

Facing the Challenges of Learning & Teaching About Evolution: A Synthesis

Goals:

Identify robust areas of research with promise to shed light on the challenges learners and educators face with respect to biological evolution.

Generate transdisciplinary conversation amongst researchers and stakeholders from different areas and contexts, finding ways to translate amongst those disciplines.

Find paths by which research might be transformed into practical recommendations for formal and informal education.

Identify issues and areas that will fuel basic and applied research in the future.

Process:

Summer 2006 (pre-grant): Identified key areas through lit review and discussion with colleagues in those disciplines.

Spring/Summer 2007: The co-PIs hosted 5 regional meetings. Each was attended by participants chosen to represent the diversity of the full membership. Technical reports were produced for each by SKB and revised according to feedback from the membership. These sessions helped us to identify key areas of research, whilst learning the goals, conceptualizations, and jargon of each discipline, to facilitate later discussion.

Fall 2007: A "summit" meeting at ASU created member working groups on issues emerging from the regional process

Spring/Summer/Fall 2008: Projects arising from the summit began taking form (see products for selected examples).

COGNITIVE BIASES

Developmental psychologists have uncovered several heuristics, or "rules of thumb" that shape thinking (Wellman and Gelman, 1998). Evolution doesn't follow these rules (Evans 2000, 2001), creating challenges for learning.

The **essentialist constraint** supports the belief that things have an immutable essence that bestows upon them their basic identity (Gelman 2003). On this view, evolving from one kind of organism into another is highly implausible.



Teleology is the attribution of design and purpose to nature and artifacts. Children are **teleological thinkers**; animals have eyes because they need to see, birds have wings because they need to fly. Although such thinking persists in adults, children apply these principles more broadly. Related to teleological thinking, the **intentionality constraint** causes individuals to assume events are not only purposeful, but caused by an intentional agent, making creationist or intelligent design views appealing and easily acquired (Evans 2000, 2001, 2008).

SOCIAL & PERSONAL FEARS

Historically, theoretical models of the learning process tend not to address affective characteristics such as beliefs, motivations, and emotions. More recently, however, researchers are increasingly calling for conceptual change to be examined as a contextualized social event that is motivational and affective in nature. Still, evidence remains primarily anecdotal. For example, in *Unweaving the Rainbow*, Dawkins recounts, "A foreign publisher of my first book confessed that he could not sleep for three nights after reading it, so troubled was he by what he saw as its cold, bleak message." (Dawkins 1998, pg. ix)

Will accepting evolution mean that...?

- People will be able to justify violence and selfishness
- There will be conflicts with their spiritual beliefs
- They will have to accept genetic determinism
- Individuals will lose their a special sense of place, purpose
- People will be able to justify racism, eugenics

Systematic studies are consistent with such tales. Brem et al. (2003) found that both students who accepted evolutionary theory and those who did not reported very similar beliefs regarding key matters of personal and social consequence. Both reported concerns that accepting evolution would increase racism and selfishness, reduce spirituality, and challenge individual's sense of purpose and self-determination. Griffith and Brem (2004) found that Biology teachers too worried about such matters, with some experiencing clinically measurable stress just thinking about teaching evolution.

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LEARNED MISCONCEPTIONS

Experience can further entrench biases. Naïve or folk theories, provide simple explanations for natural phenomena that work well in everyday life, even if not scientifically accurate (Wellman and Gelman 1998). We develop beliefs about living things, inheritance, and change through experience, and this can give rise to misconceptions.

For example, a 4- or 5-year-old knows that offspring resemble their parents; however, they believe this resemblance will hold even if the child is adopted. It is not until they are 7 or 8 that they understand that some forms of parentage lead to inheritance and some do not (Solomon et al. 1996). Until a child understands biological reproduction (Johnson and Solomon 1997) they will believe essence is passed from the parent, regardless of how one became a parent.

Some misconceptions dissipate with time, while others persist, experience consistently failing to refute the error. They fit so neatly with our existing understanding of the world, that we fail to see them as errors, (Ferrari & Chi, 1998; Evans 2000, 2001, 2008).

Through the process of finding consensus, we identified three areas in which there was a solid research base from which to begin making pedagogical recommendations, but that could also serve as rich sources of research in the future.

PRODUCTS & FUTURE DIRECTIONS

The following is a list of selected examples of products arising from the project:

1. Sherry Southerland (FSU) and Louis Nadelson (Boise State) developed a macroevolution assessment, an area often overlooked in favor of the less controversial microevolution.
2. Micki Chi (ASU) and Sarah Brem (ASU) have proposed a concept inventory for studying emergent systems, such as those present in evolution.
3. Gale Sinatra and Tom Bean (UNLV) are examining beliefs about intentionality in evolution, and the role simulation exercises play in reinforcing or reducing those beliefs.
4. Sarah Brem (ASU) is participating in activities celebrating the 200th anniversary of Darwin's birth, including a podcast symposium, and teacher workshop.
5. In addition, the project has fostered an informal referral network for online discussions, publication of new articles and commentaries, and connecting people from different disciplines.