

Design Principles for Scaffolding Reflection and Argumentation in Science

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Knowledge Integration Environment

The screenshot shows a Netscape browser window with the title "Netscape: KIE Evidence: Galaxies in the Young Universe". The main content area has a light blue background and features the text "KIE Evidence" in a large, serif font, underlined. Below this is the title "Galaxies in the Young Universe" in a smaller, bold serif font, followed by "by other... Scientist". A paragraph of text explains that scientists use telescopes to see stars that are hard to see with the naked eye. Below the text is a list of three bullet points:

- **On the left** is a picture of the night sky taken with a camera, which is similar to looking up at the sky with your eyes. A small square is used to highlight a dark part of the sky where not many stars are visible.
- **In the middle** is that same highlighted part of the sky as seen with the Hubble telescope.
- **In the upper right** there is an enlargement of part of the middle picture.

At the bottom of the text area is a small image showing a night sky with a bright star and a small square highlighting a region. To the right of the main content area is a sidebar with several sections:

- KIE Tools**: A section with a "CHECKLIST" for a "Project" titled "How Far Does Light Go". It lists activities: "Look at Theories", "Survey Evidence", "Create Evidence", "Add Frames", "Plan for Debate", and "Class Debate". There are "Details" and "Done ✓" buttons.
- PLACES**: A section with icons for "Mildred SenseMaker" and "SpeakEasy Documents". There is a "Save from Net" button.
- TOOLS**: A section with icons for "Netscape" and "Works".
- EXIT**: A section with a green "EXIT" button and a "Log-Out" button.

The browser's address bar is empty, and the status bar at the bottom shows various system icons.

<http://www.kie.berkeley.edu/KIE.html>

Basic Research Question

- What socio-cognitive scaffolds can help students engage in scientific critique and argumentation?

Defining “Scaffold”

- A support that helps learners engage in a practice or way of thinking they wouldn't be able to do otherwise
- Wood, Bruner, & Ross (1976): one-on-one (human) tutoring + Vygotsky's ZPD...
- ... Our work: complex, technology-rich classroom systems
 - each component of the system is “designed” to do what it can do best

Mildred the Science Guide

Netscape: KIE Evidence: Bicyclists at Night

Mildred

Note for activity... Critique Evidence

Thinking Ahead
Evidence Science [3]
Evidence Methods [3]
Evidence Credibility ...
Evidence Usefulness [3]
Checking Our Understanding
More Thinking Ahead

Get Hint Show Notes

When we critique evidence, we need to...

Activity Evidence Claim
A E C

Show Hint for EVIDENCE Bicyclists at Night

Hints

up sooner ?

EVIDENCE HINT for "Bicyclists at Night": SCIENCE (2 of 2) - What would this evidence be like if they had filmed it during the day?

EVIDENCE HINT for "Bicyclists at Night": METHODS (1 of 2) - Can you tell if the two bicyclists are riding up right next to each other? Would it matter?

KIE Tools

CHECKLIST
Project

All The News DP F96

Activities

✓ Get Started
Critique Evidence
Critique Claims
Write Letter

Details Done ✓

PLACES

Mildred SenseMaker
SpeakEasy Documents

Save from Net

TOOLS

Netscape Works

EXIT
Log-Out

Two Sets of Studies

- Reflection Studies: What effect do reflection prompts have on students' learning?
- Argumentation Studies: How can students be supported in coordinating scientific evidence with theory?

Three Reflection Studies

- Do students benefit from planning and reflection?
 - Group 1: Activity Prompts
 - Group 2: Self-Monitoring + Activity Prompts
- What effect does each prompt type have?
 - Group 1: Activity Prompts
 - Group 2: Self-Monitoring Prompts
- What role does specificity play?
 - Group 1: Directed (Self-Monitoring) Prompts
 - Group 2: Generic (Self-Monitoring) Prompts

Reflection Prompts

Thinking Ahead:

The information we need to include in our critique is...

