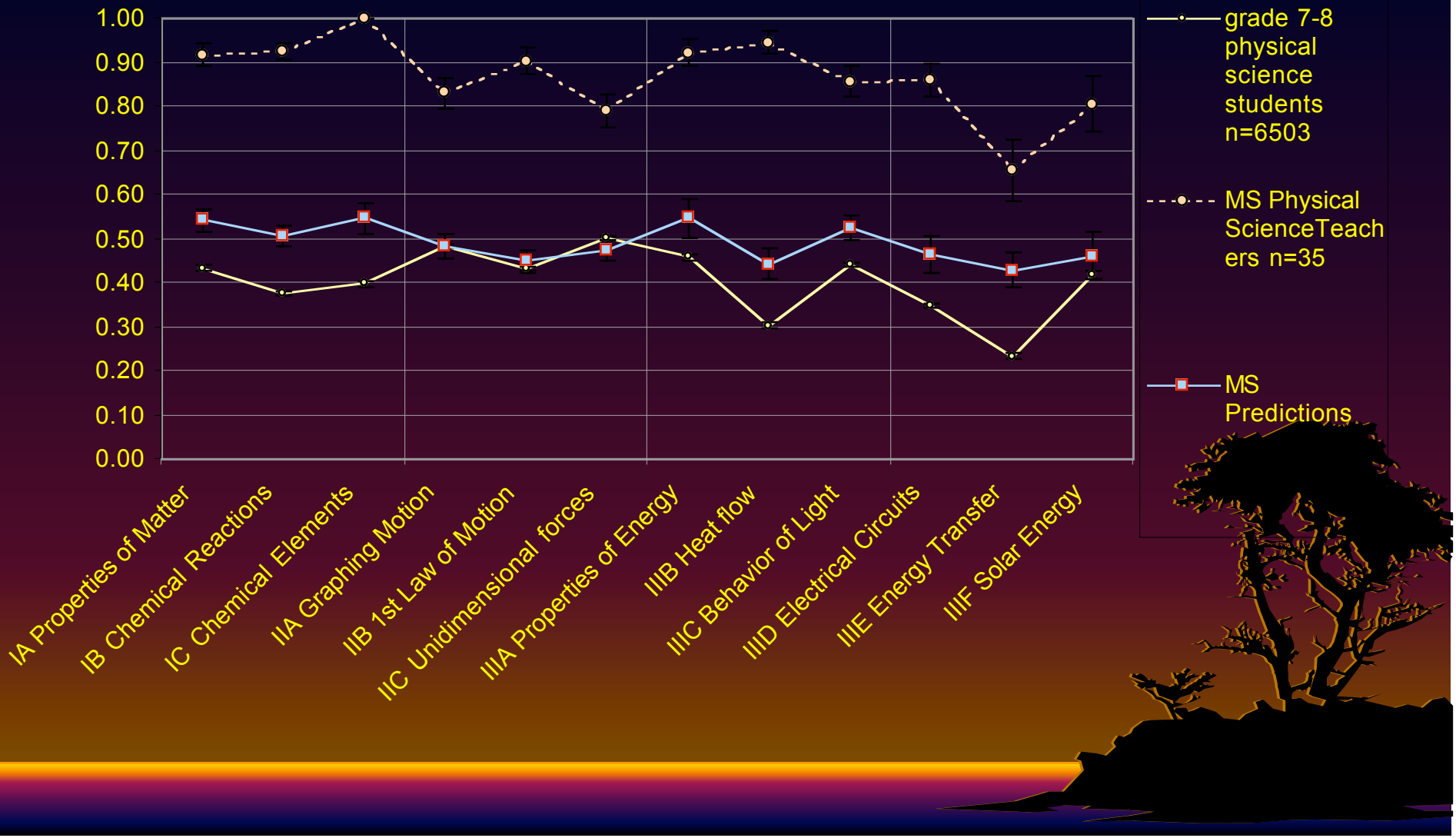
Middle School Astronomy Standards



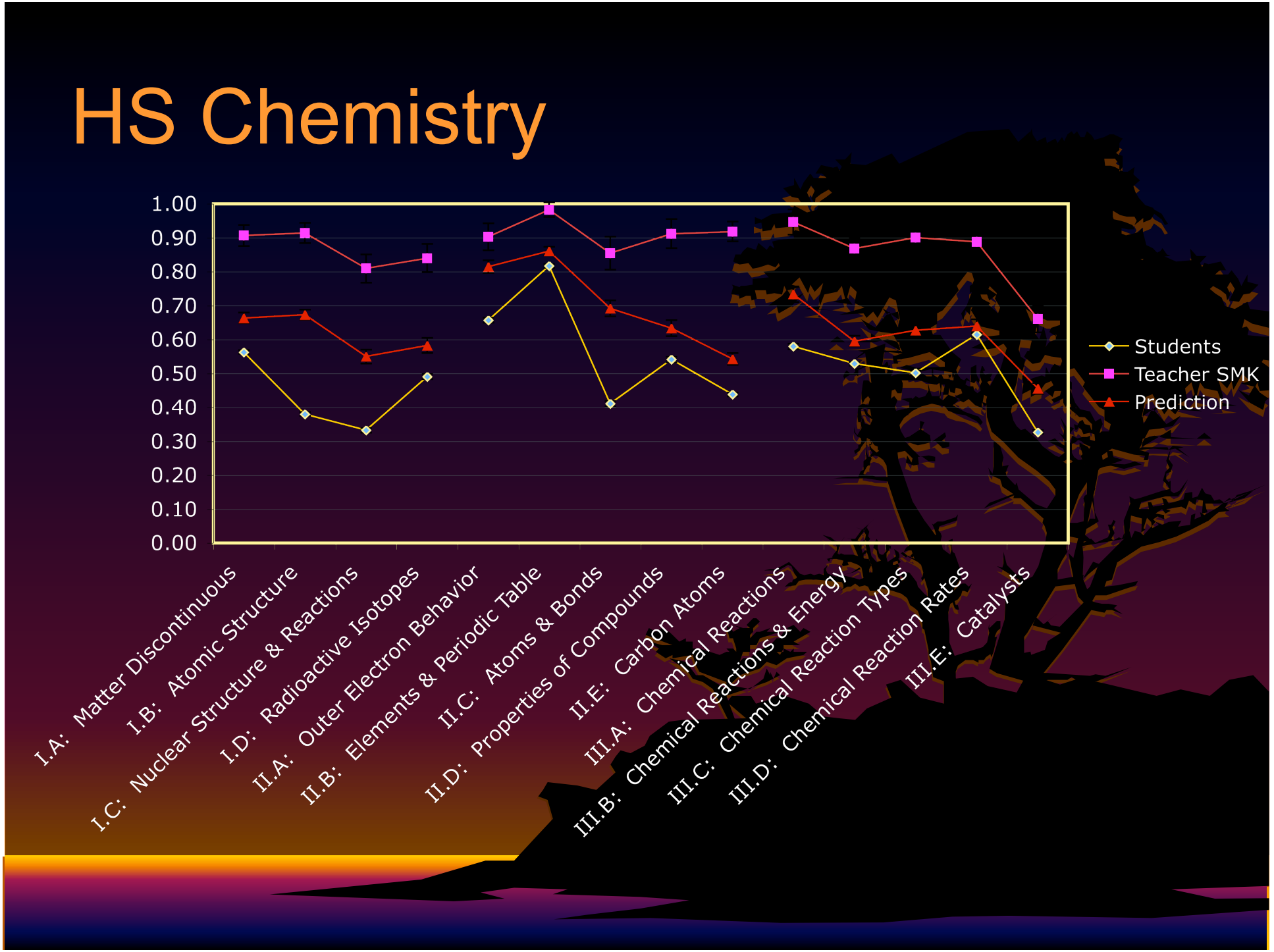
High School Astronomy Standards



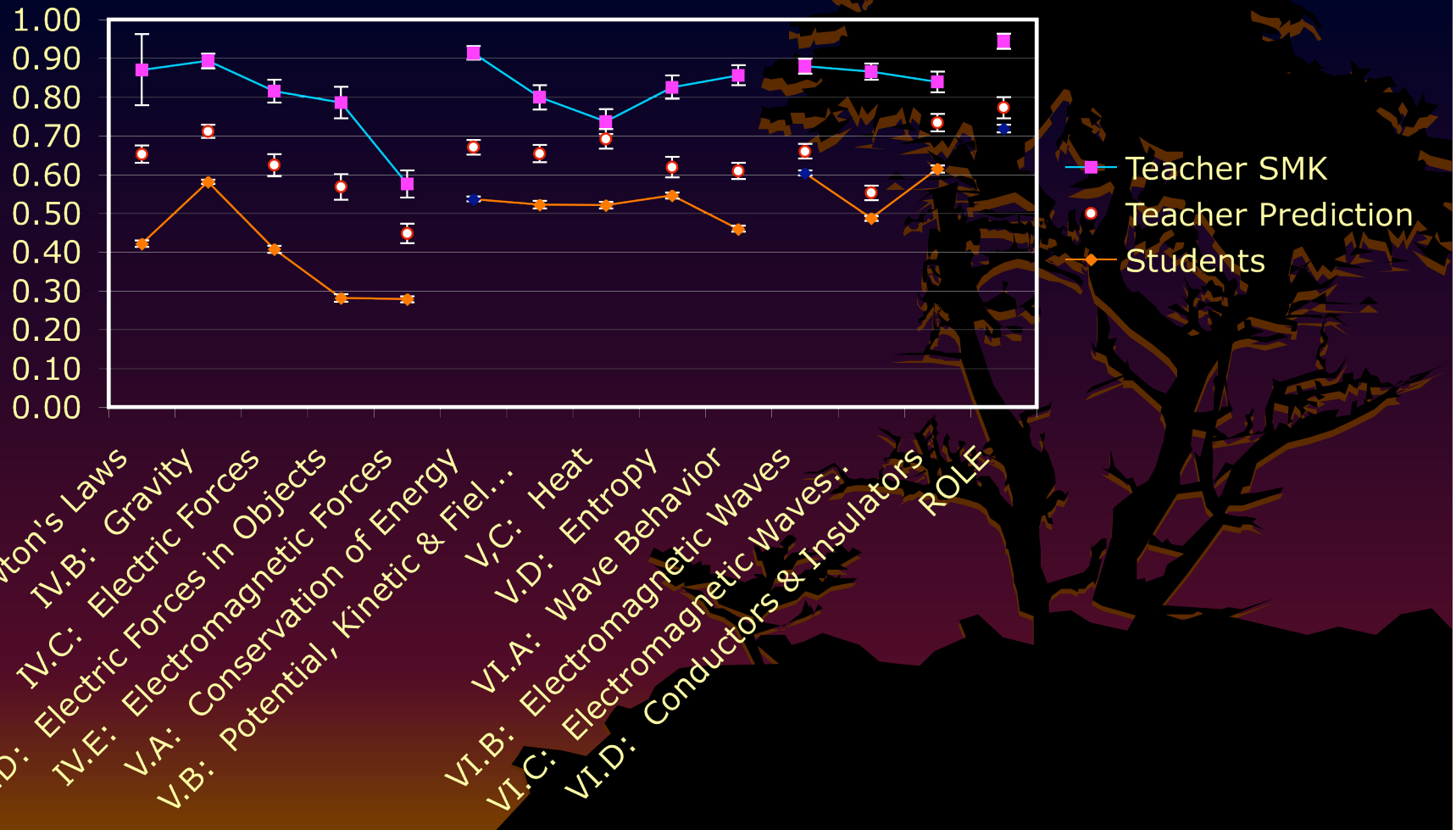
MS Physical Science



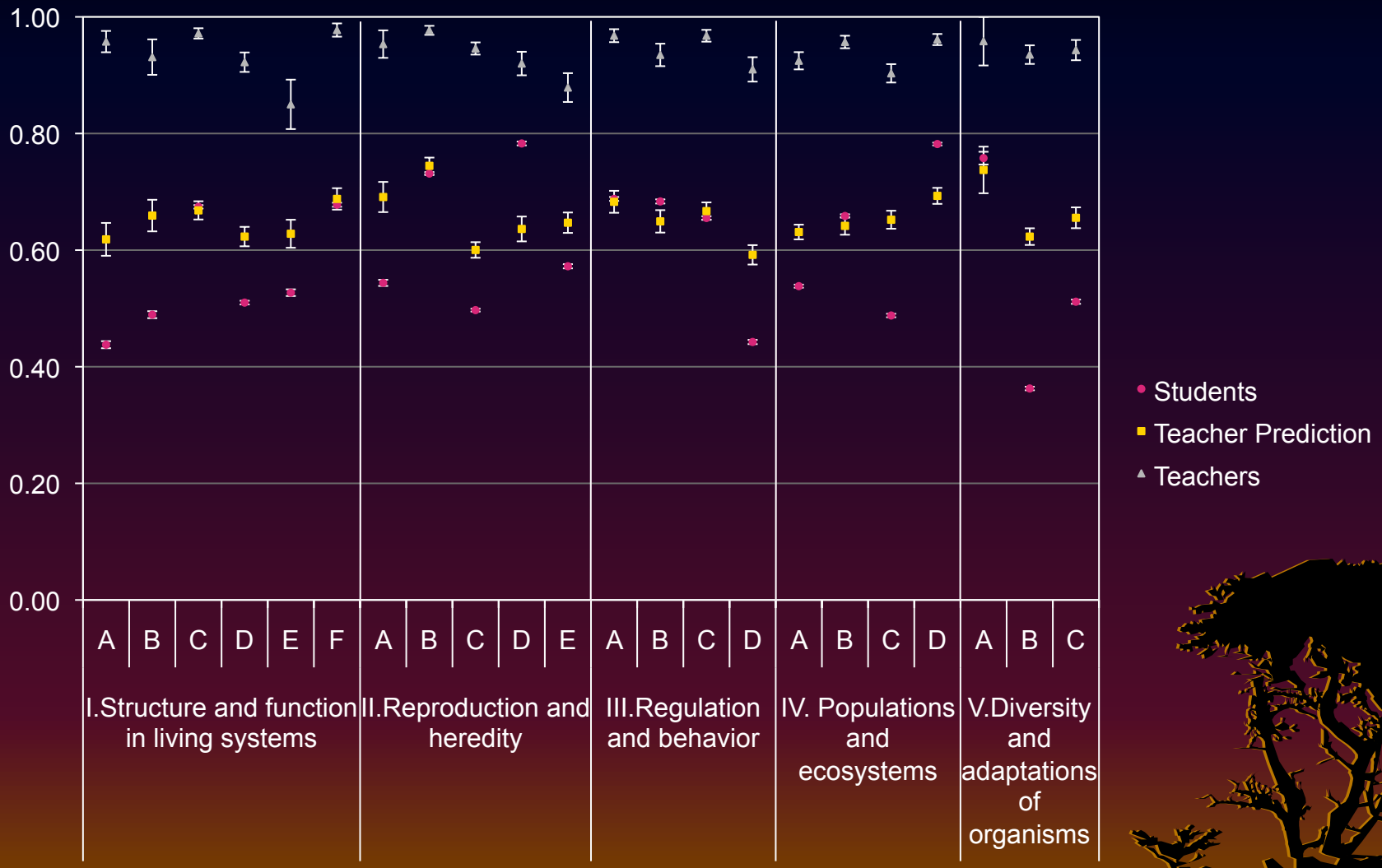
HS Chemistry



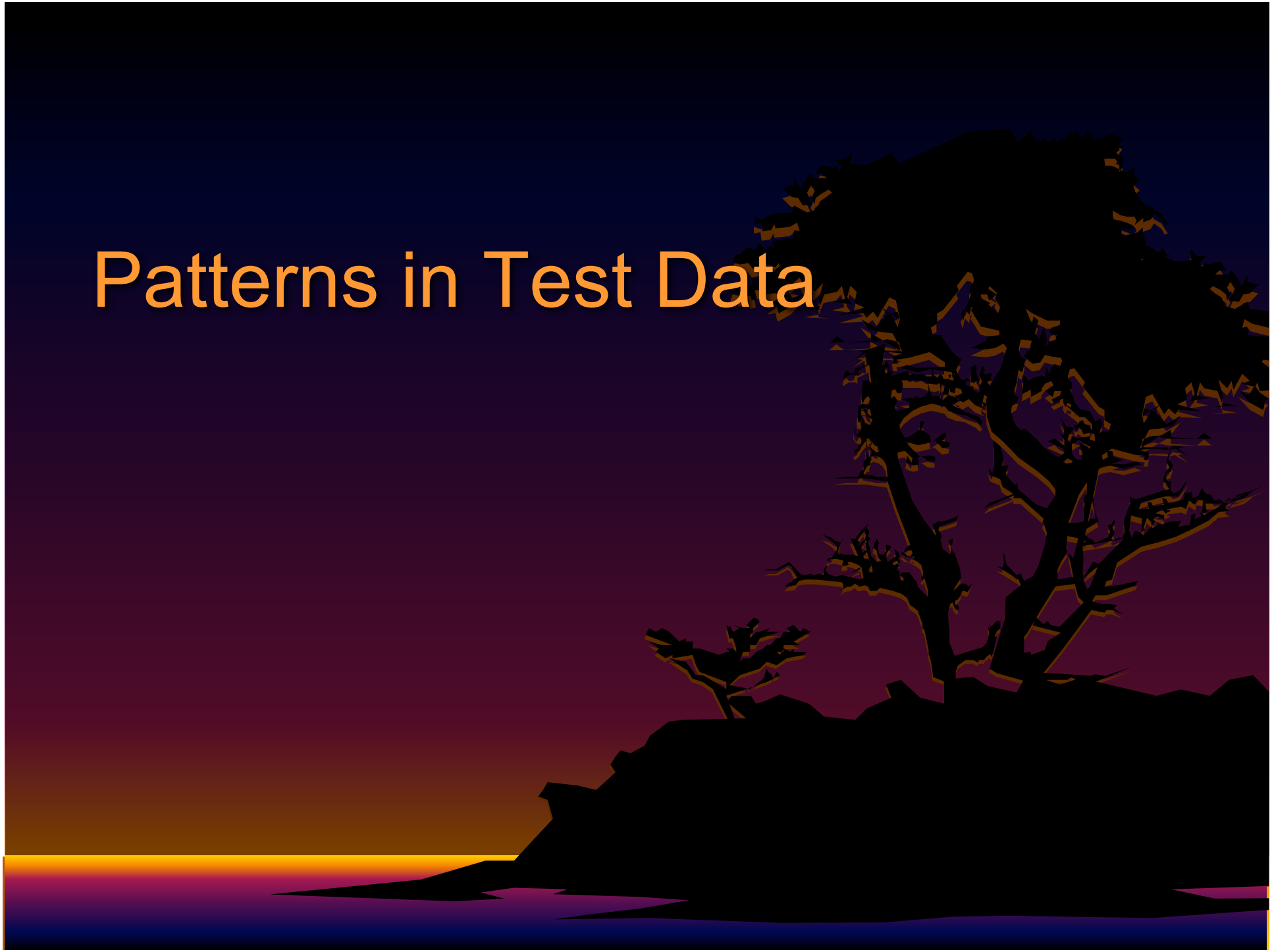
HS Physics


1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
IV.A: Newton's Laws
IV.B: Gravity
IV.C: Electric Forces
IV.D: Electric Forces in Objects
IV.E: Electromagnetic Forces
V.A: Conservation of Energy
