Using student-centered activities to promote a better understanding of how evolution applies to human health

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Introduction

Recently, the biology department has embarked upon an initiative to include Evolution Across the Curriculum through student-centered learning modules in all of our core courses. A large number of biology majors and non-majors enroll in the two course anatomy and physiology sequence; therefore, providing an opportunity to educate students about the role of evolutionary processes in shaping human health and disease. Modules were developed for this series course to give students an appreciation for how an understanding of evolution is key for advancing the field of medicine. Here we present a set of student-centered activities developed to address key gaps in student understanding of evolutionary processes and how they pertain to human health and disease. We will be focusing on those modules developed for the first course in the series, Human Anatomy & Physiology I (Human A&P).

Learning Objectives

Topics deemed most appropriate for the Human A&P course were determined based upon a departmental survey that evaluated the amount and type of coverage of evolution content coverage across the core courses.

Course-specific Learning Objectives for Human A&P:

1. Students should be able to explain the role natural selection plays in human evolution with specific regard to human health and disease.
2. Students should be able to acknowledge that evolutionary processes are random and do not lead to perfection.

Approach

1. Student-centered content modules and assessments for these modules were developed.
2. Modules were deployed in control & experimental sections in Fall 2012.
3. Effectiveness of assessment questions were evaluated.
   a. Individual learning gains were compared across sections.
   b. Difficulty & discrimination analyses used to evaluate the quality of assessment questions.
4. Assessment questions were modified modules & assessments deployed again in two sections of Bio 312 Spring 2013 semester.

Module Promoted a Better Understanding of Evolution

Module & Assessment Tool Evaluation:

FALL 2012	control (n=62)	exper (n=138)
% improvement	17.3	17.9
Individual learning gains	0.22	0.21
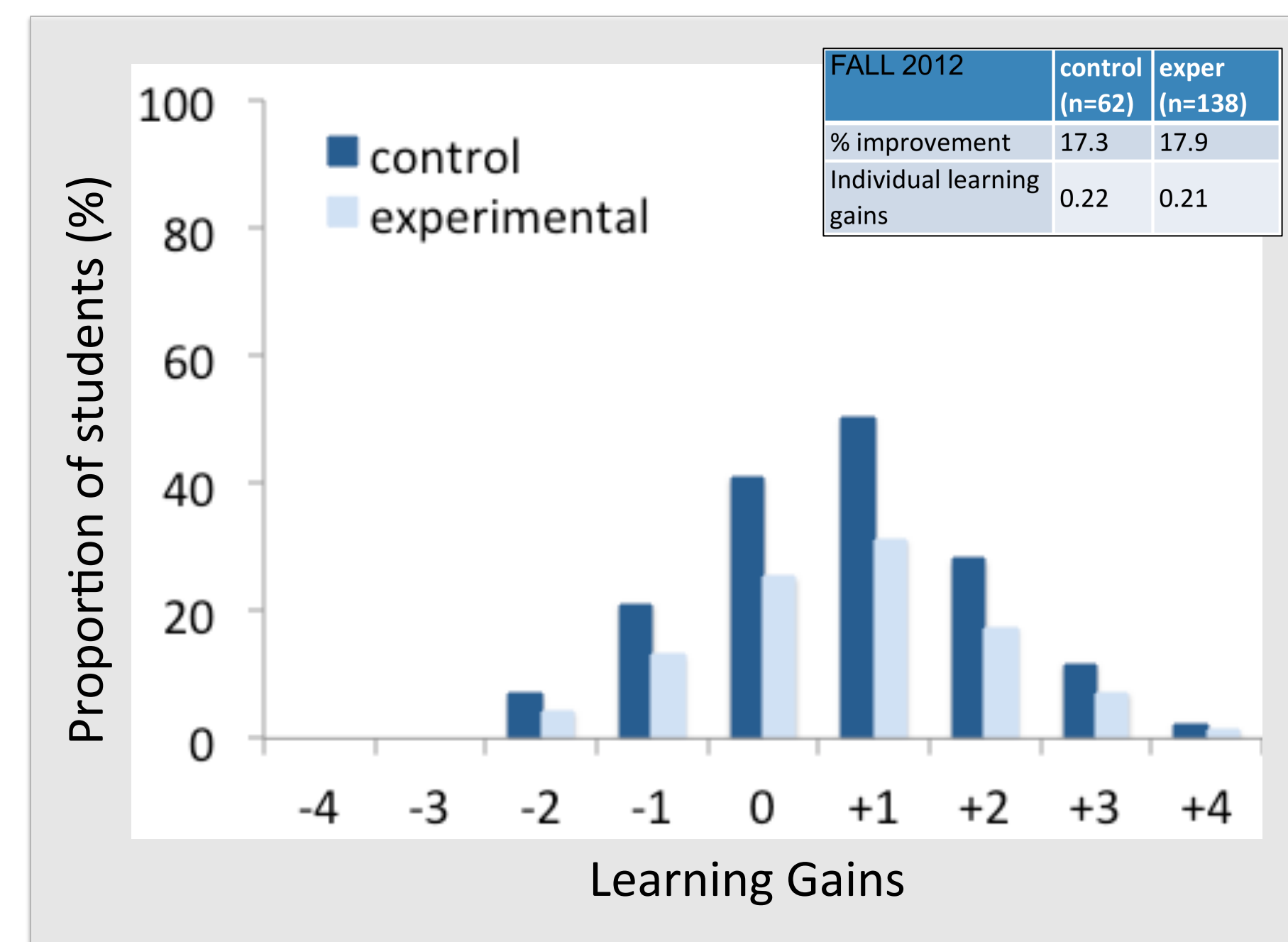
FALL 2012	Natural selection applies to humans				Evolution does not lead to perfection			
	pre-test		post-test		pre-test		post-test	
	Q9	Q10	Q11	Q12	Q7	Q8	Q9	Q10
difficulty	0.29	0.53	0.35	0.43	0.58	0.83	0.59	0.32
discrimin hi-lo	0.91	0.79	0.73	0.87	0.81	0.50	0.90	1.00

