

From APE to APL: Active Prolonged Engagement - When Does it Become Active Prolonged “Learning”?

Margaret Evans¹, Brenda Phillips², Mike Horn³, Florian Block², Judy Diamond⁴ and Chia Shen²

University of Michigan¹, Harvard University, Northwestern University, and University of Nebraska⁴

Developmental Research Outside the Lab: Children’s STEM Learning in Museums (Uttal & Hayden) SRCD Biennial Meeting, Seattle, 2013.

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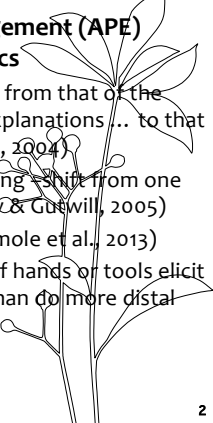
Active Prolonged Engagement (APE) Characteristics

GOAL “Shift the role of the visitor from that of the recipient of instructions and explanations ... to that of participant” (Allen & Gutwill, 2004)

- Engagement times short (grazing shift from one exhibit to the next) (Humphrey & Gutwill, 2005)

The world within reach... (Brockmole et al., 2013)

- Objects that are within reach of hands or tools elicit different cognitive resources than do more distal objects




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Can “tool” use help youth acquire STEM Topics? Focus: Evolutionary Concepts



Evolutionary relationships (macro-evolution)

1. All life on earth is related
2. Evidence: Shared traits
3. Common Descent: We share ancestors with all other living things on earth



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Learning about Evolution, in Museum Settings: (1) Prehistoric Life

- (Child) Dinosaur experts – no relationship to an understanding of evolution (Evans, 2000)
- (Adult) ~30% Natural History Museum visitors grasp evolutionary principles (Evans et al., 2010; Macfadden et al., 2007)

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(2) “Tree of Life” (ToL) Representations



•Even “simple” phylogenies (ToLs) are difficult to interpret (Novick & Catley, 2012; MacDonald & Wiley, 2010)

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Failure to learn: Why the difficulties?

(1) Representational issues

- Evolution is dynamic
- Biodiversity is vast: 8.7 million Eukaryotic species

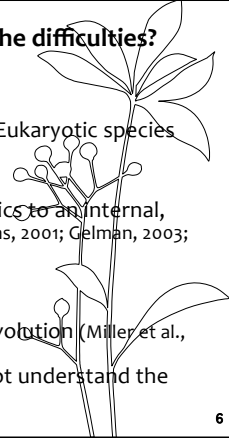
(2) Conceptual Issues

Essentialism

- Attribute outward characteristics to an internal, species-specific “essence” (Evans, 2001; Gelman, 2003; Mayr, 1982)
- Confers immutability

(3) Cultural Issues

- ~50% US public reject human evolution (Miller et al., 2006)
- Even those who accept it do not understand the mechanism (Evans, 2008)



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One Solution? “Life on Earth” Interactive Touch-Table Exhibit



Interactive Tabletop Exhibit: Two Components [Two Year Iterative, team design]

Deep Tree

- Interactive, visualization
- Fly through the Tree of Life
- **70,000 species+**,
- **Ancestral relationships (3.5 billion years)**
- Zoom in for more info
- Scrolling image wheel (200)
- **Visitors select any two species to examine relationships and traits**

FloTree

- Simulation
- Dynamic, abstract, representation of evolutionary processes
- Visitors’ hands act as environmental barriers
- Links micro-level processes to macro-level outcomes

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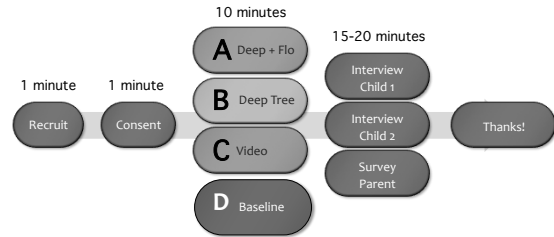
Study Design

- **Location:** Field Museum and Harvard Museum of Natural History
- **8-15 year-old dyads:** N = 248 (siblings, friends, multilingual, diverse)
- **Random assignment:** Four conditions (3 experimental, baseline)
- **Family Background:** No condition differences; Evolution acceptance & understanding; Religious interest; Educational background, child relationships



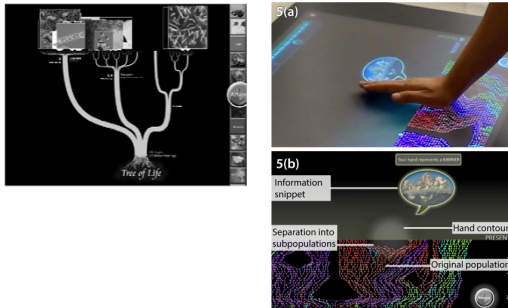
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Study Design



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Condition A: Deep Tree and Flo Tree Condition B: Deep Tree, Only