V.B: Potential, Kinetic & Fiel...
V,C: Heat
V.D: Entropy
VI.A: Wave Behavior
VI.B: Electromagnetic Waves
VI.C: Electromagnetic Waves:..
VI.D: Conductors & Insulators
ROLE
Teacher SMK
Teacher Prediction
Students

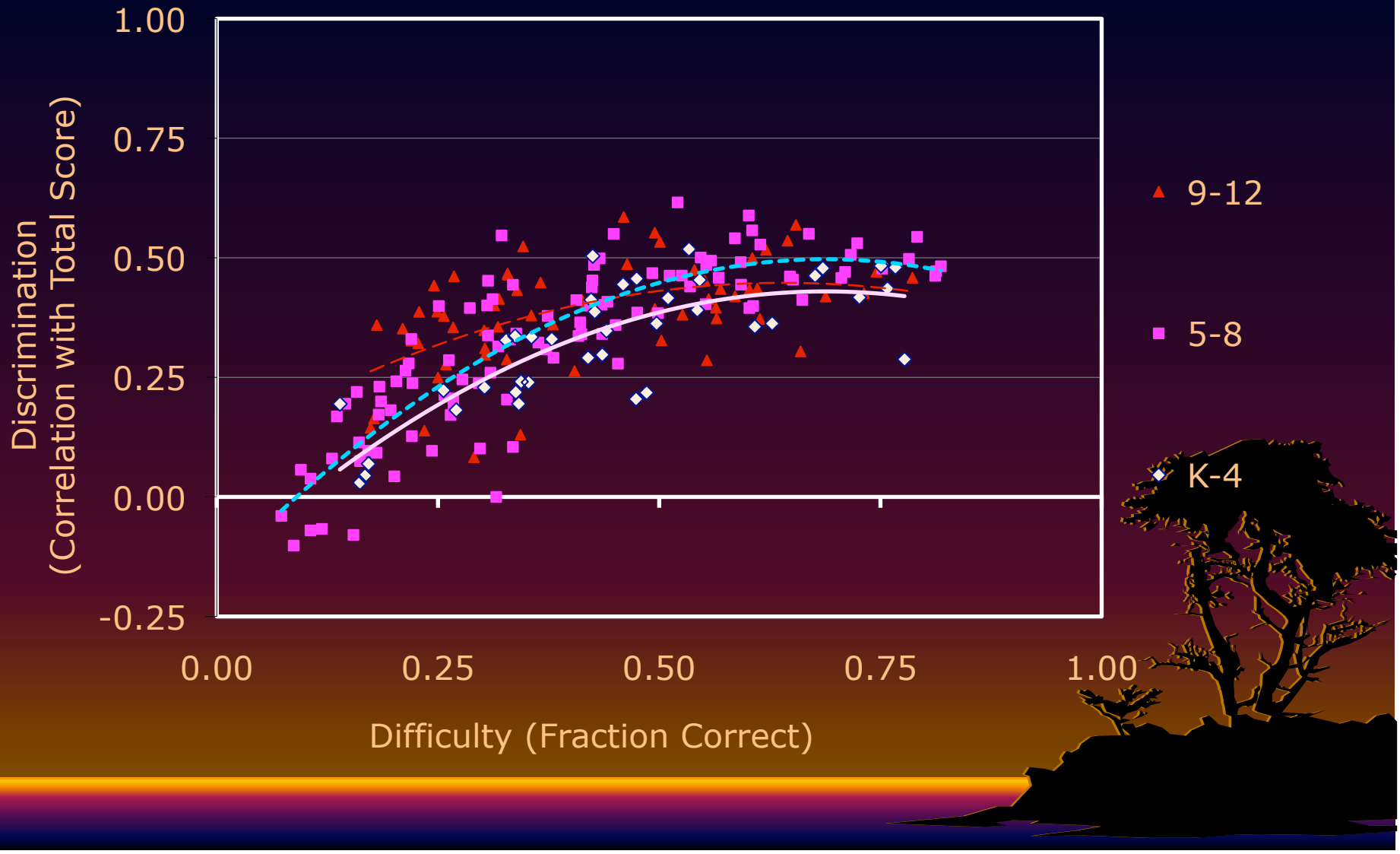
MOSART Middle School Life Science Field Test



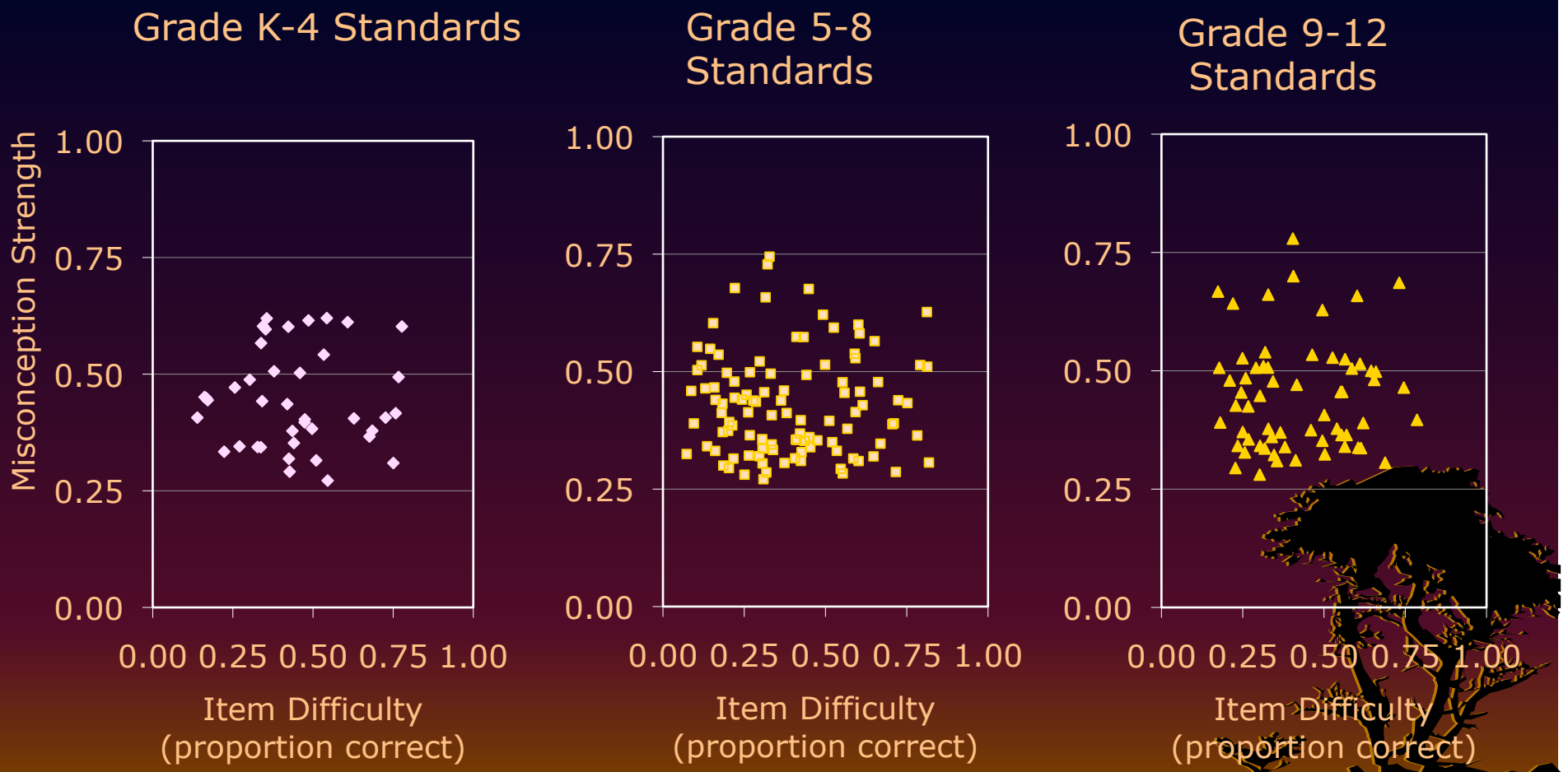
Patterns in Test Data



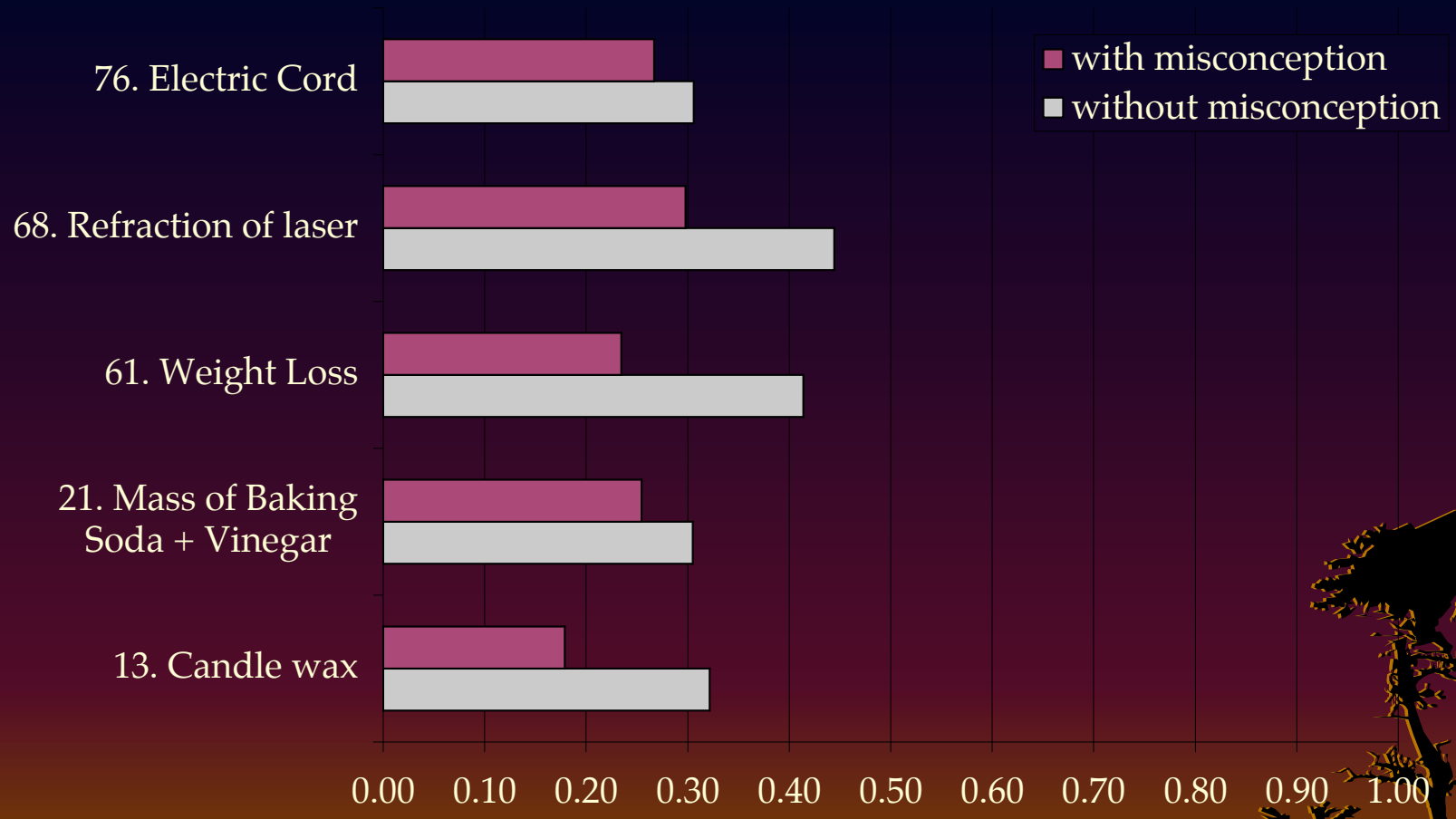
Item Characteristics
Difficulty vs. Discrimination



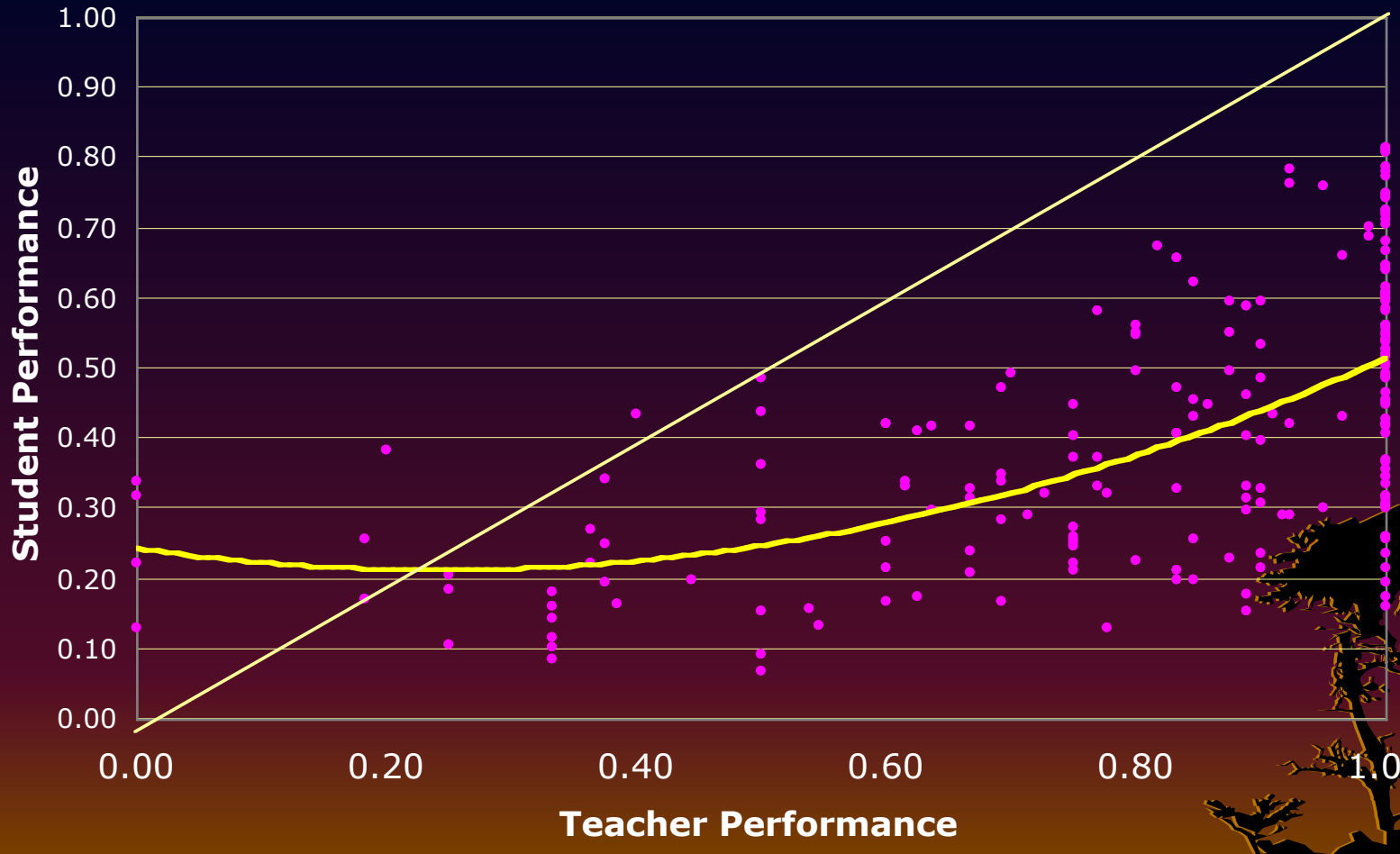
Misconception Strength vs Item Difficulty



