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A Retrospective on Student Learning and Acceptance of Evolutionary Science

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Title
A Retrospective on Student Learning and Acceptance of Evolutionary Science

Abstract
In this presentation, I provide an analysis of my work (1985-present) with non-major biology students and science teacher candidates in developing strategies for teaching and enhancing learning with respect to Evolutionary Science.

A Retrospective on Student Learning and Acceptance of Evolutionary Science

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Initial NOS Assumptions (1985-1996)

- NOS understanding develops *as a consequence* of a well designed science education.
- Evolution, as a working theory, could be used as a vehicle to promote/enhance NOS understanding.

Initial NOS & Evolution Findings for Instruction

- **Recognize Target Learners <u>BEFORE</u> Designing Curriculum** (e.g., are the learners in question HS Students, College UGs, Science Methods Students, HS Teachers, etc.) Many are "dualistic" -- requiring careful consideration.
- **Development of Evolution Instructional Module** (based on conversations with C.E. Nelson) must emphasize an explicit active learning environment and an instrumentalist philosophy.

Reflections & Transitional Insights (1997 - 2000)

- Despite success of the Evolution Instructional Module, NOS development was too tenuous (especially for students claiming a conservative religious heritage)
- Request to review a manuscript resulted in the formation of a critical writing partnership with Mike U. Smith (Mercer University of Medicine)

Key Insights

- Key Insight 1: Science as a **CONTINUUM** (More --> Less Scientific) [based on the work of Philip Kitcher]
- Key Insight 2: False Premises --> Bad Science (e.g., Kansas State Board of Education science standards 1999) [influenced by CSA; authored by Tom Willis]
- Key Insight 3: New Literature Reviewed (Lederman; Abd-El-Khalick; Akerson; Bell; Nehm; Southerland; Schwartz) … NOS instruction must be **EXPLICT and REFLECTIVE**
- Key Insight 4: NOS instruction must occur **BEFORE** introducing Evolution (Nelson).

Action Research Findings Years 1-2

- ✓ Understanding of NOS concepts is enhanced when introduced explicitly and with multiple iterative opportunities for personal reflection.
- ✓ The instructional unit must engage students as active participants.
- ✓ Allow the science-religion issue to surface and be respectfully discussed throughout the duration of the unit.

Initial Engagement

- 8 statements ranging from less -> more scientific (individually)
- Consensus on 8 statements (in pairs/groups)
- Debrief of Activity – development of criteria for “more” scientific
- Apply criteria to fields of study [IDT, evolution, Umbrellaology]

Modifications
(based on Years 1-2)

- **Key Problems to Address**: Lack of student understanding for the claims of Intelligent Design; relational placements on final reflective essays inconsistent and not well justified.
- **Solution**: Based on students' reflective comments, we sought an article written on IDT by a theologian published in a Christian journal.

Note: See Scharmann, Smith, James, & Jensen (2005) for additional details on unit design and instructional details.

Action Research Findings: Year 3

- ✓ Addition of the new IDT reading caused deeper reflections by students concerning the motives of the framers of ID "theory."
- ✓ All six students participating in year 3 listed IDT as less scientific than evolution (even for two students claiming a conservative religious heritage).
- ✓ Final order of phases in the instructional module confirmed.

NOS Assessments

- Design and Teach a NOS-based Lesson (Note: Six explicit examples are provided in the text *Teaching about Evolution and the Nature of Science*; each written in 5-E format).
- Final NOS continuum (Less to More Scientific) … placements and justifications for three fields of study: Evolution, IDT, and Umbrellaology (in relation to one another).
- Pretest/posttest comparison of scores on a 12-item NOS "quiz" developed by Chiappetta & Koballa (2004) to reflect NSES.

Action Research Findings: Years 4-5

- Explicit NOS-based lessons successfully planned and executed with accuracy and scientific integrity.
- All 15 students placed IDT as least scientific, Umbrellaology in the middle, and evolution as most scientific (based on application of developed consensus criteria).
- Gains in NOS quiz scores from a mean of 50% (range = 4-9 of 12 correct responses) to a mean of 79% (range = 8-12 correct responses).

Summary of Action Research (2001-2006)

- Published in **Science & Education** entitled: *A Multi-Year Program Developing an Explicit Reflective Pedagogy for Teaching Pre-Service Teachers the Nature of Science by Ostention.*
- Paper contains an account of three cases, all of whom identified themselves as anti-evolution prior to instruction but after experiencing the NOS instructional module recognize and accurately **justify** that evolution is "more scientific" than rival explanations.

NOS Final Justification: Alexis

- "I had never contemplated the difference between truth and scientific truth. This is why I had difficulty grasping the idea of a scientific theory; I thought it was absolute truth. And in the case of evolution, I don't believe it as absolute truth so I couldn't see it as a tool. My thought process was incorrect. This is so hard for me to say because IDT is so appealing to me. Although I have made progress on the whole theory issue, I still need to remind myself that less scientific does not mean worse or wrong thinking."

Evolution Reconciled (2006-2011)

- Mark Winslow, Southern Nazarene University [see Winslow, Staver, & Scharmann (2011)] - studied biology majors' reconciliation of evolution with religious values.

Evolution Reconciled (2006-2011)

- Participants raised to believe in creationism
- Evolution reconciled with religious belief through evaluation of evidence for evolution
- Recognition of evolution as a non-Salvation issue
- Credibility of professors who themselves had to reconcile scientific evidence with religious beliefs
- 14/15 students were able to reconcile

2011-Present

- Replication of the Winslow research difficult
- Can reconciliation be enhanced in a semester-long experience?
- Attempted at a community college through the use of journaling [see Scharmann and Butler (2015)]

Non-Majors' Biology

[Scharmann & Butler, 2015)

- NOS as antecedent learning
- Evolution then integrated as a focal lens throughout the semester
- Inquiry Lab/learning activities weekly
- Journal entries followed: in relation to NOS and Evolution, and changes in views expressed over the semester.

Non-Majors' Data

(x2 = 104.18; $p < 0.001$; $df = 5$)

	Accuracy of representations of evolutionary theory (%)		
Journal entry number (week)	Not Informed	Somewhat Informed	Informed
1 – Week 1	29	68	3
2 – Week 5	23	65	12
3 – Week 9	31	50	19
4 – Week 13	10	29	61

Future Work

- Examination of how secondary science teachers implement what they have learned in science methods courses concerning approaches to teaching evolution.
- High school students' changes in acceptance of evolution through journaling as the assessment tool.