The Impact of Biology Instruction on Evolution Acceptance and Conflict in Underrepresented Minority Undergraduates

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Abstract

Although a diverse undergraduate population enters biology degree programs, differential attrition produces underrepresentation in degree outcomes and STEM careers. The Ecological and Evolutionary Sciences (EES) prepare students for careers of central importance to society. Proposed but largely under-investigated variables that may exacerbate race-based attrition in biology in general and EES in particular include students' conflict with and acceptance of evolution. Prior work suggests (i) discussing the bounded nature of science, (ii) highlighting religious scientists, and (iii) introducing underrepresented scientist role models may collectively reduce conflict and increase acceptance. We ask: (RQ1) What pre-course patterns of acceptance, conflict, religiosity, and evolutionary knowledge characterize biology students in terms of race? and (RQ2) To what extent does standard instruction (SI) and the addition of research-based instructional strategies alter these patterns? We used a suite of validated instruments, Rasch analysis, and regression analyses to answer these questions.

Introduction and Significance

The Ecological and Evolutionary Sciences (EES) prepare students for careers in many areas of central importance to society, including environmental conservation and protection, biodiversity management, sustainability, medical genetics, and evolutionary medicine. Nevertheless, the EESs appear to be one of the least diverse areas of study in terms of degree completion and career participation (ESA 2017). Although many STEM fields have been working to address patterns of underrepresentation, the EESs have only recently begun to focus on this topic (although see important work by Mead et al. 2015). Understanding the causes of race- and gender-based attrition, and addressing them early in academic pathways, could help maintain and foster a diverse talent pool for EES degrees and careers.

Proposed but largely uninvestigated variables that may exacerbate race- and gender-based attrition in EES is students' conflict with and acceptance of evolution. Evolution is a central conceptual pillar in the biological sciences (AAAS 2011) and an unavoidable dimension of EES degree programs. The idea that individuals may harbor feelings of conflict with evolutionary principles, and that such conflict may be linked to their acceptance of evolution, has been discussed in the literature for decades (e.g., Brem et al. 2003; Clough 1994; Dagher & BouJaoude 1997; Scharmann & Harris 1992). Several studies show that feelings of conflict are important considerations in the complex web of factors accounting for evolution acceptance (e.g., Konnemann et al. 2018; Scharmann & Harris 1992). Conflict with evolution may be characterized in many ways (Brem et al. 2003): by its presence (i.e., yes, no), magnitude (high, low), sources (e.g., religion, societal implications), scales (e.g., individual, family, community), and consequences (e.g., anxiety, avoidance) (Barnes et al. 2020; Konnemann et al. 2018; Mead et al. 2015; Scharmann & Harris 1992).

Surprisingly, only in the past few years have investigations begun to explore the roles that race, gender, and religiosity (which is associated to varying degrees with race) play in evolution acceptance and EES career interest. Relatedly, "belonging" has emerged as an important variable impacting STEM persistence (Seymour & Hunter 2019). Feelings of isolation and alienation, which are central to low levels of belongingness, have been documented for URMs, women, and religious students in STEM (Seymour & Hunter 2019; Barnes et al. 2017). It is possible that low evolution acceptance and high conflict could be impacting students' sense of belonging in biology in general and EES degree pathways in particular. Overall, the interactions among race, gender, religiosity, belongingness, evolution acceptance, and STEM persistence form a complex and poorly studied conceptual system even though these variables appear to be relevant to diversifying the scientific workforce in general and the ESS in particular.

Research Questions

(RQ1) What pre-course patterns of evolution acceptance, conflict, religiosity, and knowledge characterize biology students in terms of race?

(RQ2) To what extent does standard instruction (SI) and the addition of research-based instructional strategies (RBIS) impact these patterns?

Variables

Construct	Variable	Instrument or reference	Items and Reliabilities
Religiosity	Religiosity	Religiosity scale	9 items: reliability (Rasch): EAP = 0.94, WLE = 0.92
Acceptance of evolution	I-SEA: Acceptance of microevolution	I-SEA instrument	3 items: reliability (Rasch): EAP = 0.82, WLE = 0.74
	I-SEA Acceptance of macroevolution	I-SEA instrument	8 items: reliability (Rasch): EAP = 0.79, WLE = 0.73
	I-SEA Acceptance of human evolution	I-SEA instrument	8 items: reliability (Rasch): EAP = 0.88, WLE = 0.84
Conflict with evolution	SECM: personal conflict with evolution	SECM instrument	8 items: reliability (Rasch): EAP = 0.85, WLE = 0.82
	SECM: family conflict with evolution	SECM instrument	3 items: reliability (Rasch): EAP = 0.88, WLE = 0.90
	SECM: community conflict with evolution	SECM instrument	3 items: reliability (Rasch): EAP = 0.90, WLE = 0.91
Knowledge of evolution	CANS: knowledge of natural selection	CANS instrument	20 items; reliability (Rasch): EAP = 0.80, WLE = 0.78
n/a	Compatibility of evolutionary ideas and your family	1 item	n/a
n/a	Likelihood of a pursuing a biology degree that includes evolution	1 Item	n/a
n/a	Family reaction to career in evolutionary biology	1 Item	n/a
n/a	Demographics and degree plan	Multiple items	Race/ethnicity, gender, age, biocourses, etc.