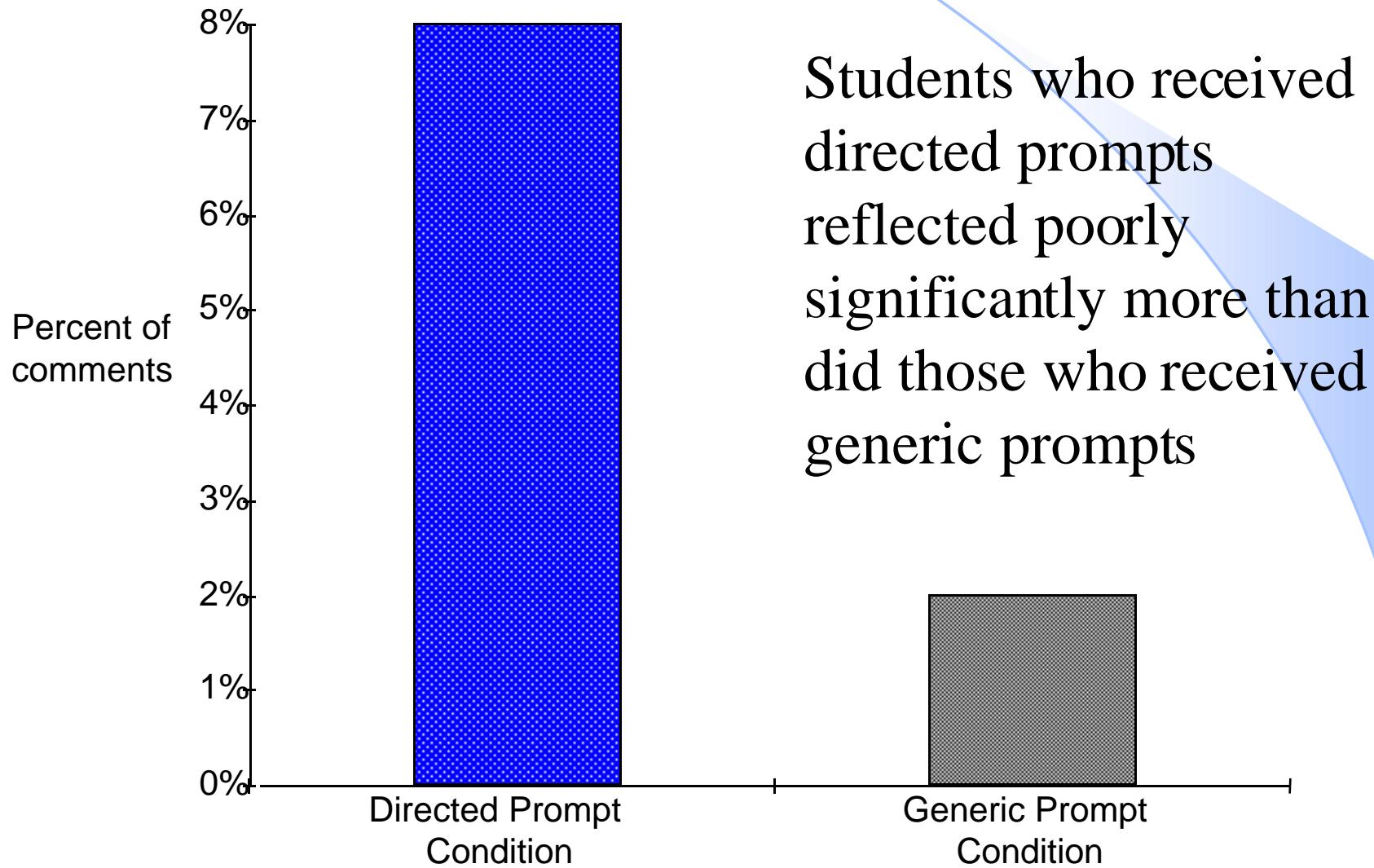
Checking Our Understanding:

Claims in the article we didn't understand very well included...