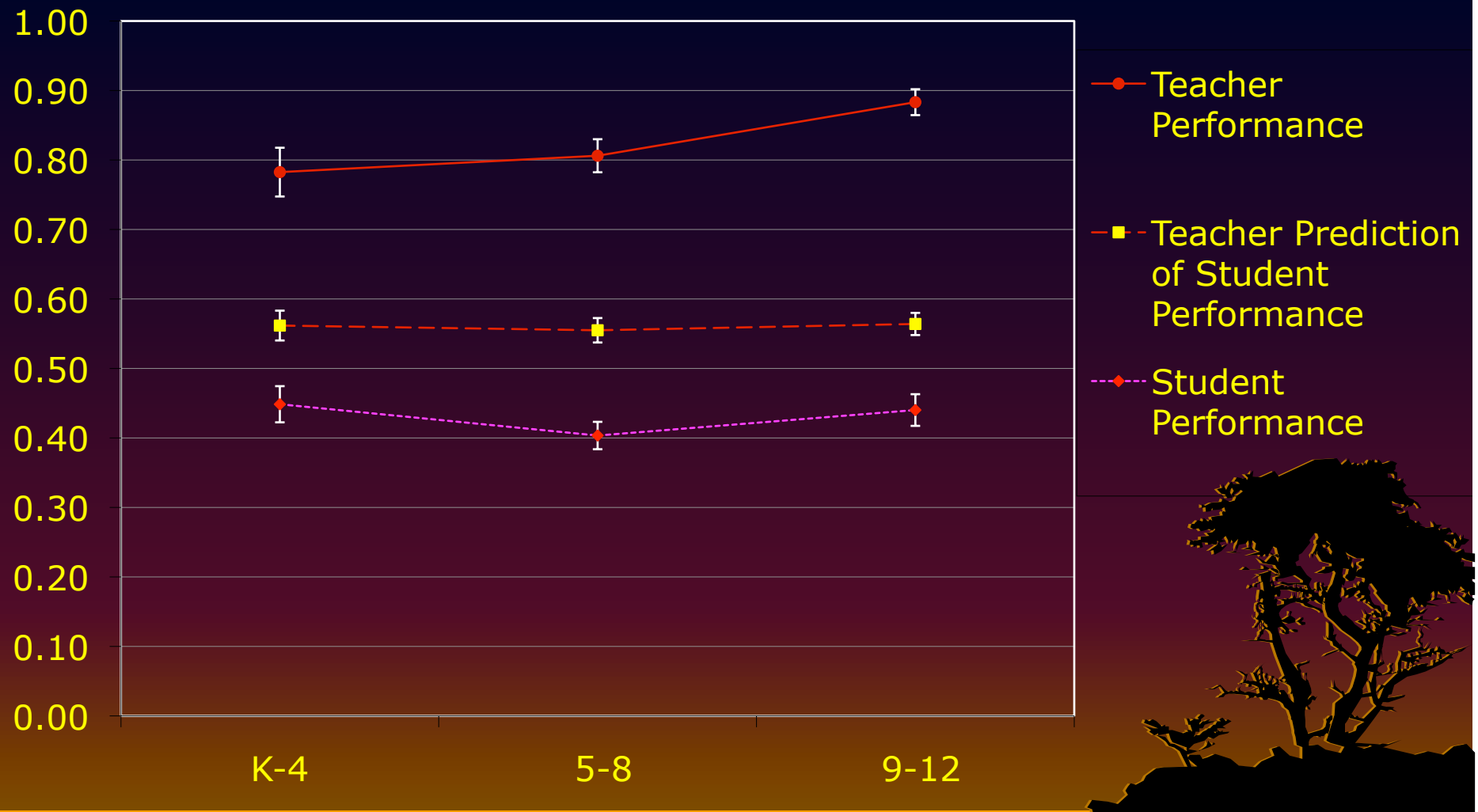
Comparison of Item Formats with and without strong misconception



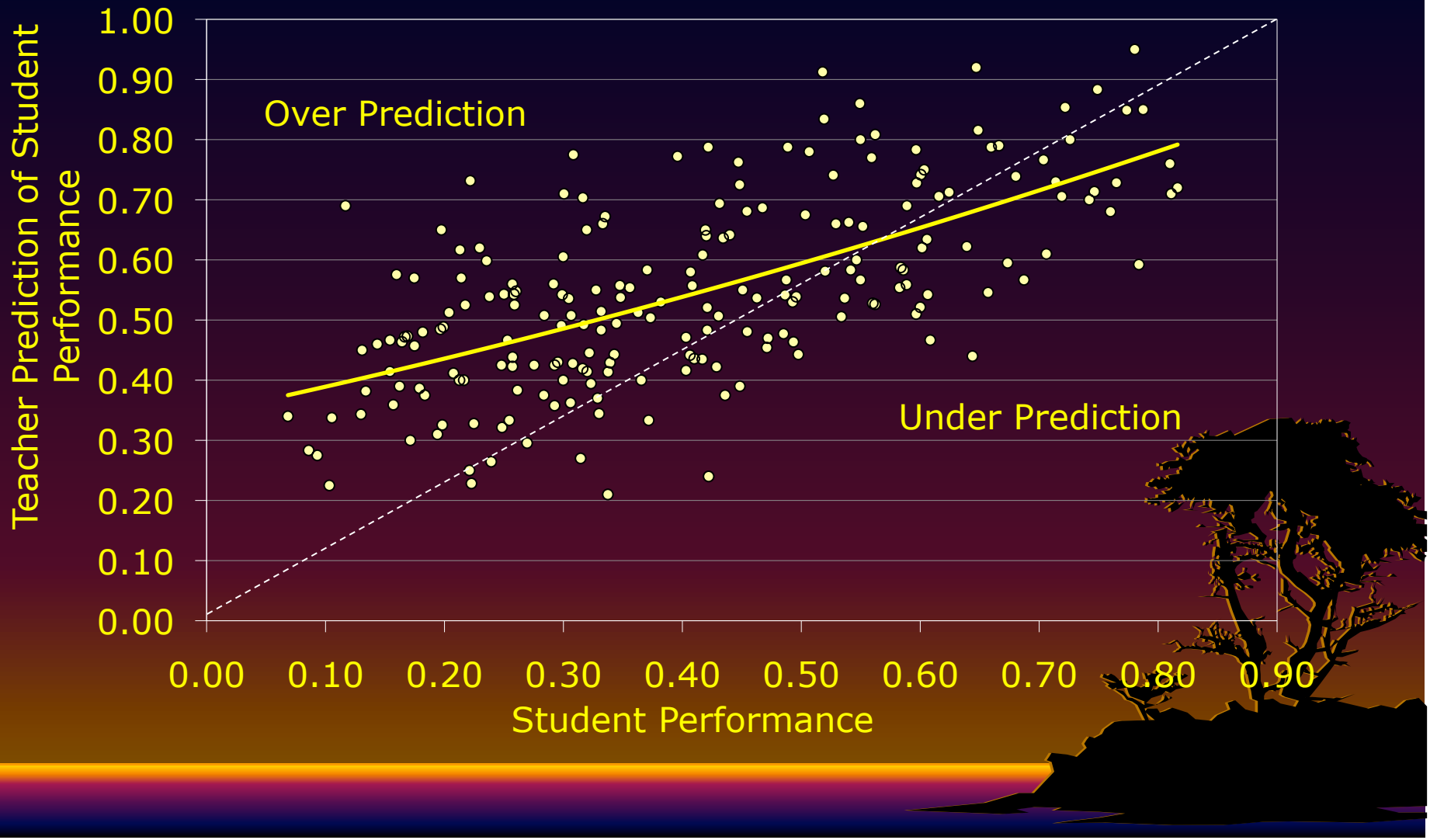
Relationship between Teacher and Student Knowledge



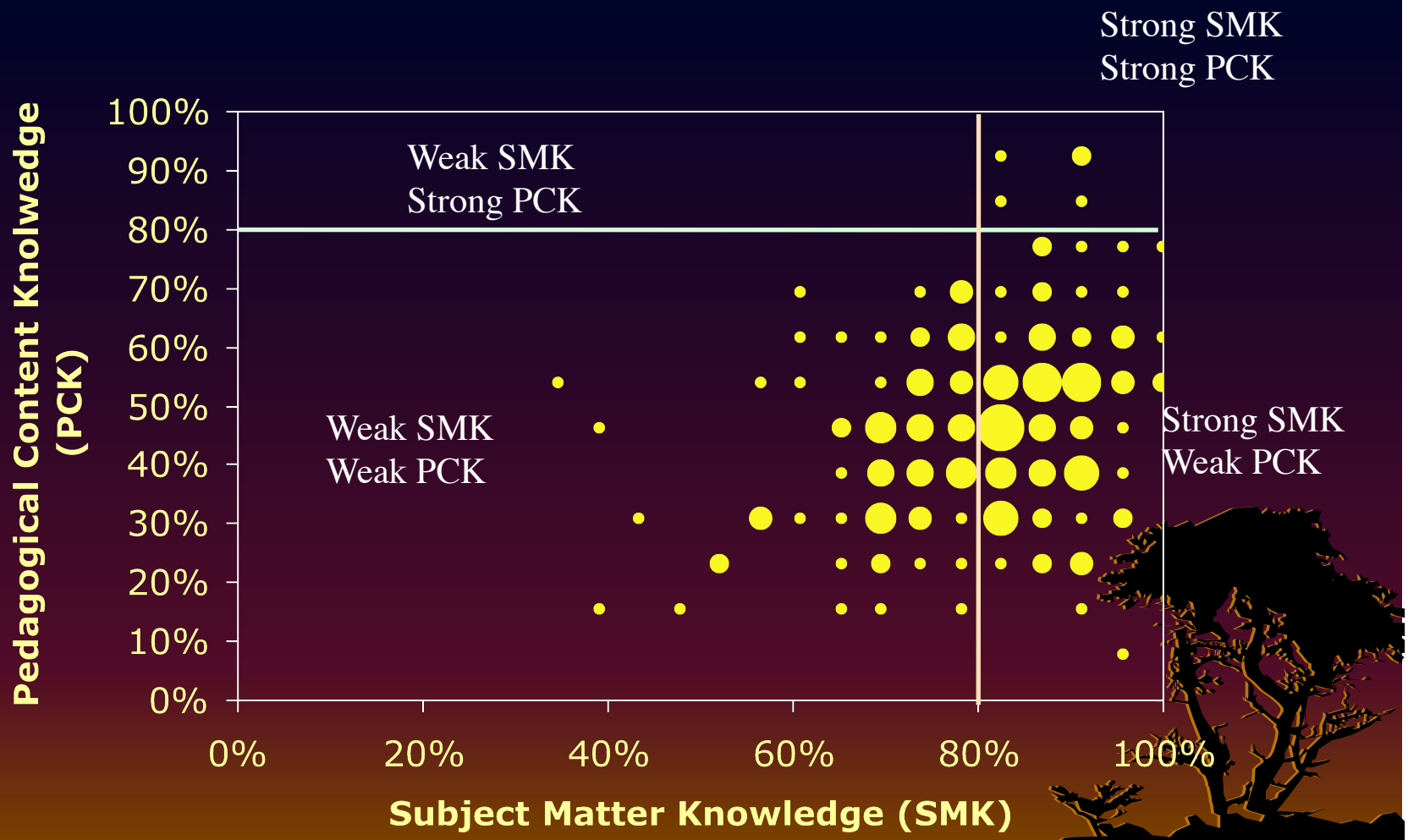
Across Grade Bands



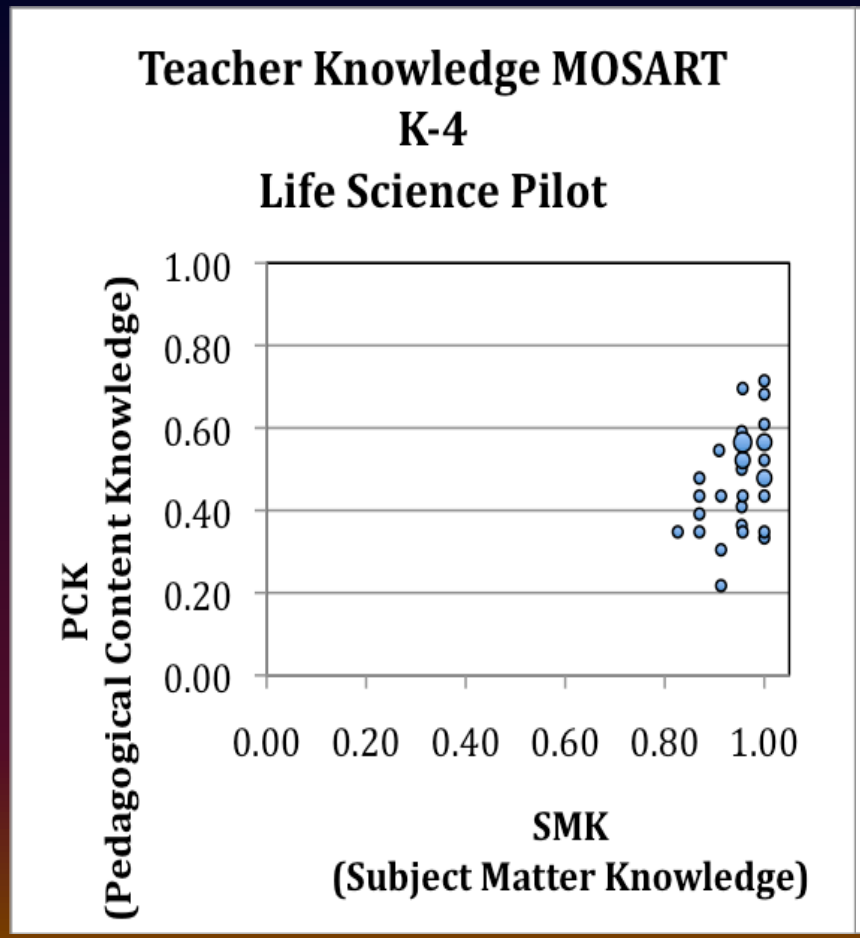
How well do teachers predict student knowledge?