Methods

Pre-variables (week 1)

Standard Instruction (SI; n (all) = 613)

Research-Based Instruction (30 min total) (RBI; n (all) = 552)

Post-variables (week 14)

Condition	Evolution content	Religion	URM role model examples	Bounded Nature of Science
Standard or traditional Instruction (SI)	Micro- and macroevolution; misconceptions about evolution (same across conditions)	Not addressed	Not addressed	Not addressed
Intervention: Research-based instructional strategies (~30 minutes of instruction). (RBI)	Micro- and macroevolution; misconceptions about evolution (same across conditions)	Religious scientist video (Dr. Francis Collins discussing his religious beliefs and science).	African-American female evolutionary biologist discusses the importance of evolution in a socially-relevant context (saving human lives).	Curriculum materials on different ways of knowing and the boundaries of scientific inquiry. Religion and science was discussed.

Results

(RQ1) What pre-course patterns of evolution acceptance, conflict, religiosity, and knowledge characterize biology students in terms of race?

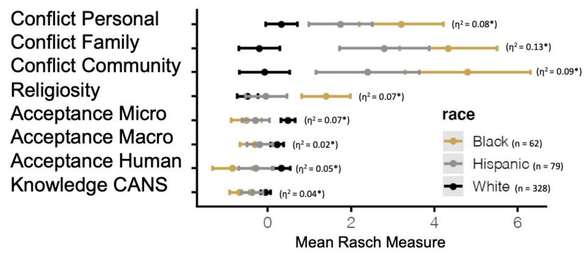

Figure 1. Pre-course Rasch measures for acceptance, conflict, religiosity and knowledge variables in STEM students. Black and hispanic STEM majors have higher conflict, lower acceptance, and lower knowledge than white STEM majors. Error bars reflect two standard errors. Eta squared values (η^2) are reported (small effect = <0.01, side, medium = 0.06; large> 0.14). *Indicates $p < 0.001$.

Results

(RQ2) To what extent does standard instruction (SI) and the addition of research-based instructional strategies (RBI) impact key variables?

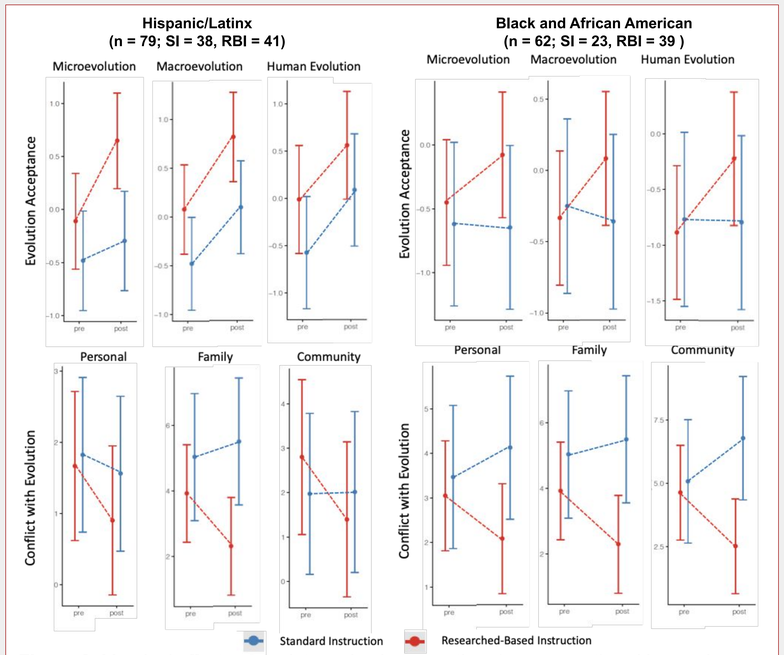

Figure 2. Marginal effects of the interaction between time (pre vs. post) and instruction type (SI vs. RBI). For both Hispanic and Black STEM majors, the role of instruction in acceptance of and conflict about evolution often depended on the type of instruction received. Overall, although evolution knowledge increased in both semesters ($p<0.05$, η^2G = 0.07-0.12, not shown), RBI semesters showed a steeper increase in acceptance and a steeper decline in conflict than SI semesters (see above). Error bars reflect two standard errors.

Conclusions and Next Steps

A major finding of this study is that URM students in both samples began biology instruction with significantly and meaningfully lower evolution knowledge, lower evolution acceptance, higher levels of conflict with evolution (at multiple scales), and higher religiosities than non-URM students. These patterns corroborate concerns of an uneven educational environment for biology students from different backgrounds at the beginning of their first biology course. Although both traditional and RBI conditions were associated with significant increases in evolution knowledge, the traditional course had minimal impact on student conflict or acceptance of evolution. For URM students, conflict measures in some cases increased in response to traditional instruction. The brief (<30 min. total) research-based interventions had positive effects for URM students long after (>12 weeks) implementation. Given that we found that limited intervention dosages can yield significant effects, it is clear that institutional structures can (and must) be modified to prevent the perpetuation of inequities documented at pre-course. Family compatibility with evolution and family reactions to student interest in an evolutionary biology careers also emerged as significant and meaningful variables that are the focus of ongoing investigation. Pre-course patterns in URM students appear to be harbingers of downstream disparities in degree pursuits and career participation in the ecological and evolutionary sciences.

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Funding and Contact Information

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