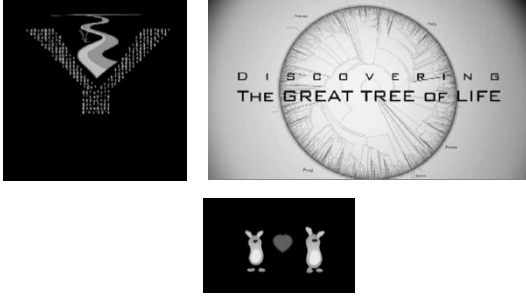
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Conditions A & B: Relate function



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Condition C: Peabody Video



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Condition C: Peabody Video



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Demographics by Condition

	A	B	C	D	Total
Total Children	59	62	63	64	248
Site					
Harvard	29	32	31	32	124
Field	20	30	32	32	124
Age					
8-11 years	28	28	29	28	113
12-15 years	31	34	34	36	135
Gender					
Male	26	31	31	32	120
Female	33	31	32	32	128
Parent Education (12-21 years)	16.90	16.62	16.79	16.44	ns

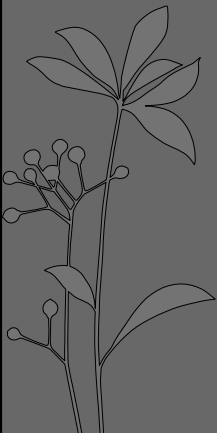
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Research Questions
Focus on "Informed" Reasoning

What is the effect by condition and age-group on:

1. "Informed Reasoning" Language: "Relatedness"
2. The evidence: Shared traits with common ancestors
3. Relatedness because of common descent
4. Linking evolution concepts to exhibit interaction patterns

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Informed Reasoning
RESULTS

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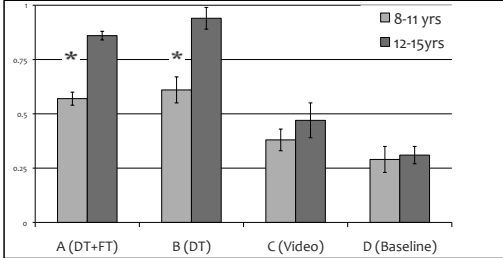
(1 a/b) Language coding: Open ended questions

Biological Terms	<input type="checkbox"/> Adaptation <input type="checkbox"/> Ancestry <input type="checkbox"/> Barriers <input type="checkbox"/> Relatedness	<input type="checkbox"/> Branching <input type="checkbox"/> Evolution <input type="checkbox"/> Genes / DNA <input type="checkbox"/> Time	<input type="checkbox"/> Humans <input type="checkbox"/> Mutation <input type="checkbox"/> Population
Informed Reasoning	<input type="checkbox"/> Common Descent <input type="checkbox"/> Taxonomic <input type="checkbox"/> Natural Selection	<input type="checkbox"/> Variation <input type="checkbox"/> Diff. Survival <input type="checkbox"/> Diff. Reproduction	<input type="checkbox"/> Inheritance <input type="checkbox"/> Branching <input type="checkbox"/> Shared Traits <input type="checkbox"/> Environ. Press.
Novice Reasoning	<input type="checkbox"/> Need-based <input type="checkbox"/> Intentional (Want) <input type="checkbox"/> Design: Someone made it	<input type="checkbox"/> Reproduction <input type="checkbox"/> Hybridization <input type="checkbox"/> Adaptive environment	<input type="checkbox"/> Feature list <input type="checkbox"/> Connectedness
Creationist Reasoning	<input type="checkbox"/> God		
Biological Change	<input type="checkbox"/> Individual change <input type="checkbox"/> Transformation	<input type="checkbox"/> Environmental <input type="checkbox"/> Ongoing change	<input type="checkbox"/> Origins

Inter-rater reliability: 96.1% (kappa = 0.659)

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(1a) Language Use: Use of term "relate"
(Proportion +/- SE)

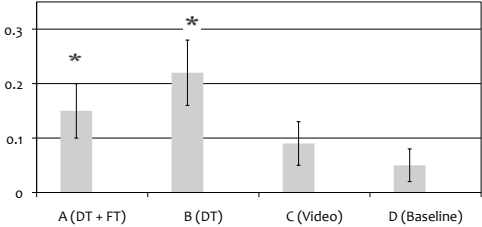


Condition	8-11 yrs	12-15 yrs
A (DT+FT)	~0.55	~0.85*
B (DT)	~0.60	~0.90*
C (Video)	~0.35	~0.45
D (Baseline)	~0.25	~0.25

Age ($p = 0.06$); Condition ($p = 0.001$)
 A (FloTree/DeepTree) > D (Baseline); B (DeepTree) > D
 B (DeepTree > C (Peabody Video)

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(1b) Language Use: "What is the 'Tree of Life' all about?"
(Proportion Informed Reasoning Concepts +/- SE)



Condition	8-11 yrs	12-15 yrs
A (DT + FT)	~0.15	~0.22*
B (DT)	~0.10	~0.25*
C (Video)	~0.05	~0.05
D (Baseline)	~0.05	~0.05

Main effect for condition ($p = 0.036$)
 A (DeepTree/FloTree) > D (Baseline); B (DeepTree) > D