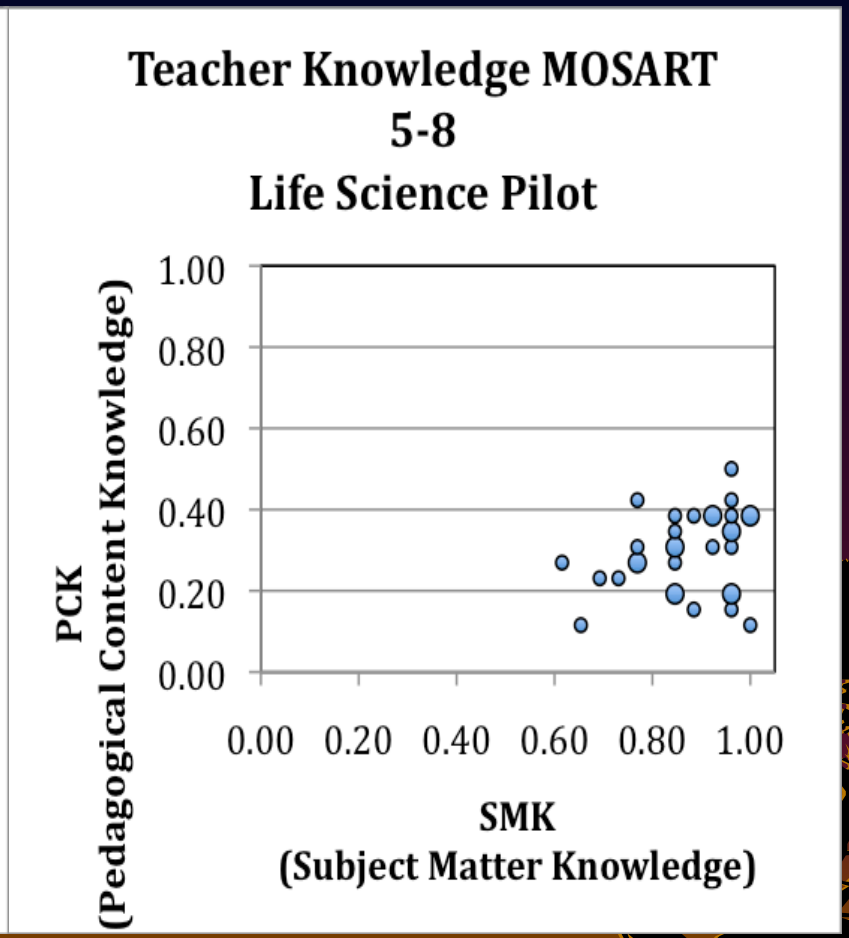


Performance on MOSART Assessment of 196 Middle School Physical Science Teachers

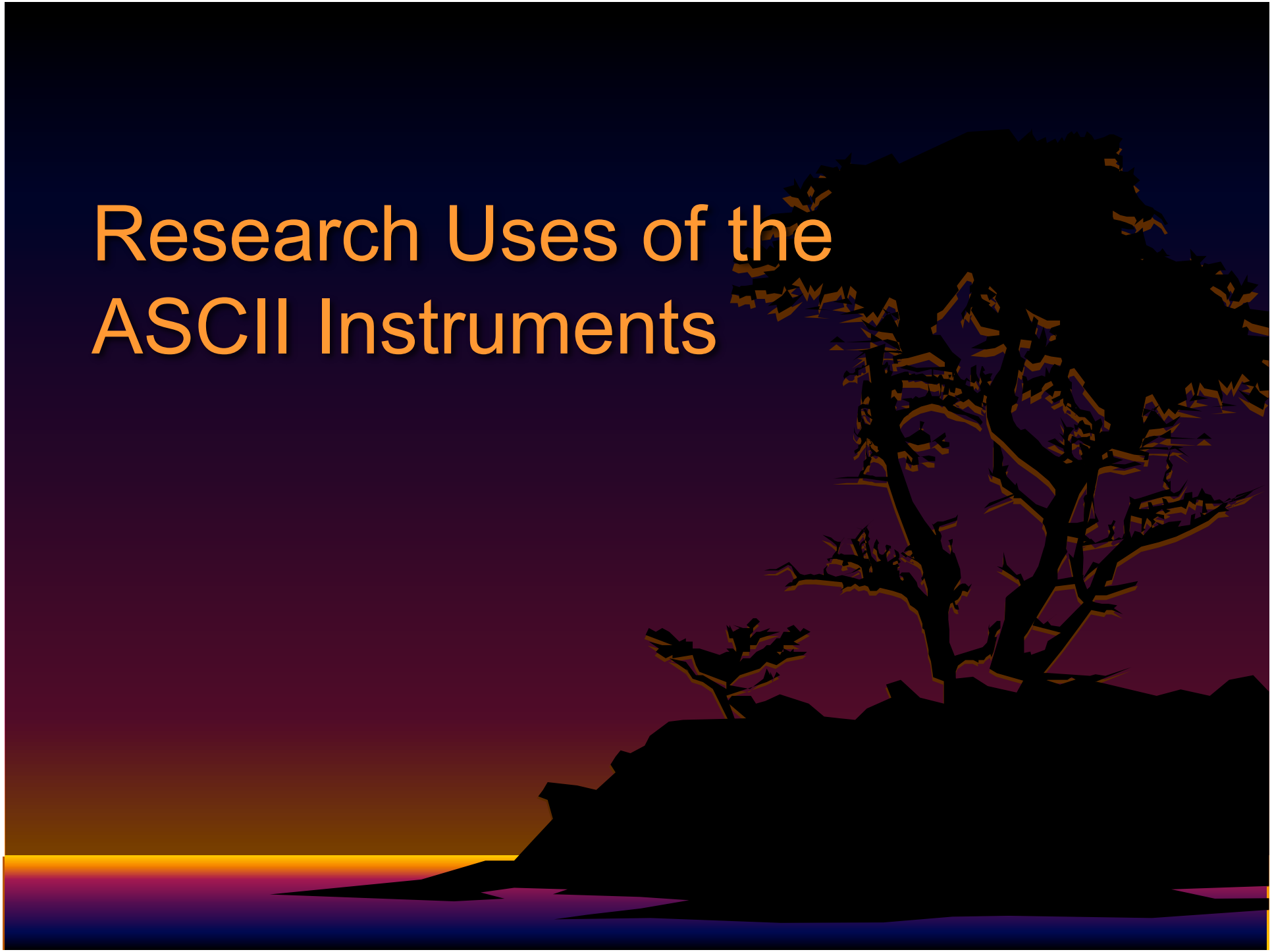


K-4 and 5-8 LS Teacher Knowledge

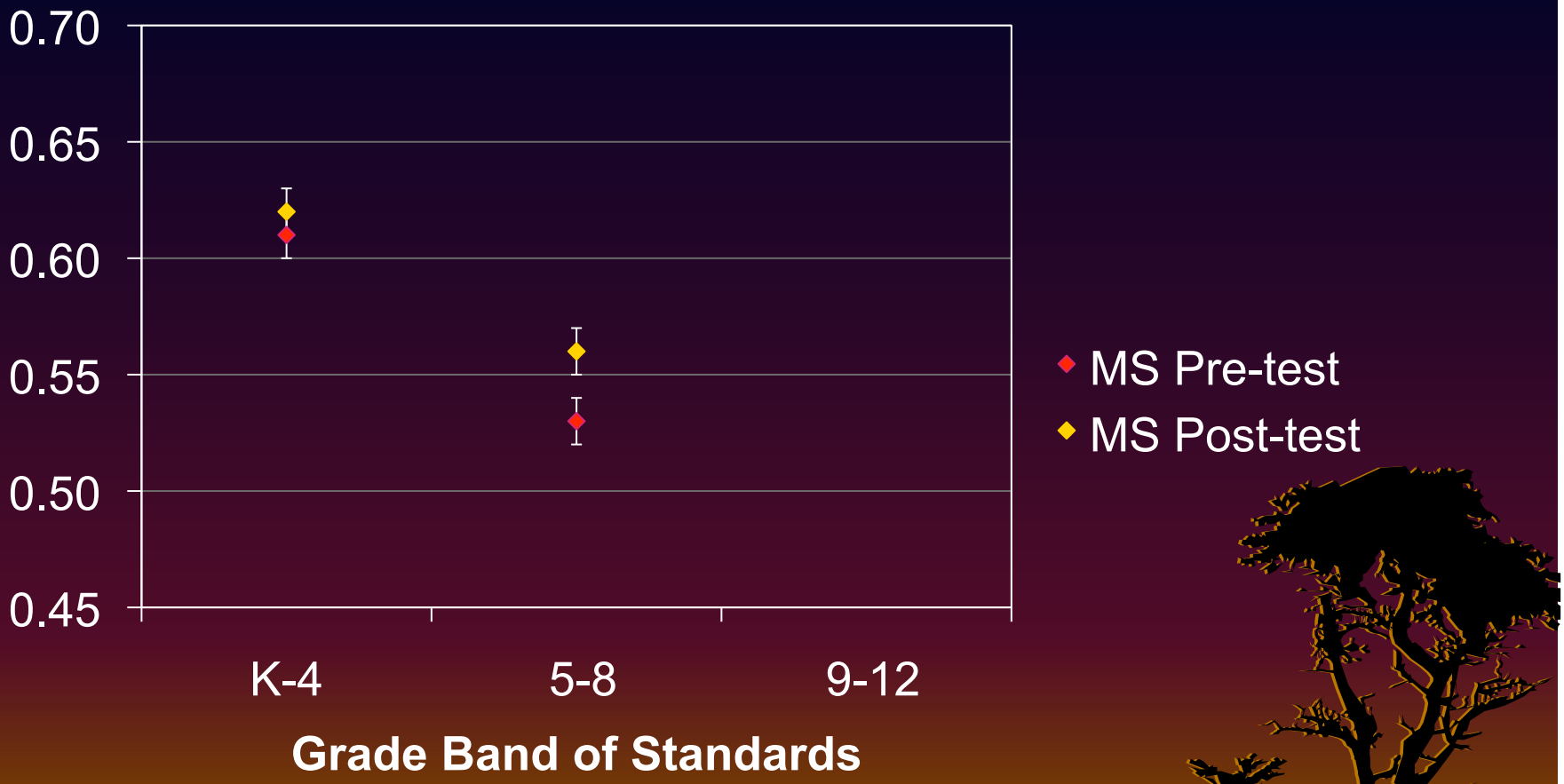




Research Uses of the ASCII Instruments



Results of a Year of Instruction



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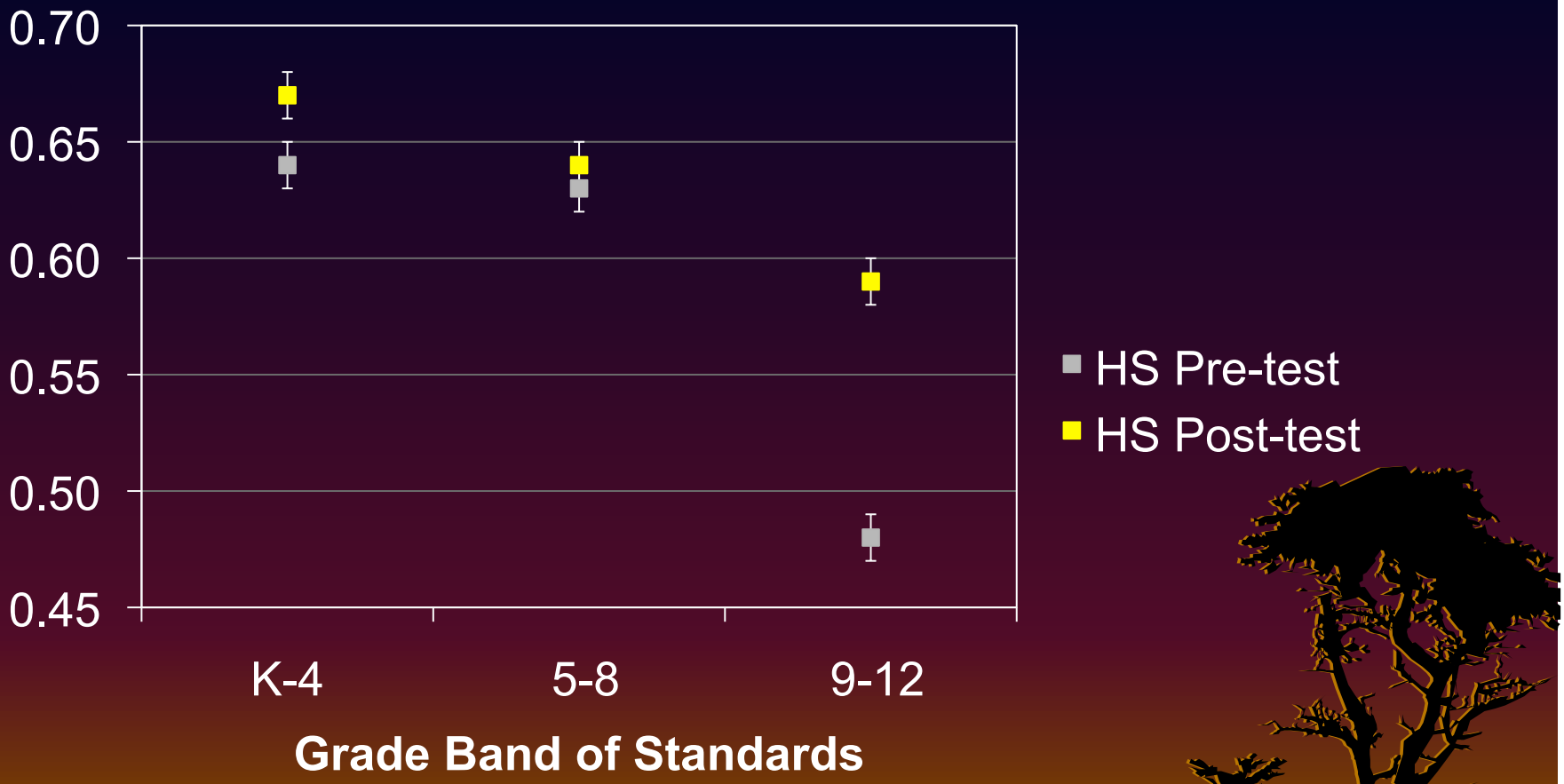
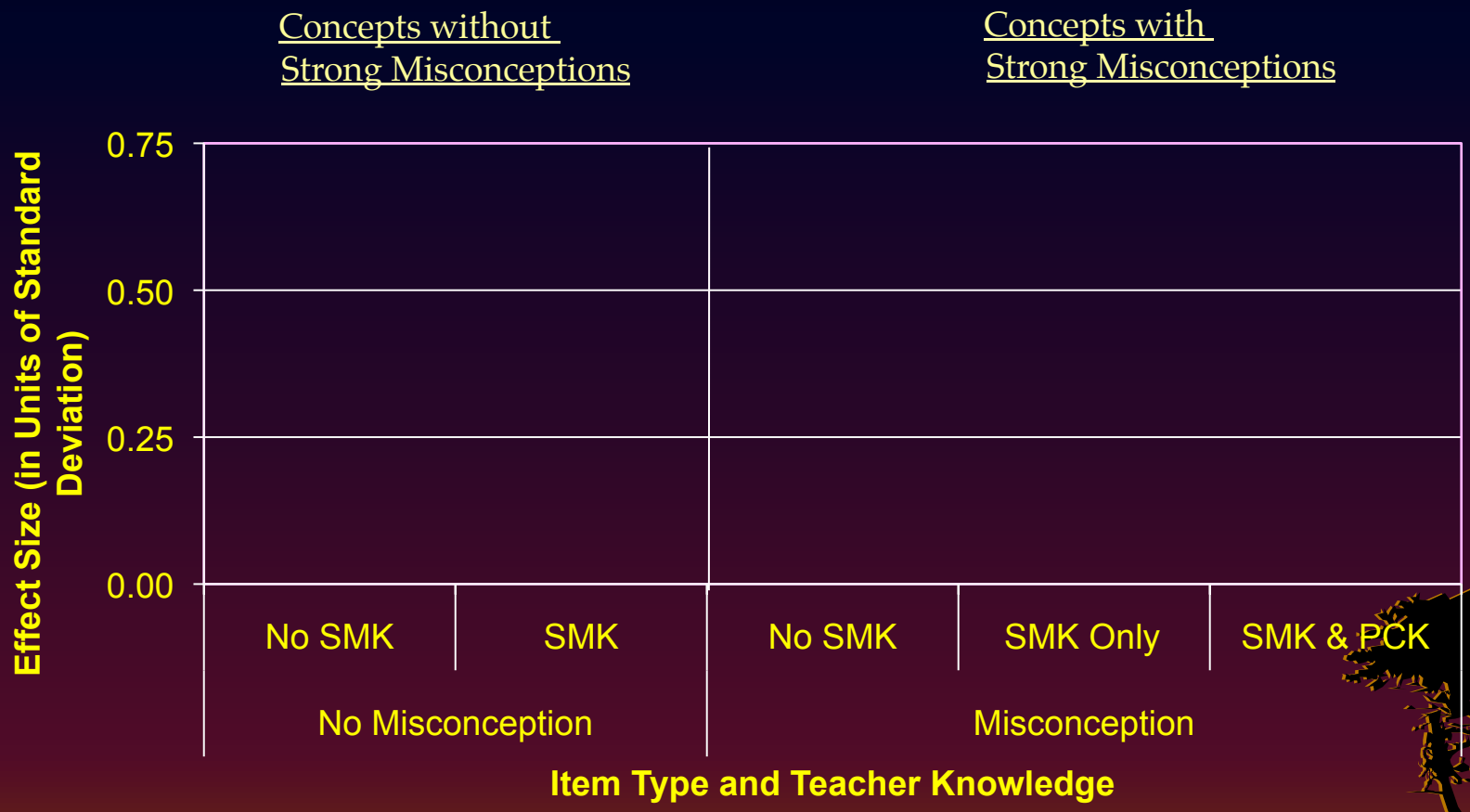


Yearly Classroom Gain in Middle School Physical Science Courses, N= 15029 students of 160 teachers