Generic Prompt:

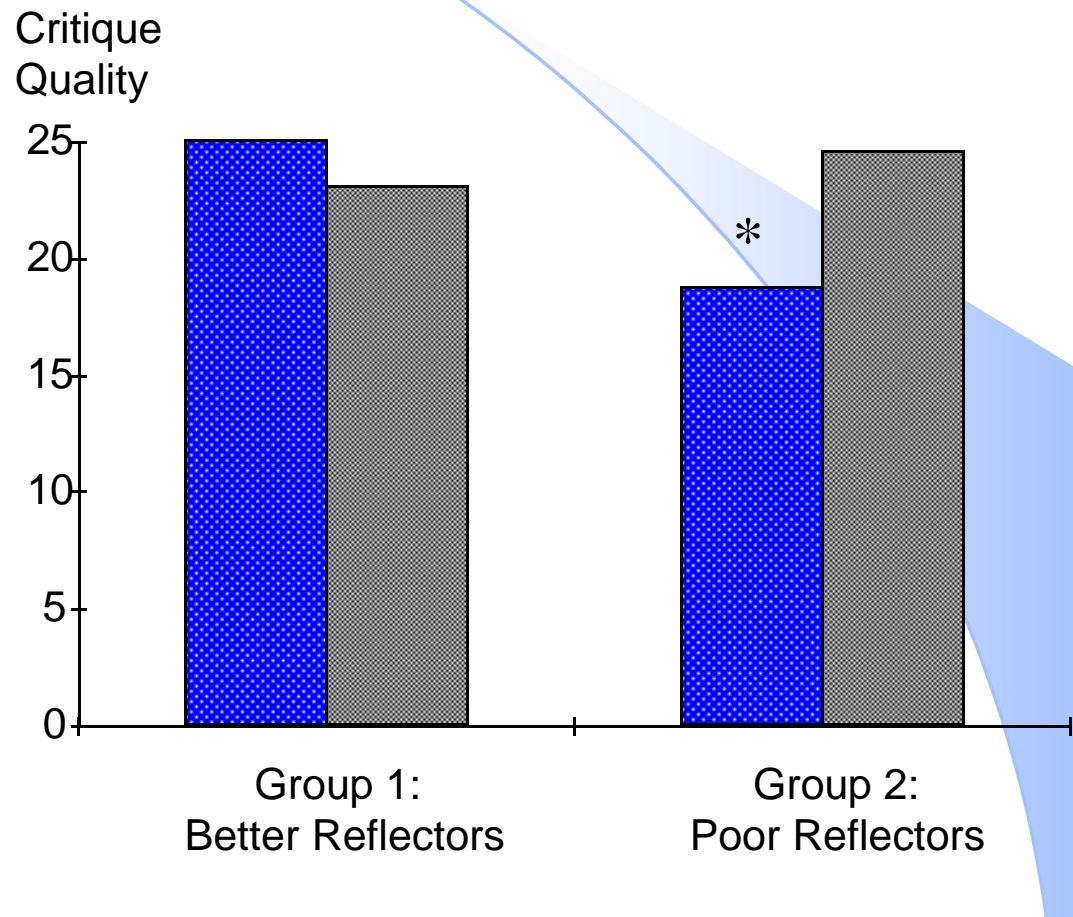
Right now, we're thinking...