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(2) Evidence: Interpreting a Tree of Life Graphic

Cladogram with 5 species & 4 traits:
Point to the living things that have:

- (1) Backbone
- (2) Amniotic Sac
- (3) DNA

- A = 5 minutes Tree Of Life Interaction
- B = 10 minutes Tree Of Life interaction

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(2) Evidence: Tree of Life Graphic Questions (# Completely correct 0-3)

Condition	9-11 yrs	12-15 yrs
Exhibit A	~1.4	~2.5
Exhibit B	~1.9	~2.7
Video	~1.7	~2.2
Control	~1.3	~2.4

Effects of age and condition ($p_s < 0.01$)
B (DeepTree > D (Baseline))

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(3) Acceptance of Common Ancestry

1. Some kids said that RABBITS and LIZARDS had the same ancestor a long, long time ago. (1-5 scale: Disagree to agree)
2. ... HUMANS and MUSHROOMS ...
3. ... BEARS and SUNFLOWERS ...
4. ... ALL these living things had the same ancestor ...

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(3) Acceptance of Common Ancestry (Mean score: 1 to 5, disagree to agree; +/- SE)

Condition	8-11 years	12-15 years
A (DT+FT)	~1.9	~3.1
B (DT)	~2.4	~2.7
C (Video)	~2.1	~2.6
D (Baseline)	~1.8	~2.1

Main effects of age & condition ($p_s < 0.001$)
*A > D ($p = 0.01$); *B > D ($p = 0.007$); *C > D ($p = 0.061$)

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(3) Linking Evolutionary Concepts to Exhibit Interaction Patterns

- Semantic Logging System
- All “touches” automatically recorded
- Exploratory analyses
- A & B Touch-table Conditions Only

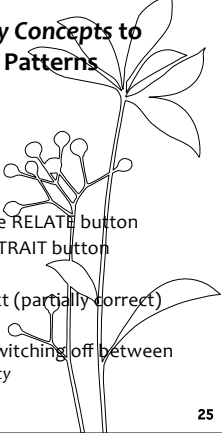
Exhibit Interaction Patterns

1. RELATE = Number of touches of the RELATE button
2. TRAIT = Number of touches of the TRAIT button

Evolutionary Concepts

1. *Tree of Life Graphic*: #Species correct (partially correct)
2. *Common Ancestry* acceptance

Dyads: One interacts, one observes (switching off between dyad members) – *shared intentionality*



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(3) Linking Evolutionary Concepts to Exhibit Interaction Patterns

Exhibit Interaction Patterns:	# RELATE Activations		# TRAIT Activations	
	8 to 11 Years	12 to 15 Years	8 to 11 Years	12 to 15 Years
<i>Tree of Life Graphic</i> (#species correct)	.37**	ns	.35*	ns
<i>Common Ancestry</i> Acceptance	.37**	ns	.38**	ns

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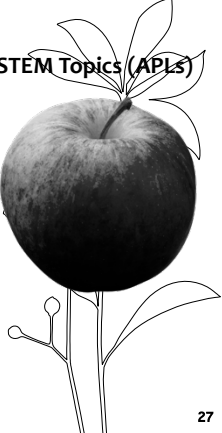
Conclusion

Active Prolonged Learning of STEM Topics (APLs)

CONDITION COMPARISONS

Active, collaborative, self-directed, interactive touch-table learning experiences:


- Create an opportunity to absorb complex STEM content in informal settings
- A passive (video) presentation is (mostly) no more effective than baseline



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Why is the Touchtable Effective?

Claim: “Tool” Use Enhances Learning

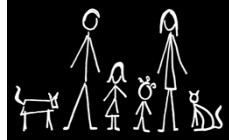


- Participants who **touch** “relate” & “trait” were more likely to grasp evolutionary concepts (APL)
- Hand and tool use alters our understanding of the physical world
- “Tool” use “compels observers to more fully evaluate objects that are near the hands” (Brockmole et al., 2013)

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Effects of Age and Family Background

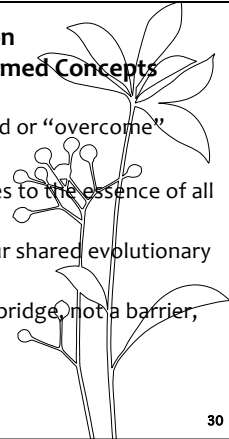
- The exhibit was effective across age-groups
 - The exhibit was effective, irrespective of family background
- (Family characteristics do have an effect – but that is another story)



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Conclusion From Intuitive to Informed Concepts

- (1) Essentialism is not abandoned or “overcome”
 - (2) Intuitive reasoning acts as a bridge, not a barrier, to more informed reasoning
- It is co-opted and expanded
 - From the “essence” of a species to the essence of all living things
 - Our shared DNA, represents our shared evolutionary heritage



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- PI Shen; Co-PIs Diamond, Evans, Horn
- For more information on this research project, visit [www. lifeonearth.seas.harvard.edu](http://www.lifeonearth.seas.harvard.edu)



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