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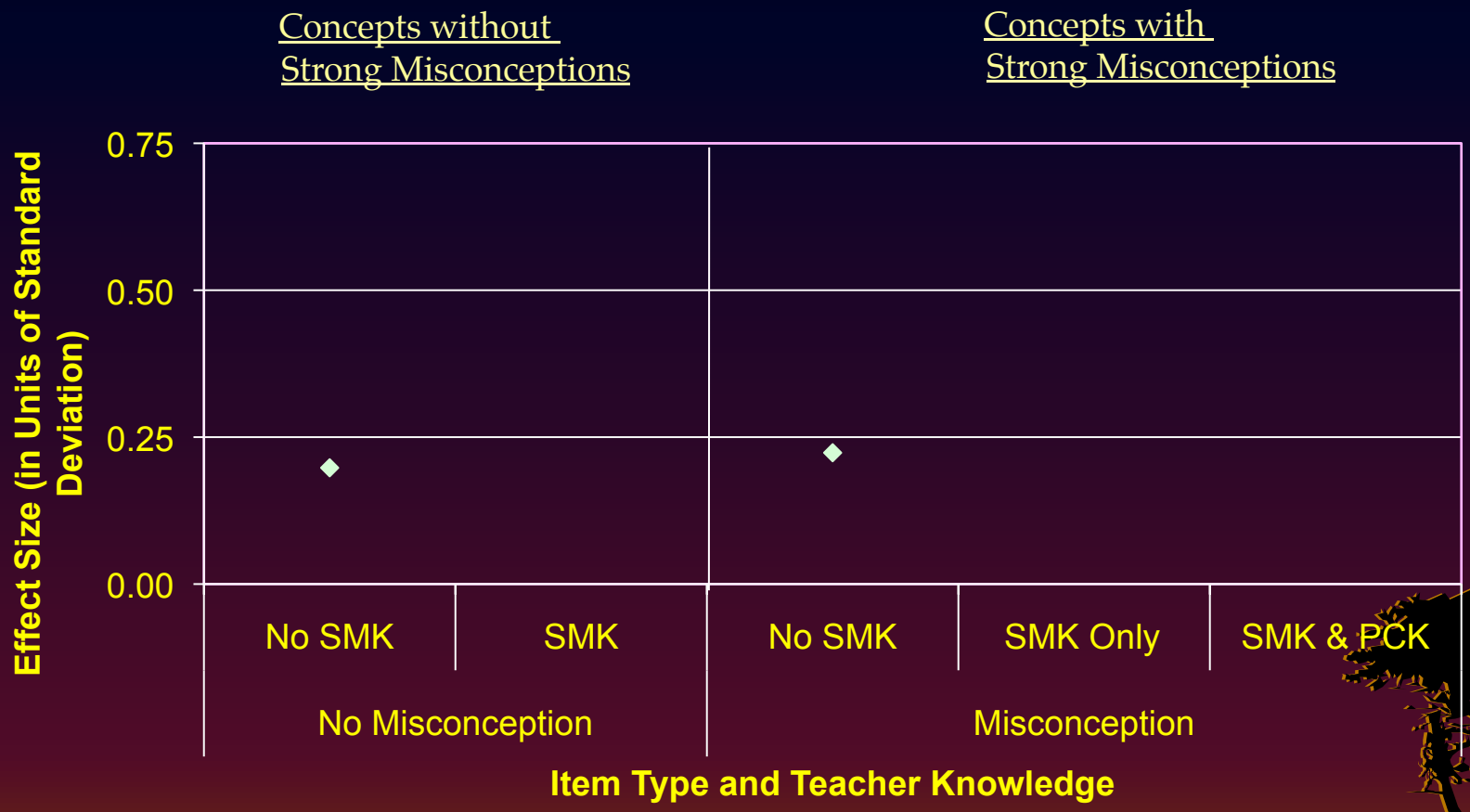

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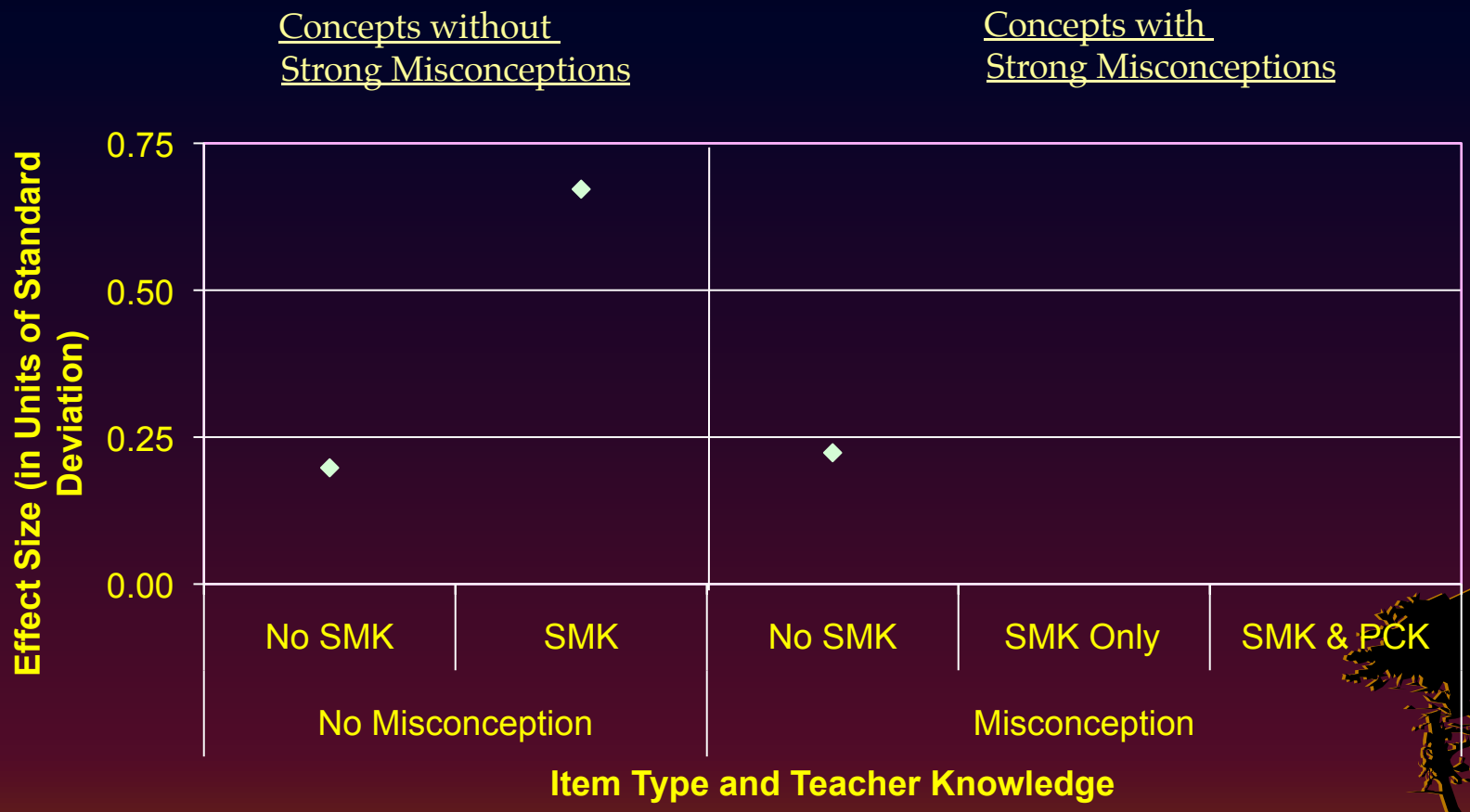

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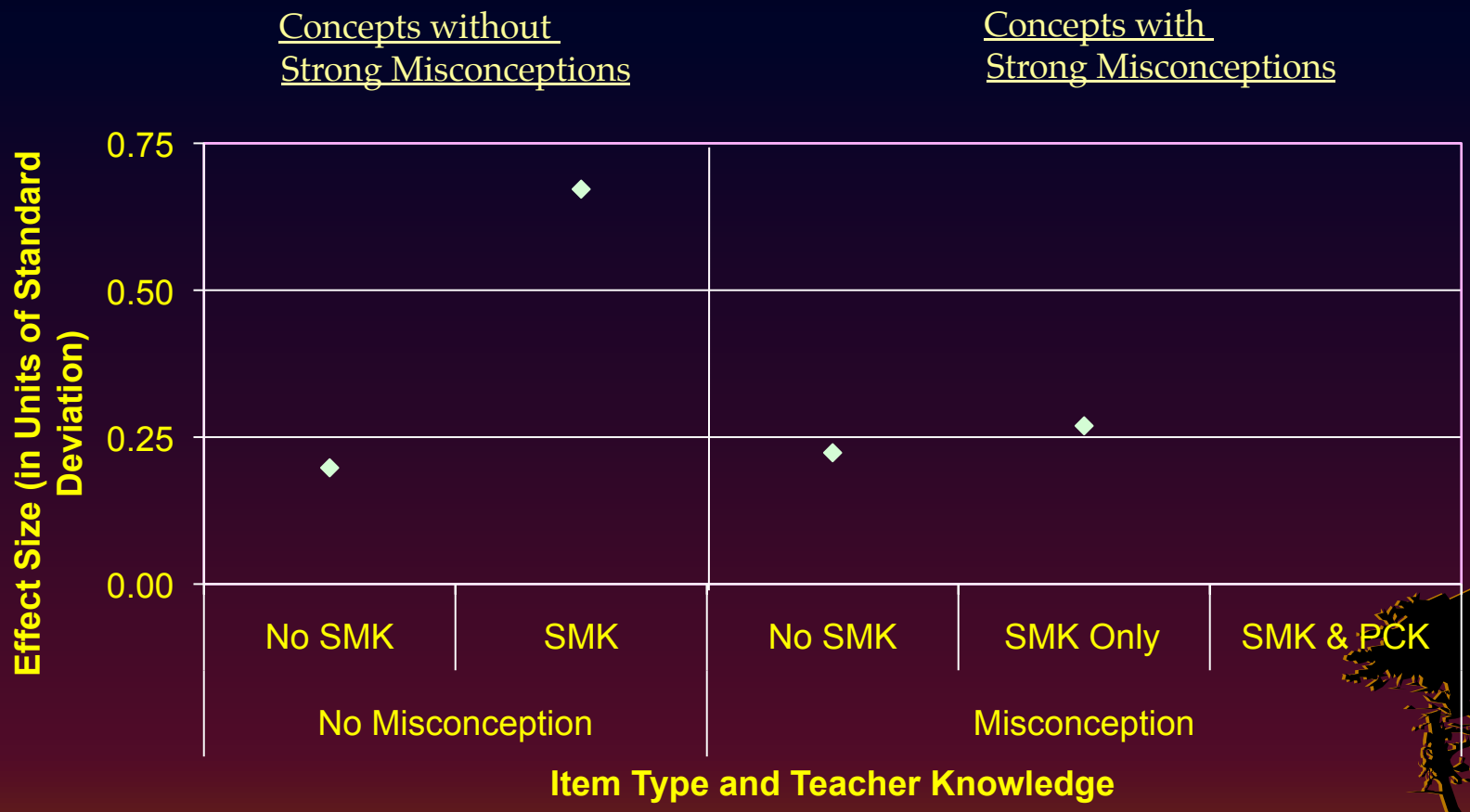

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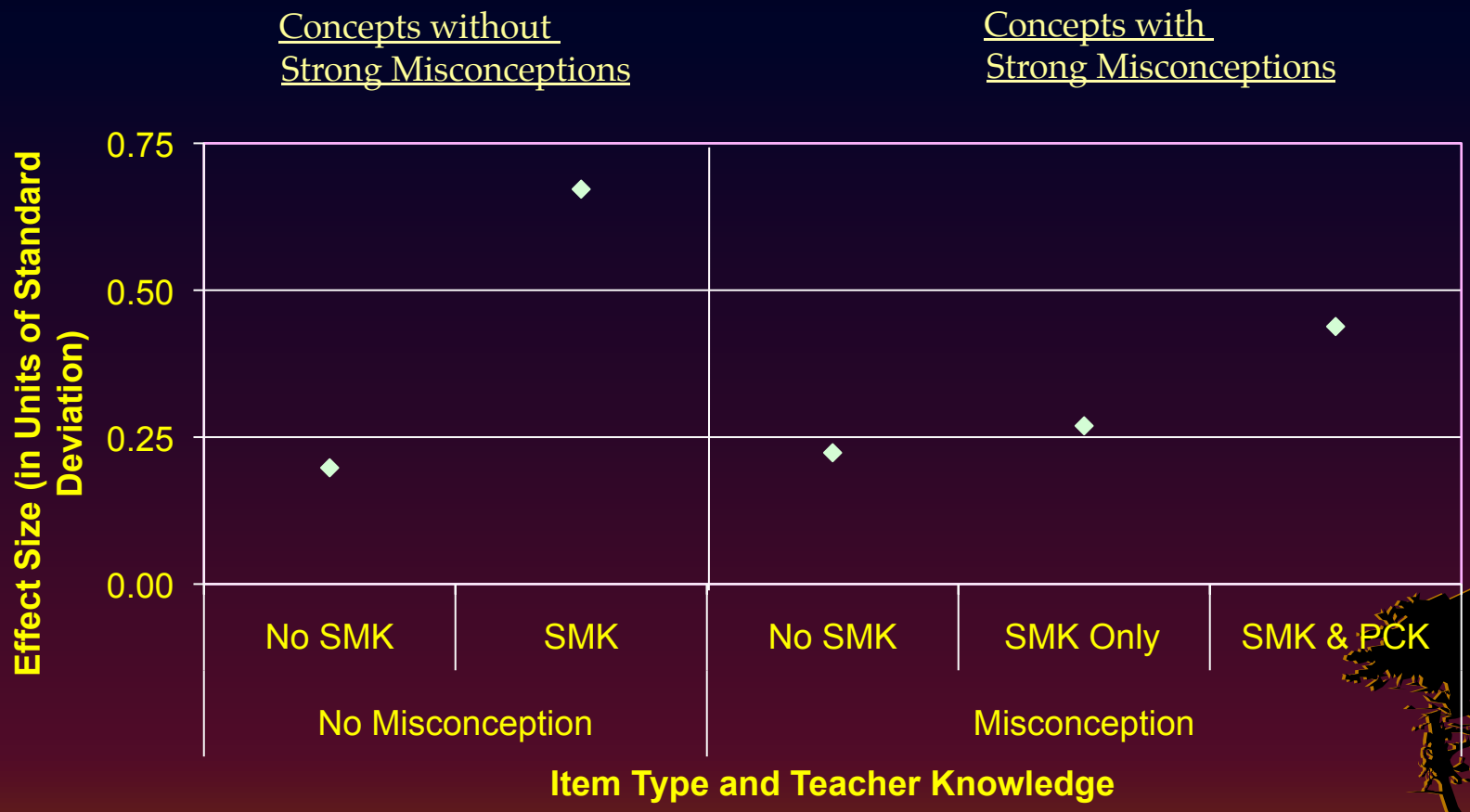

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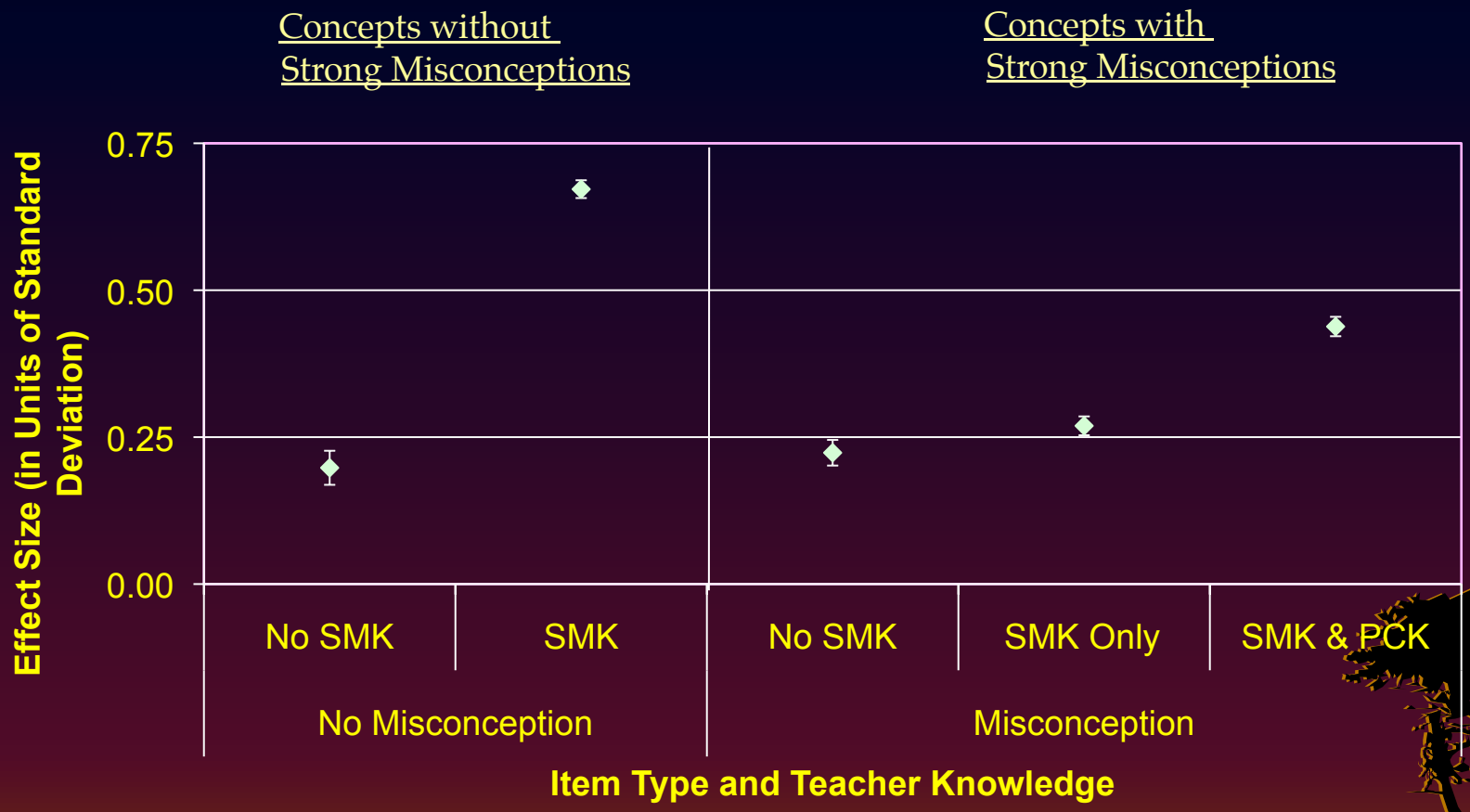