Poor Reflection in Response to Prompts

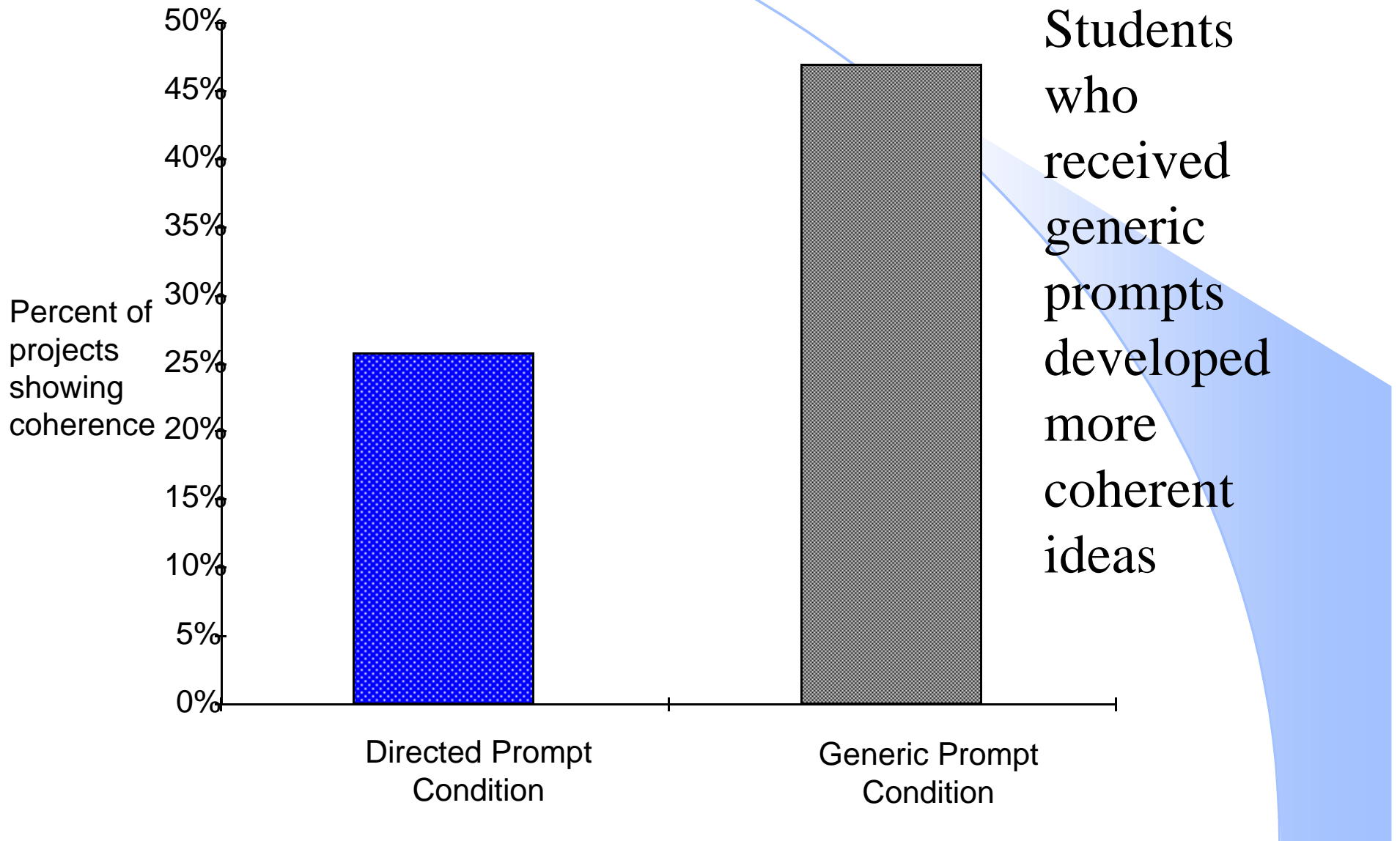


Critique Quality & Poor Reflection

Students who received directed prompts and reflected poorly produced significantly worse critiques



Coherence of Ideas



Summary of Reflection Results

- Generic prompts helped students add ideas to their repertoire *and* identify weaknesses in their knowledge... in this context and as compared to these directed prompts

Argumentation Studies

- Investigate how students create, use, and learn from scientific arguments
 - Study individual learning, pair collaboration, and whole class discourse in the classroom
 - Study design and use of a knowledge representation software tool called SenseMaker
- Approach explored over 5 classroom studies
 - Final study investigated two alternative activity structures for argumentation




Prompt Students to Articulate Ideas

File Edit View Go 8:51 PM

Netscape: KIE Evidence: Blue Light Experiment with Prisms

Back Forward

The KIE Guide

 ACTIVITY: Read Arguments Activity Hint

EVIDENCE: Newton's Blue Light Experiment Evidence Hint

CLAIM: White sunlight is a mixture of different colo... Claim Hint


Hints

HINT FOR "Newton's Blue Light Experiment": Can you come up with another way to explain Newton's experiment?

ACTIVITY HINT: When you're reading the arguments, pay close attention to what the scientists are saying. How are they using the evidence to support their ideas?

Notes

Your Opinion
Claim Note
Evidence Note


 Show Notes

Evidence Note:
Rate the usefulness of this evidence in the debate and take notes about it:

High
 Sort of High
 Medium
 Sort of Low
 Low
 (unrated)

What we want to remember about this evidence is... that Newton showed that blue light wasn't changed by putting it through a second prism. Kepler was wrong about light picking up color from objects.

Blue L

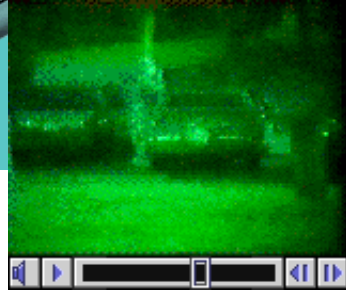


Newton (1642-1727) about how objects r

Newton knew that thought color came from white light being changed by an object's color. But, he also knew that

KIE Tools
CHECKLIST

EXIT
Log-Out

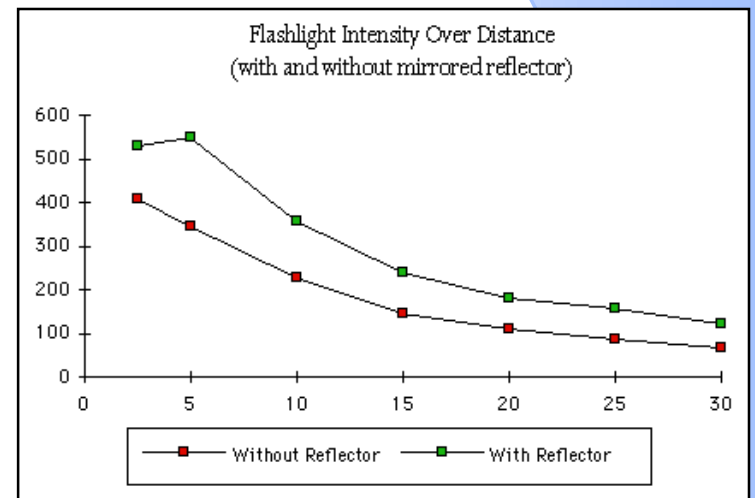
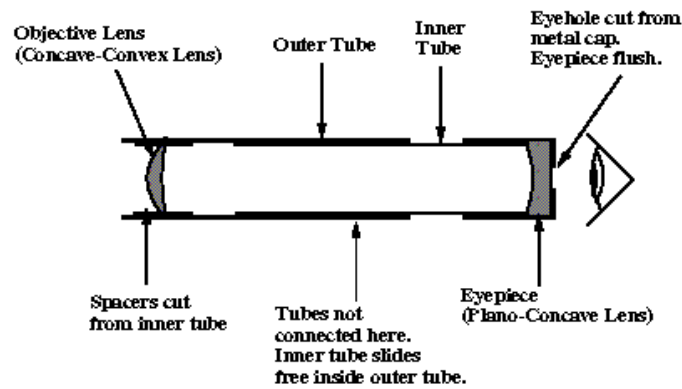
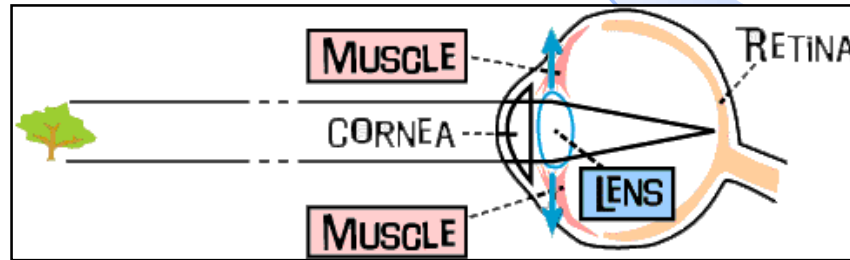


light intensity

Distance

Autoplay

To use: drag the black flashlight, the red point, or turn autoplay on.



Sample SenseMaker Argument

File Edit Frame Library 3:12 PM

Sample S-M 2.html

Title: The How Far Does Light Go? Debate

To Be Sorted . . .