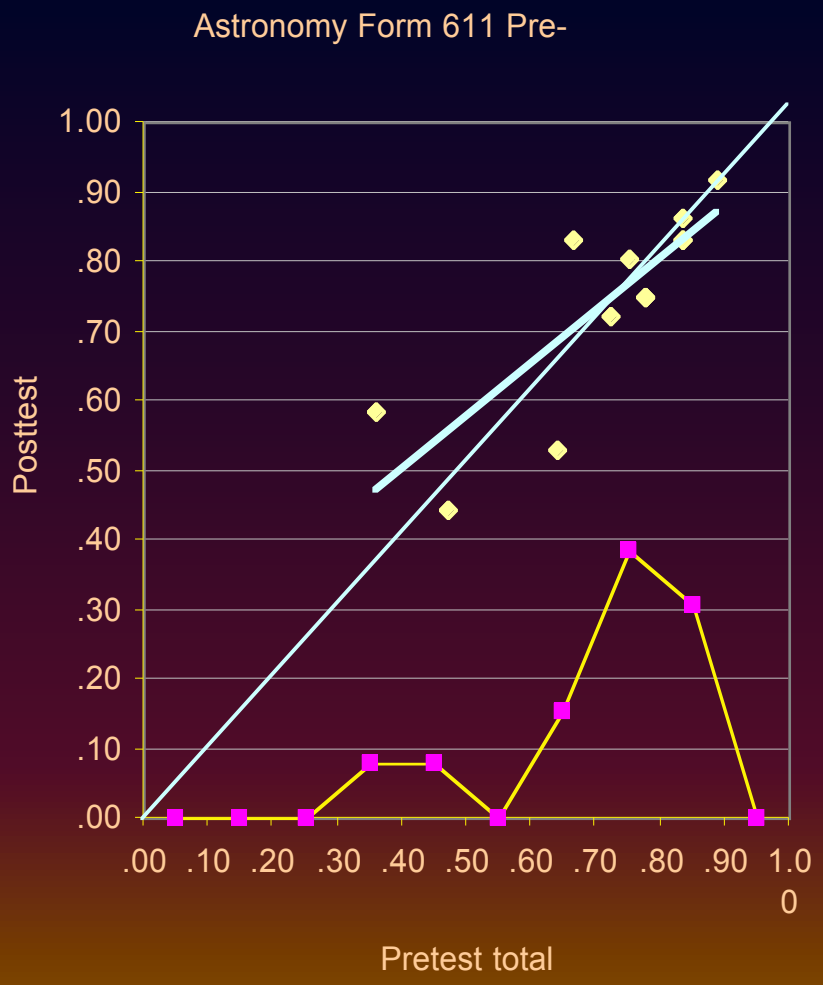
SMK=Subject Matter Knowledge (knows correct answer)
PCK=Pedagogical Content Knowledge (can identify student misconceptions)

Results of Teacher Professional Development

1-Week Astronomy Institute

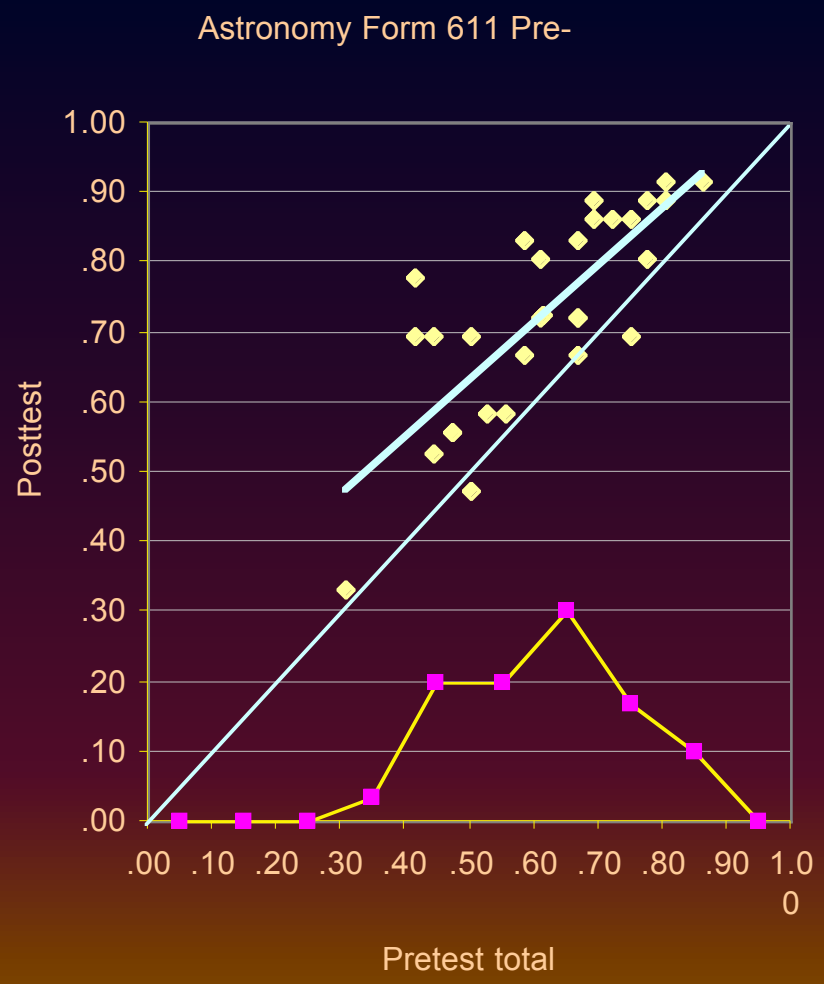
- Instrumentation
- Earth-Sun connection only
- Only relevant items
- Speakers
- Activities
- Observing

1-Week Astronomy Institute



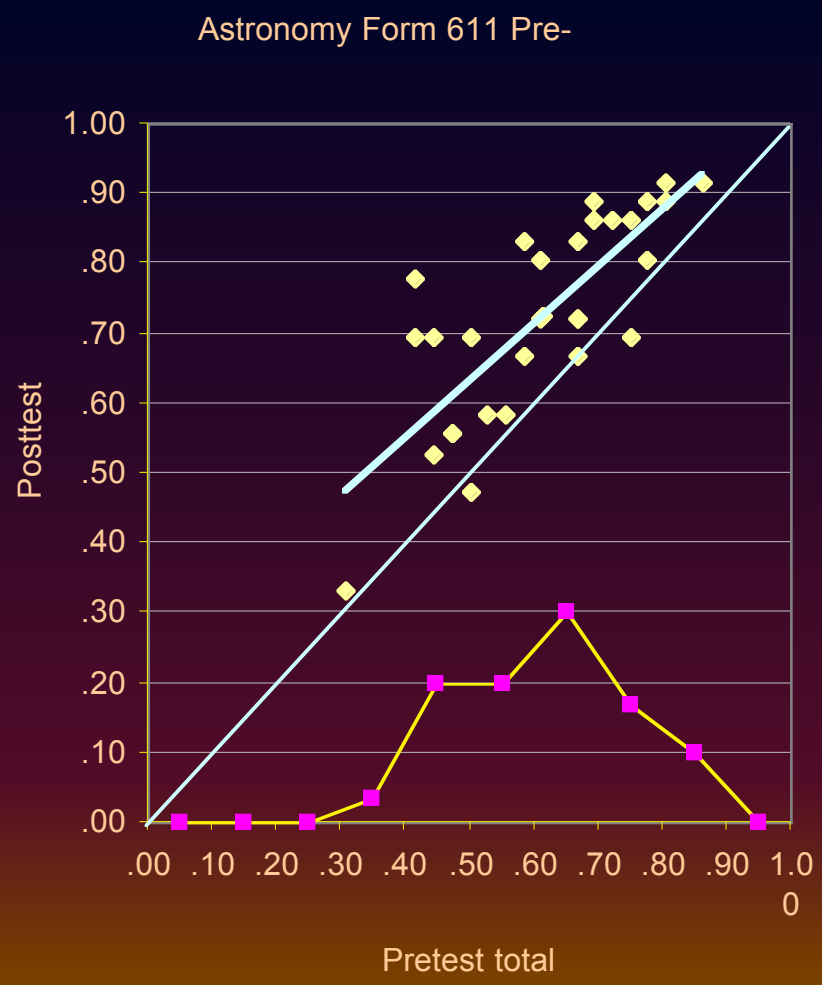
- Learn to use professional instrumentation
- Disciplinary domain focus
- Speakers

2-Week Astronomy Institute



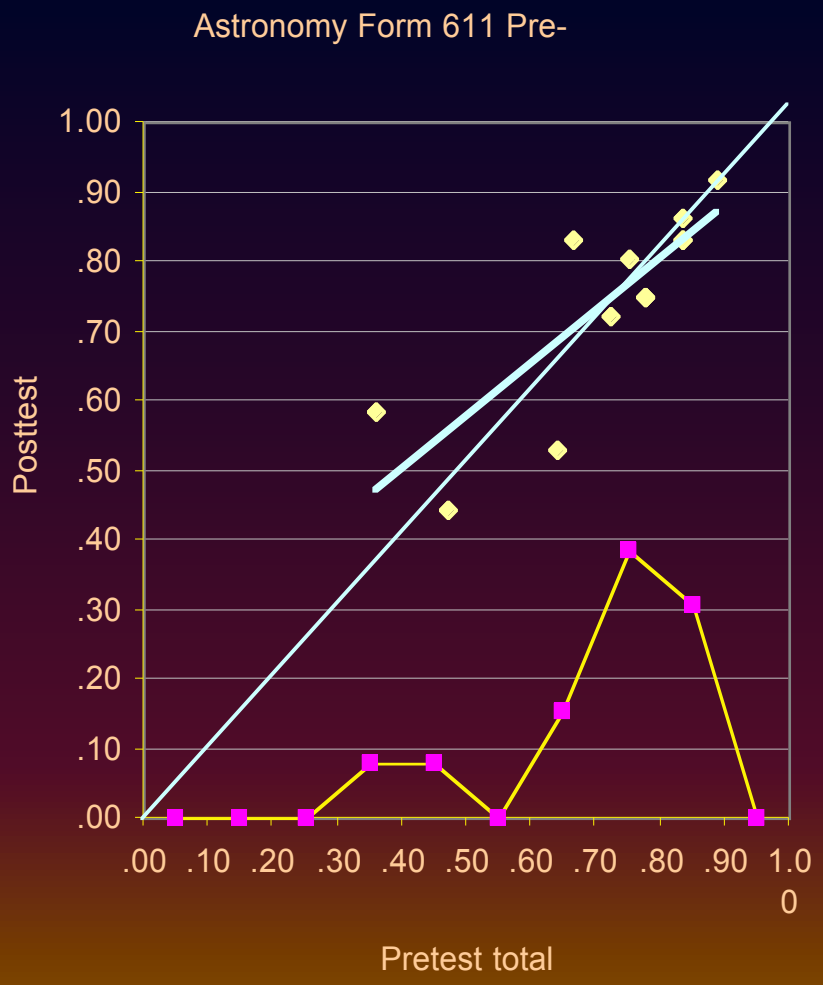
- Basics
- To boost astronomy background
- General astronomy test
- Speakers
- Activities
- Observing

2-Week Astronomy Institute



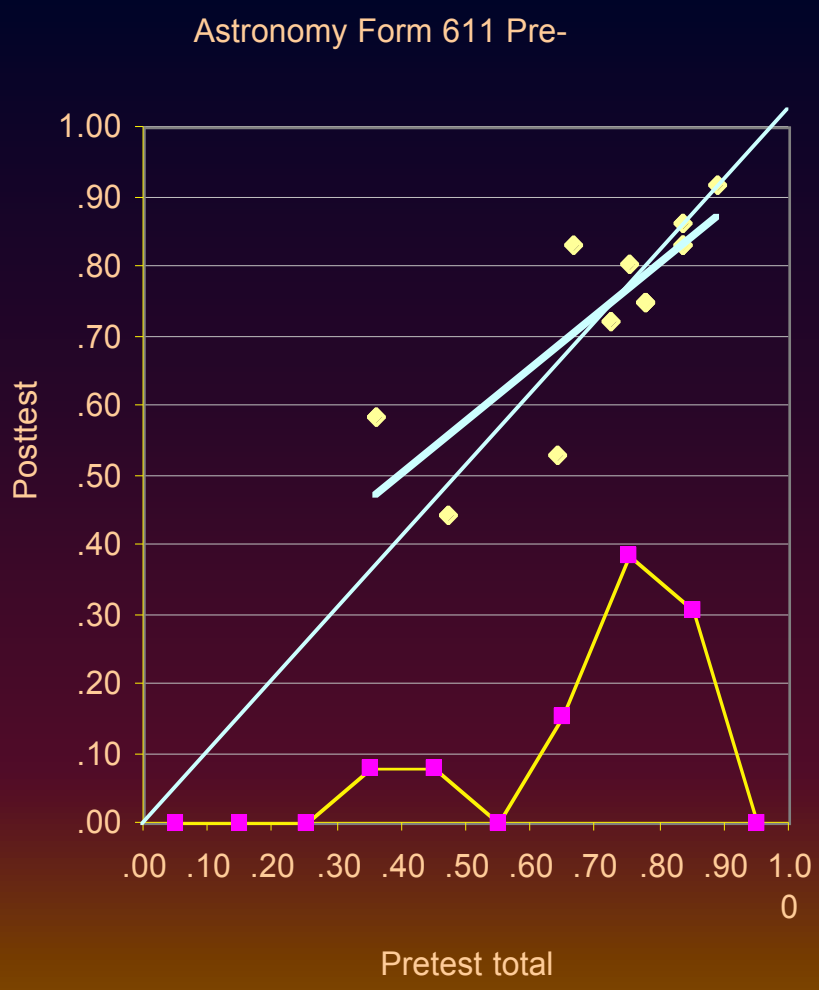
- Moderate initial knowledge
- Gains at all levels of teacher knowledge
- Few teachers with no or negative growth

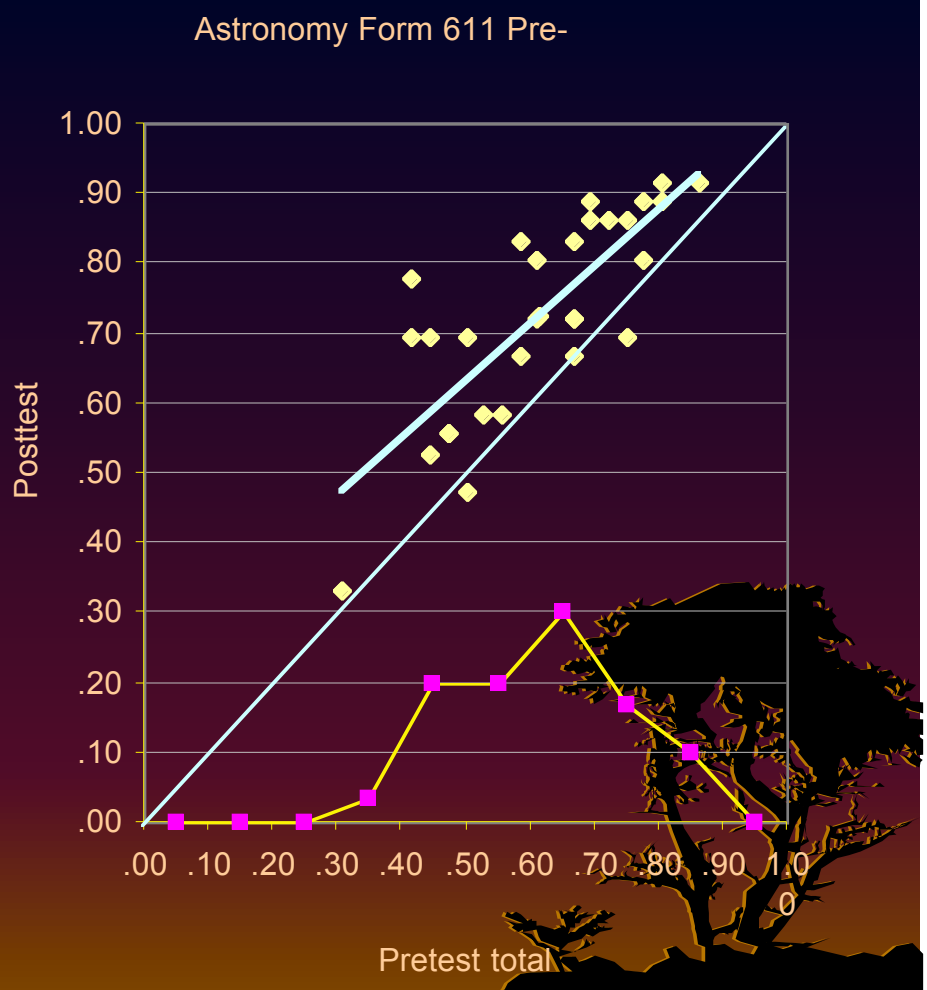
1-Week Astronomy Institute



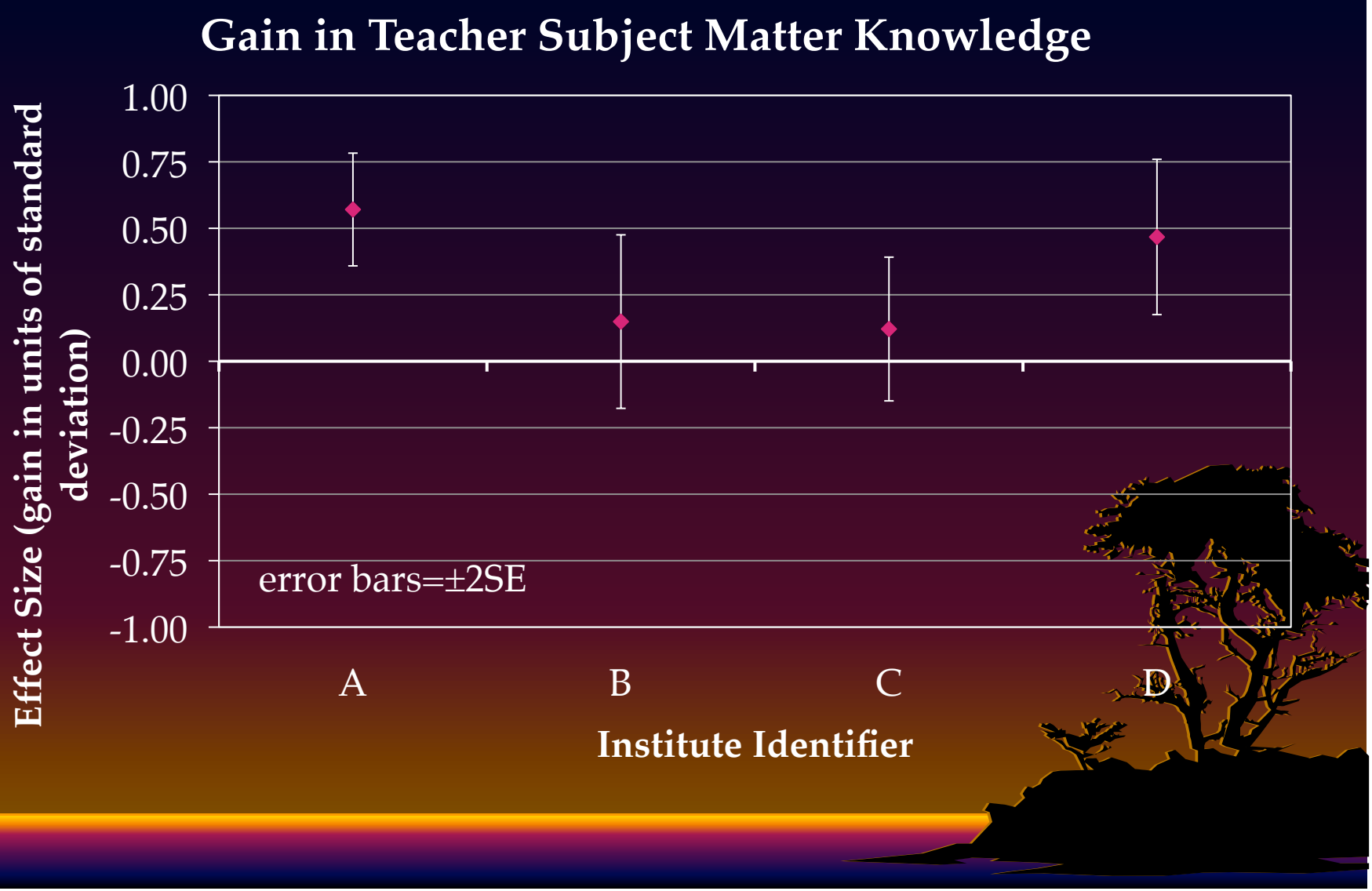
- High initial knowledge
- No gains at highest level of teacher knowledge
- Many teachers with no or negative growth

Comparison of 2 MSP Institutes



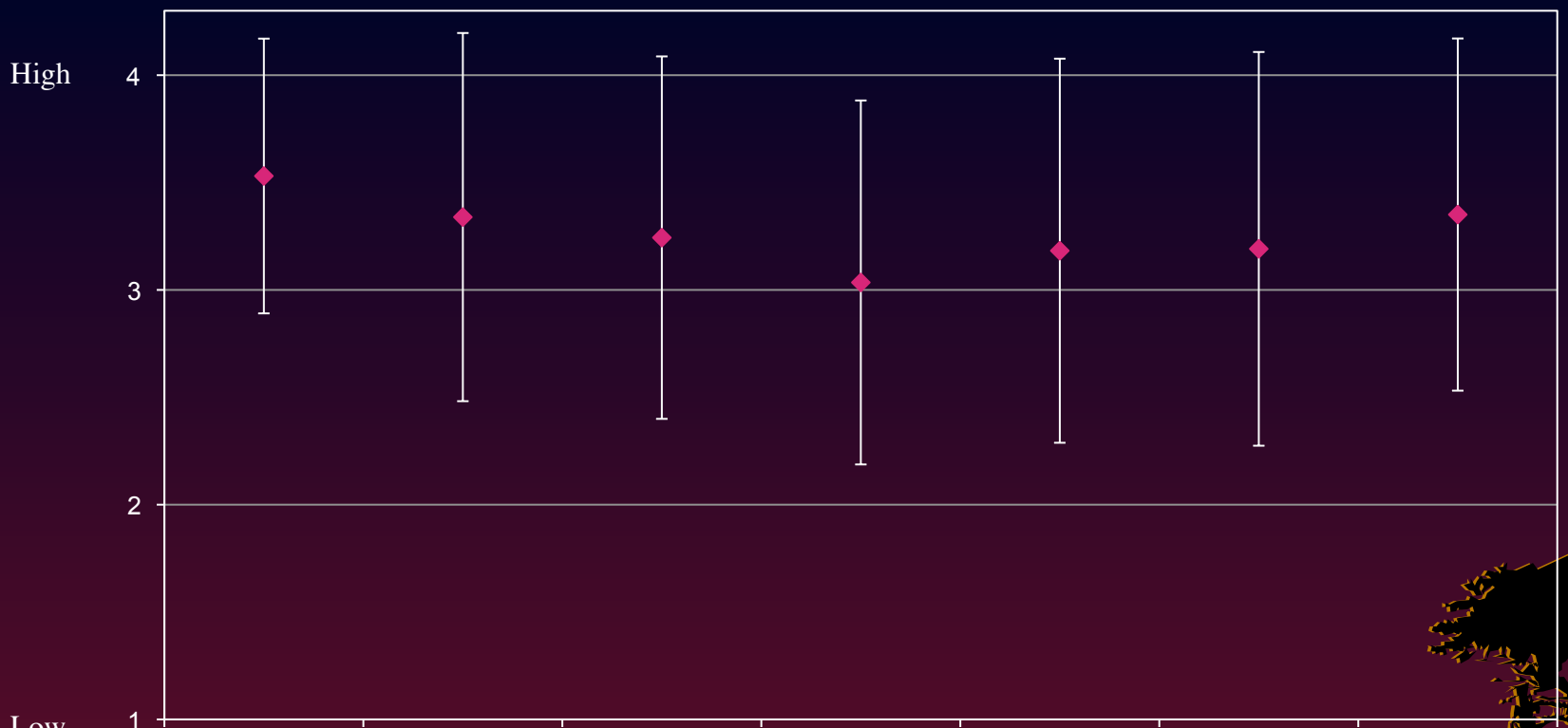


Astronomy Institutes, SMK

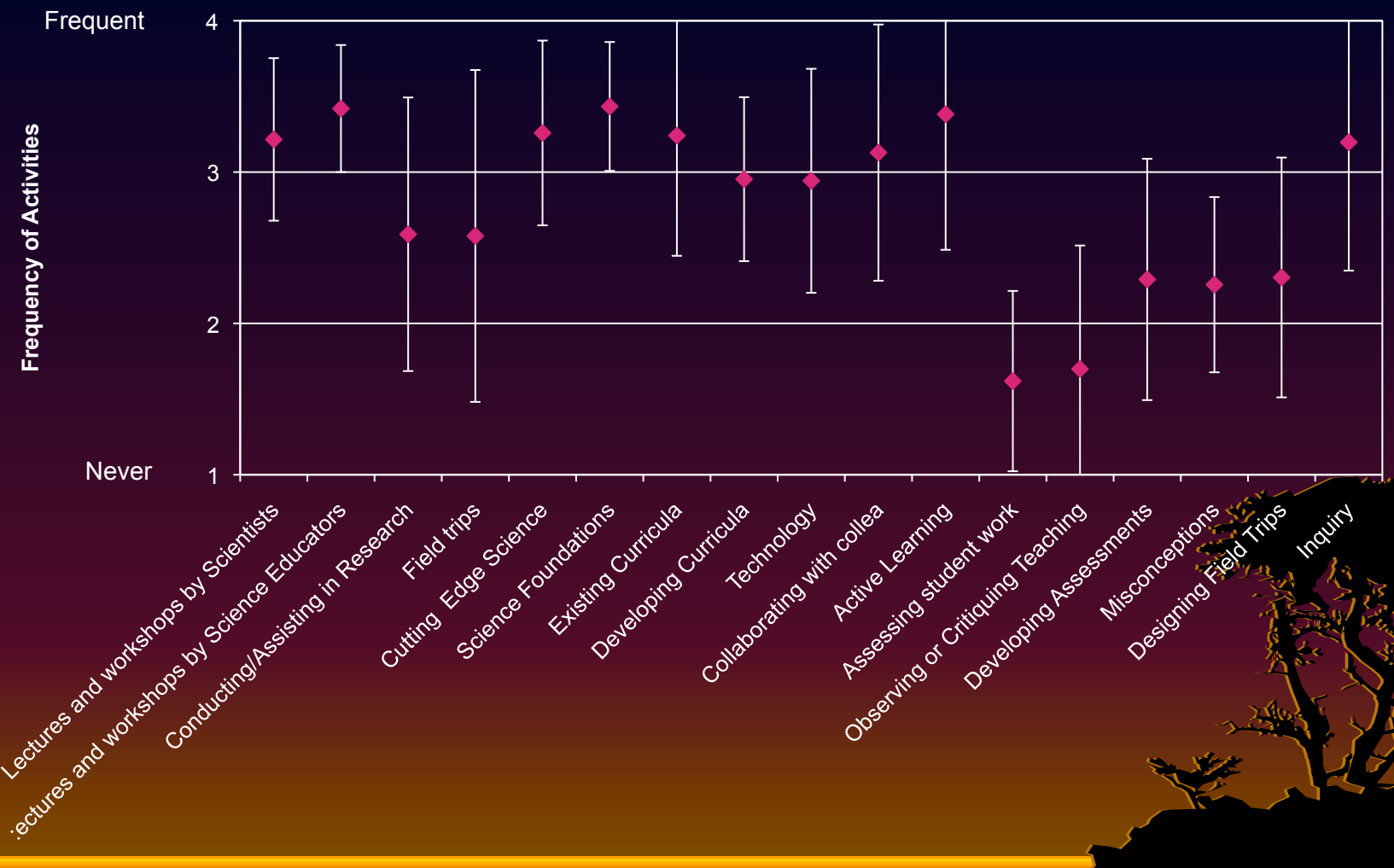


Next Steps: Attribution of Gains to Institute Attributes

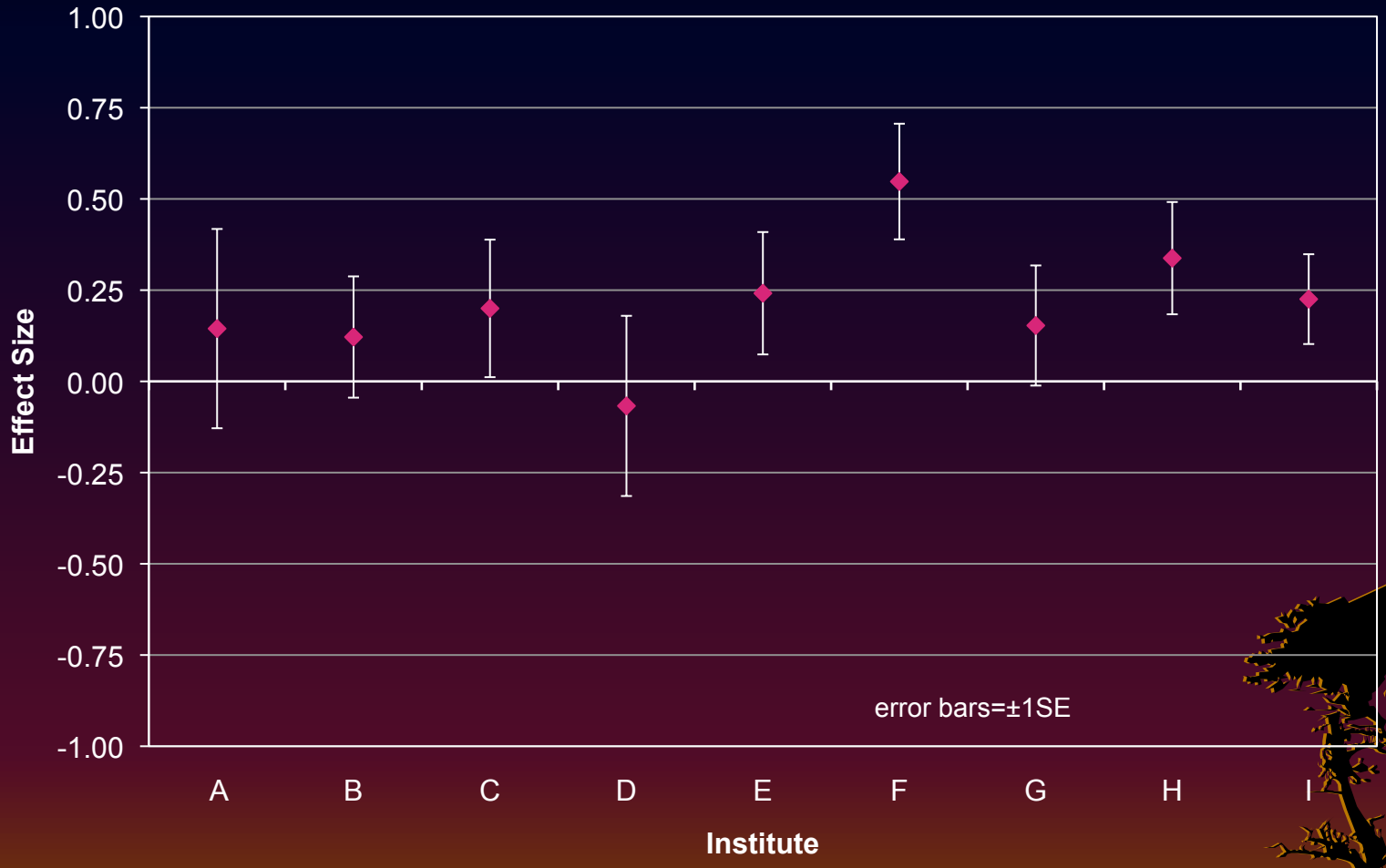
Teacher Views of Effectiveness



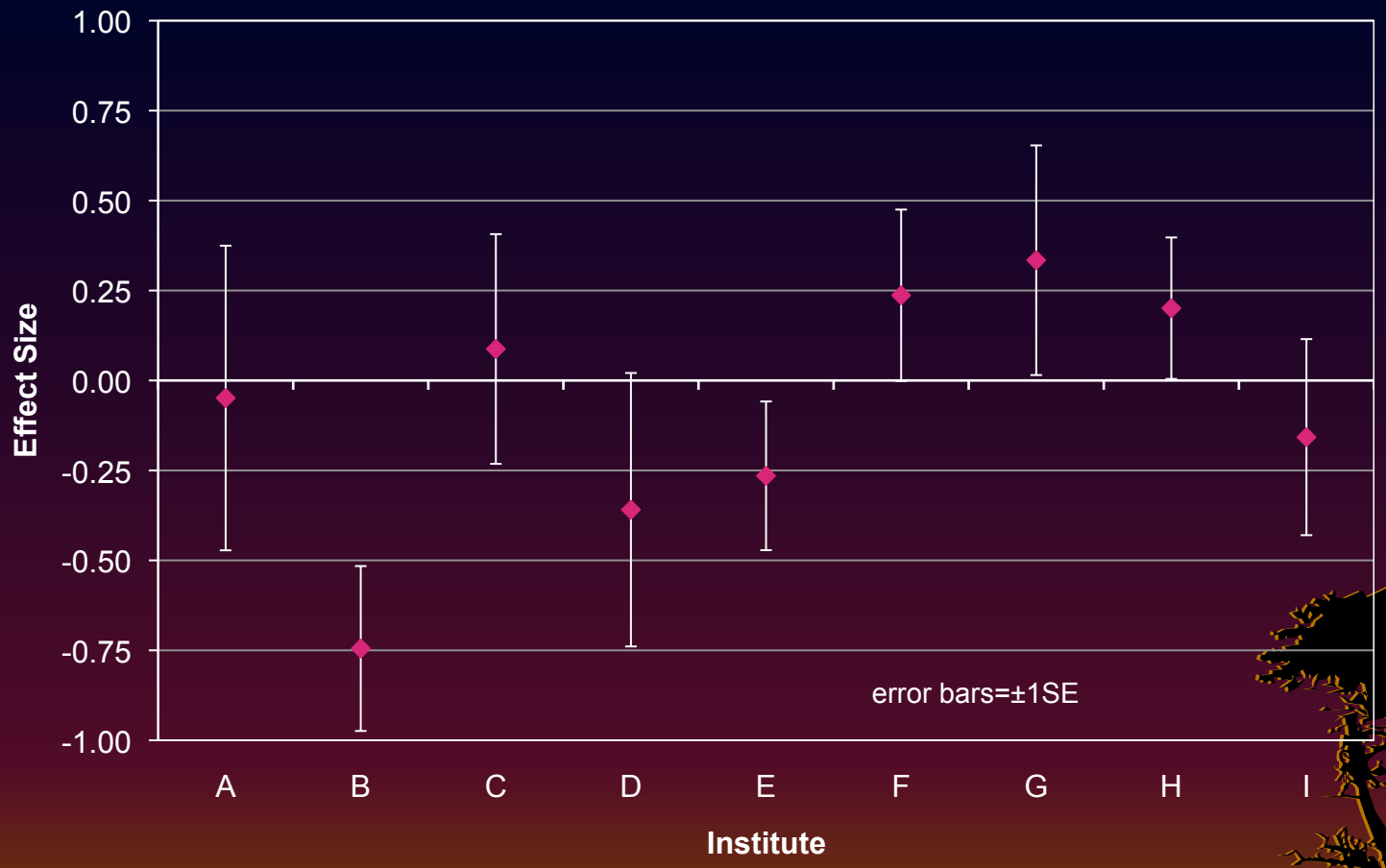
Variation in Institute Activities Institute-level