THEORY 1 : Light Goes Forever Until Absorbed (LGF)

- [A Little Light Poetry](#)
- Light Spreads Out
 - [Searchlight Photo](#)
 - [Our Candle](#)
- Telescopes Bring The Light Together
 - [Galaxies in the Young Universe](#)
 - [Brian Star-gazes](#)
- Light Gets Dimmer
 - [Light Intensity Over Distance](#)
 - [Far-away Candle](#)
 - [Robert in the Car](#)
 - [The Soccer Field](#)
- Our Eyes Aren't Strong Enough
 - [The Human Eye and Glasses](#)
 - [We look at stars](#)

THEORY 2: Light Dies Out (LDO)

- Stars
 - [Our Telescope](#)

Irrelevant

- How Light Is Measured
 - [Flashlight Data](#)
- Colored Light
 - [Bicyclists at Night](#)
- Sensors
 - [Vernier Light Sensor](#)

Telescope Evidence

- [The History of the Telescope](#)
- [How a Telescope Works](#)
- [The Hubble Space Telescope](#)

Light Detector Evidence

COLOR RATINGS :

- High
- Sort of High
- Medium
- Sort of Low
- Low
- (not rated)

KIE Tools

CHECKLIST
Project
How Far Does Light Go

Activities

- Look at Theories
- Survey Evidence
- Create Evidence
- Add Frames
- Plan for Debate
- Class Debate