Growth in Teachers' Subject Matter Knowledge
Middle School Life Science Summer Institutes, N=113, 11/17/10



Growth in Teachers' Pedagogical Content Knowledge
Middle School Life Science Summer Institutes, N=113, 11/17/10

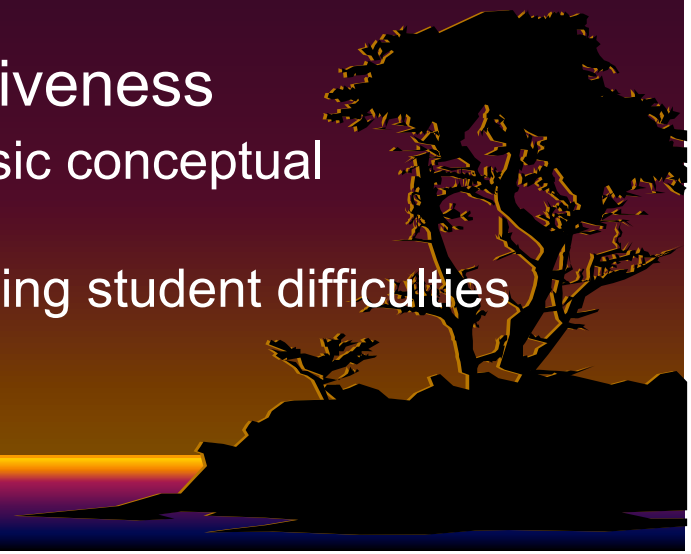


Assessment and PD

For each standard at each level

- Students have not achieved mastery
- Teachers generally overestimate student knowledge.
- Teachers know far more than their students
- Teacher knowledge is a not a guarantee of student knowledge
- Subject do much better on items if misconceptions are not a choice

- SMK and PCK not highly related to each other
  - Both predict performance
- PD can have varying degrees of effectiveness
  - Advanced activities have little effect on basic conceptual understanding
  - Experience has little impact on understanding student difficulties

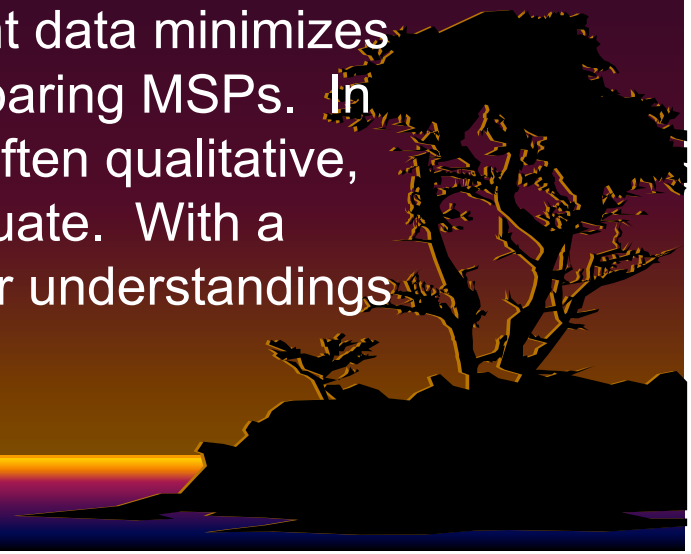


Key Findings

- Institutes vary in the pre-post gains made by teachers in both SMK and PCK.
- Length of time spent on various participant activities, rather than more formal (passive) learning, improves both SMK and PCK.
- Students taught by teachers who have SMK are more likely to change their conceptions than students of teachers who do not know the correct response.
- Students of teachers who accurately predict the most common incorrect response to an item are more likely to reject that conception and embrace the scientifically correct response.

Key insights that have value for the Learning Network

- With our new online testing system, we expect to provide early useful pre-test results to participating MSPs. The first report will be a “diagnosis” of participants’ areas of strength and weakness.
- The use of MOSART assessments will allow us to compare the gains made by one institute's participants to other institutes targeting the same content and thus facilitate the sharing of practices.
- Using robust, technically validated assessment data minimizes the problems of “apples and oranges” in comparing MSPs. In addition, entirely idiosyncratic measures are often qualitative, and may be biased, as well as difficult to evaluate. With a common evaluation suite, NSF can gain better understandings of what MSPs are accomplishing.



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2. Ward, R. B., Sadler, P.M., & Shapiro, I.I. (2007). Learning Science Through Astronomy Activities: A Comparison Between Constructivist and Traditional Approaches in Grades 3-6. *Astronomy Education Review*, 6(2), 1-19.
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4. Schwartz, M., Sadler, P.M., Sonnert, G., & Tai, R.H. (2009) Depth Versus Breadth: How Content Coverage in High School Science Relates to Later Success in College Science Coursework. *Science Education*, 93(4), 798-826.
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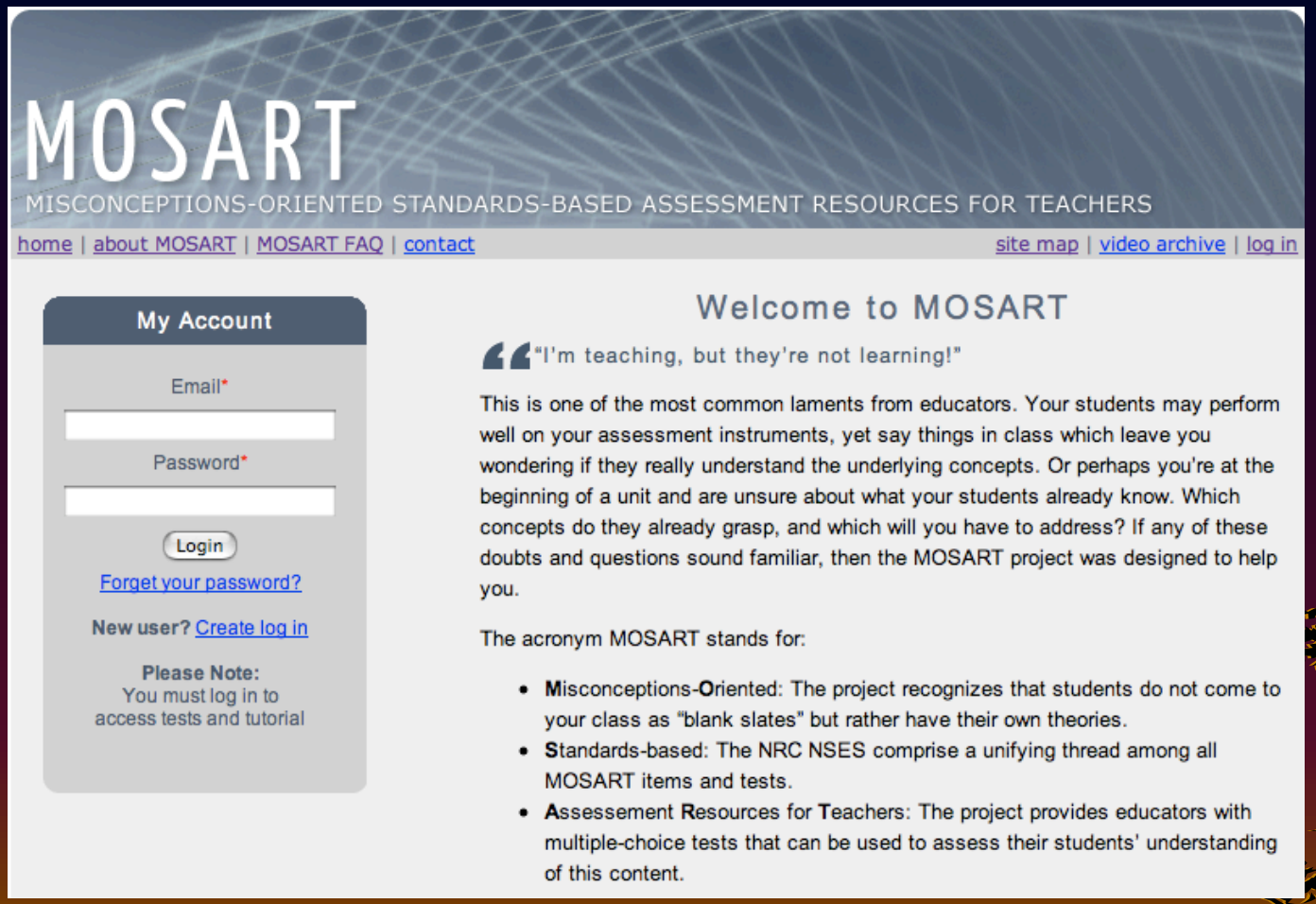
MOSART Website

www.cfa.harvard.edu/smgphp/mosart



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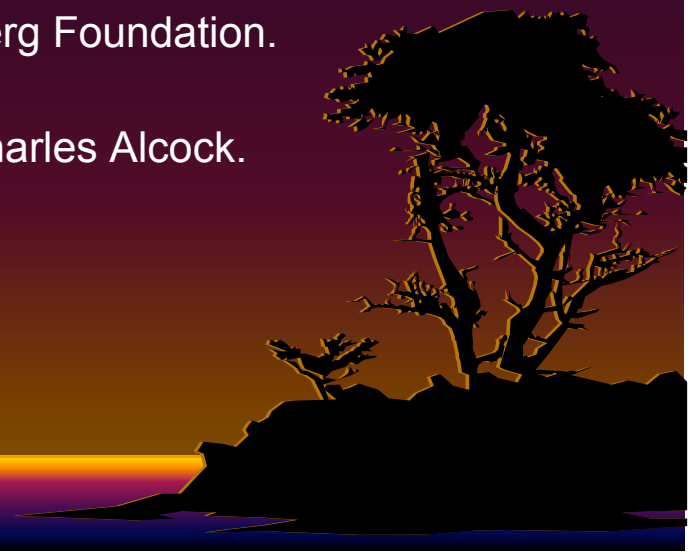

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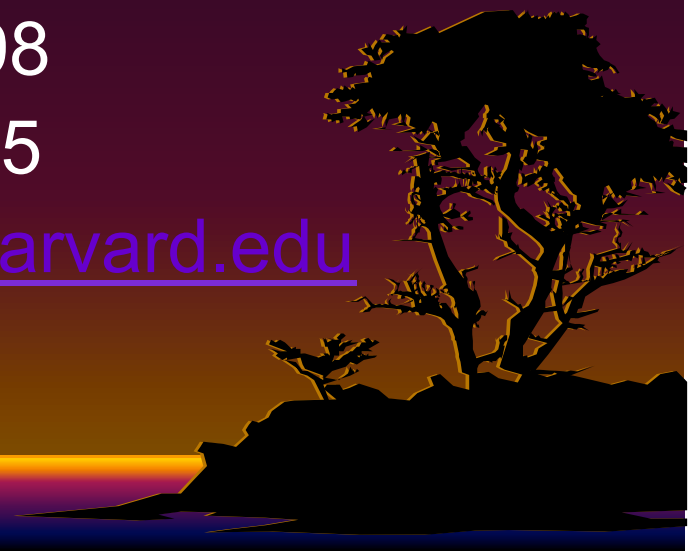
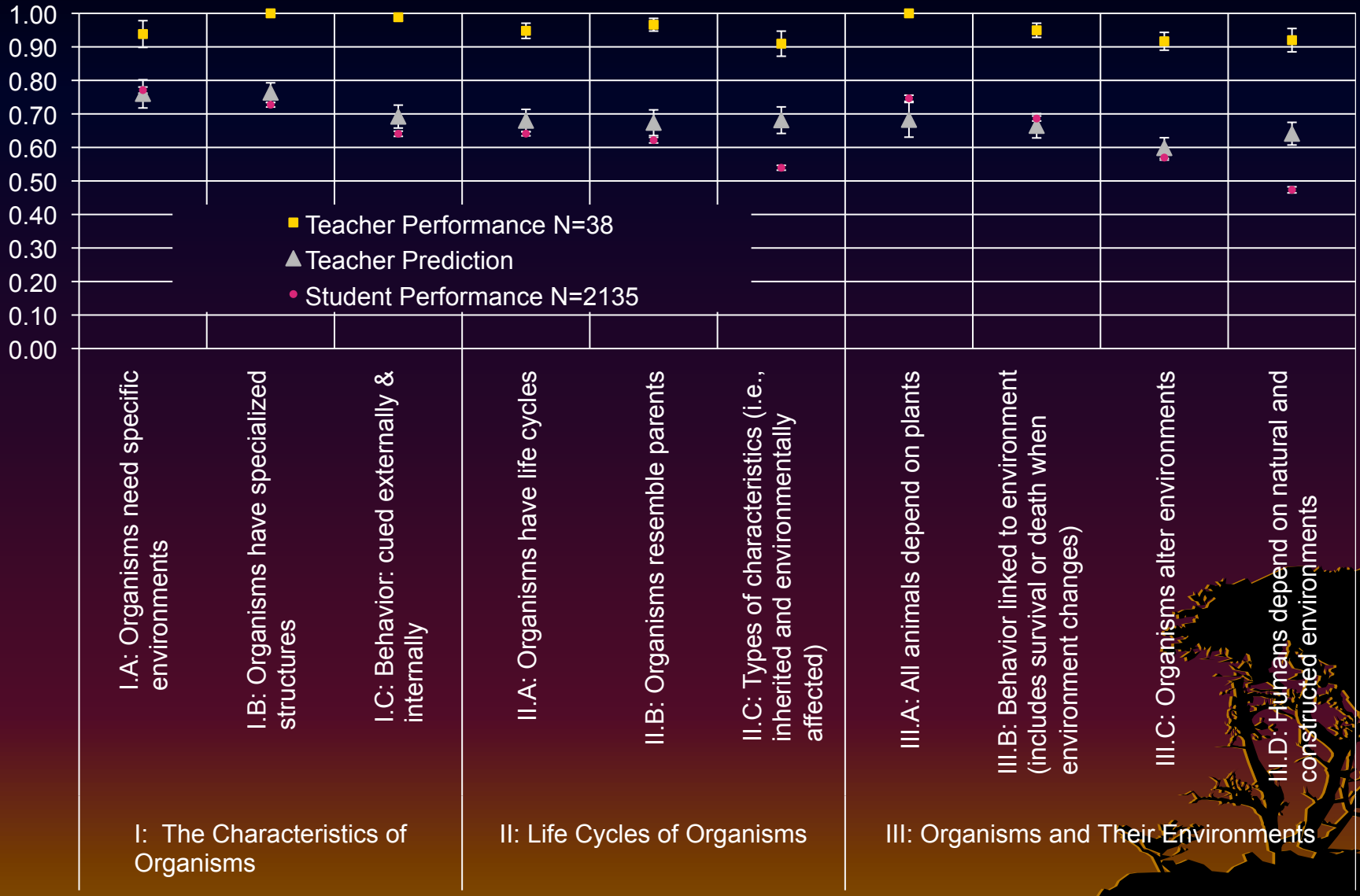


K-4 Life Science Standards



Multiple Topics and Levels, SMK