Details Done ✓

PLACES

- Mildred SenseMaker
- SpeakEasy Documents

Save from Net

TOOLS

- Netscape
- Works

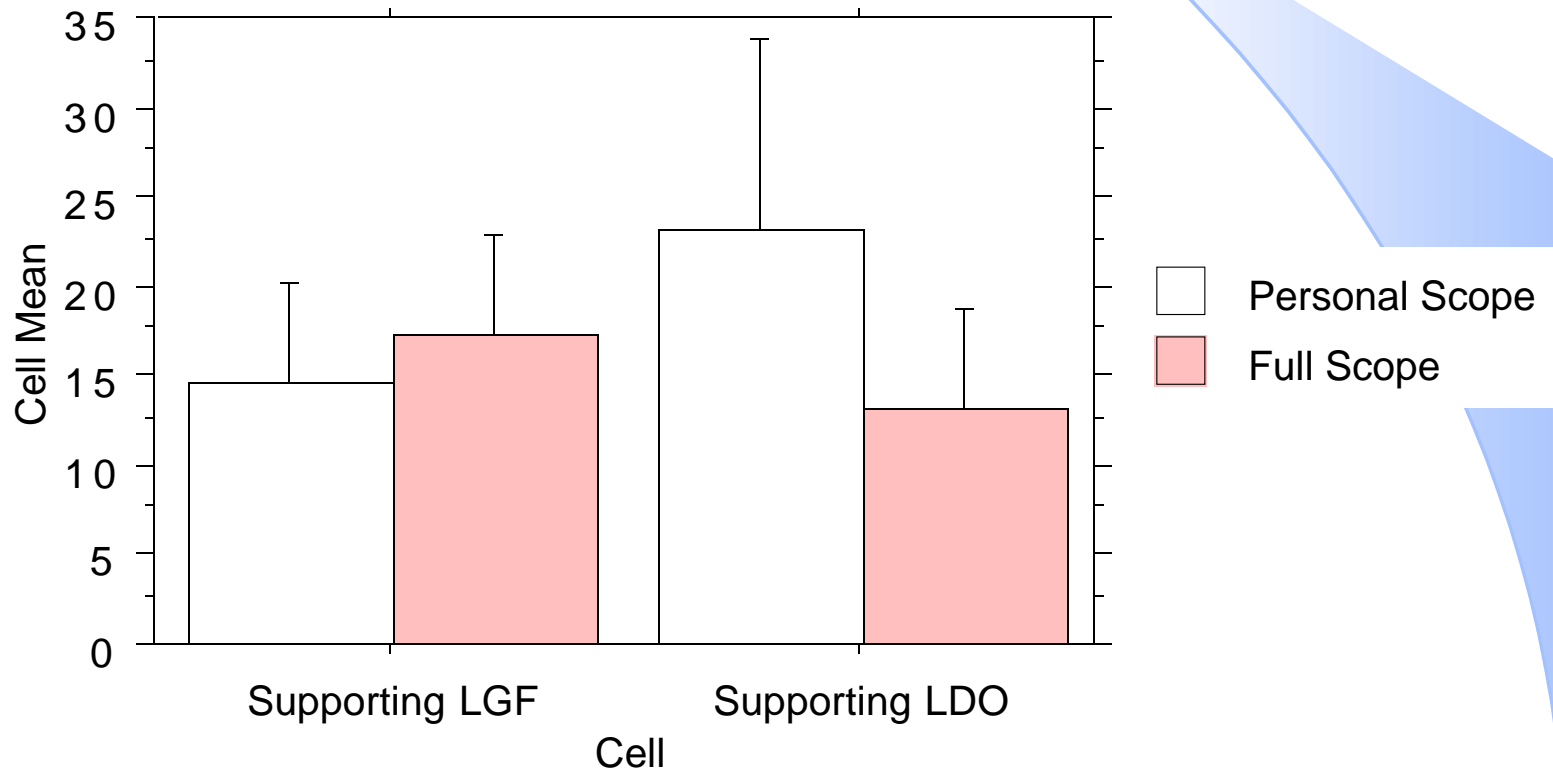
EXIT
Log-Out

Scaffolds allowed students to coordinate evidence with theory using causal explanations (for the most part)

<u>Evidence Explanations</u>	<u>Mean</u>	<u>Std. Dev.</u>
Percentage of Causal Warrants	79.5%	(15.7%)
Percentage of Descriptions	16.2%	(14.5%)
Percentage of Statements of Irrelevance	4.2%	(6.6%)
Total Explanations per group (out of 13)	10.3	(2.3)
Average Explanation Length (in words)	68.6	(34.7)

The framing activity structure for the project influenced students' use of the explanation scaffold

Interaction Bar Plot for Descriptive
Effect: Condition * Debate Position
Error Bars: 95% Confidence Interval



One case was omitted due to missing values.

Summary of Argumentation Results

- Scaffolds allowed students to connect evidence to theory using causal explanations (for the most part)
- The framing activity structure for the project influenced students' use of the explanation scaffold
 - the perspective-taking activity structure supported students theorizing and learning

Design Principles

- Speak to the pragmatic, but bridge to and from theory
- Ground design principles in empirical analysis—
during and after enactment
- Develop principles to increase the likelihood of (not
ensure) specific learning events
- Explore a continuum from localized to generalized
principles. Generality of principles bounded by:
 - the nature of the learning phenomena
 - contextual features of the system
 - the design of the study and our analytical understanding of
theoretical concerns and empirical effects

Design Principles about Reflection

- Encourage reflection
- Promote productive reflection, including true self-monitoring
- Provide generic prompts for reflection (*)
- Promote identification of weaknesses in students' own knowledge

Design Principles about Argumentation

- Engage students in explaining and making connections between evidence and claims as part of the classroom community interaction
- Use activity structure and software design to support a flow of inquiry, rather than lock-step use of tools
- Engage students in incremental, long-term argumentation centered around articulation, collaboration, and refinement of ideas

Synthesizing Design Principles

- Develop software components with discipline's epistemic elements and practices in mind
- A single software cognitive guide could accommodate different epistemic practices
- For specific epistemic practices...
 - make expert thinking visible to students
 - make student thinking visible to selves, peers, and teachers
- Provide multiple, complementary scaffolds in the system to support multiple, complementary knowledge integration processes

Issues about Scaffolding

- Is everything a scaffold? Do we all mean the same thing when we say scaffold? When is it a useful construct?
- Do we agree that there is a difference between tools and scaffolds?
- Is it necessary to be specific about the nature of the different types of scaffolds under consideration?
- Is all scaffolding beneficial?
- What do we give up by using scaffolds which necessitate having a specific educational target?

Issues about Design Research

- What are the forms of productive design principles? (diSessa, 1991)
 - How general should design principles be? How localized?
 - What contextual information is important to report as we make design principles a shareable product?
 - How interconnected are design principles within a system? What are the consequences for the diffusion of innovation?
- How can we accumulate design principles? And on what basis should we reconcile conflicting ones?
 - What is the possible life of a design principle?

For More Information

See our session's website:

<http://www-personal.umich.edu/~betsyd/scaffolding.htm>

Or email Betsy Davis: betsyd@umich.edu