Implementation:

SPRING 2013	All	Natural Selection	Evolution is not perfect
% improvement	22.6	31.9	13.3
Individual learning gains	0.13	0.37	-0.49
Majors (39%)	0.32	0.38	0.21
Non-majors (61%)	0.002	0.36	-0.94

Overall understanding of evolution

Natural selection applies to humans

Evolution does not lead to perfection

Pilot Findings

- Showed negative learning gains in experimental population
- It was determined assessment tool was not reliably assessing evolution concepts.
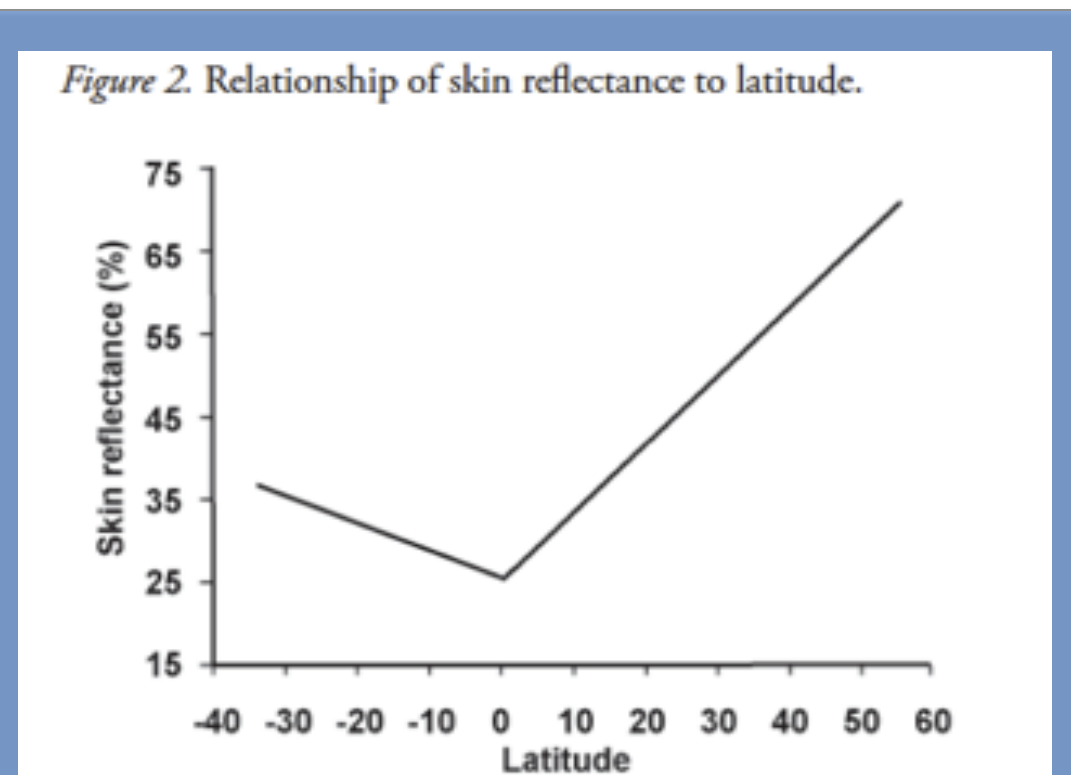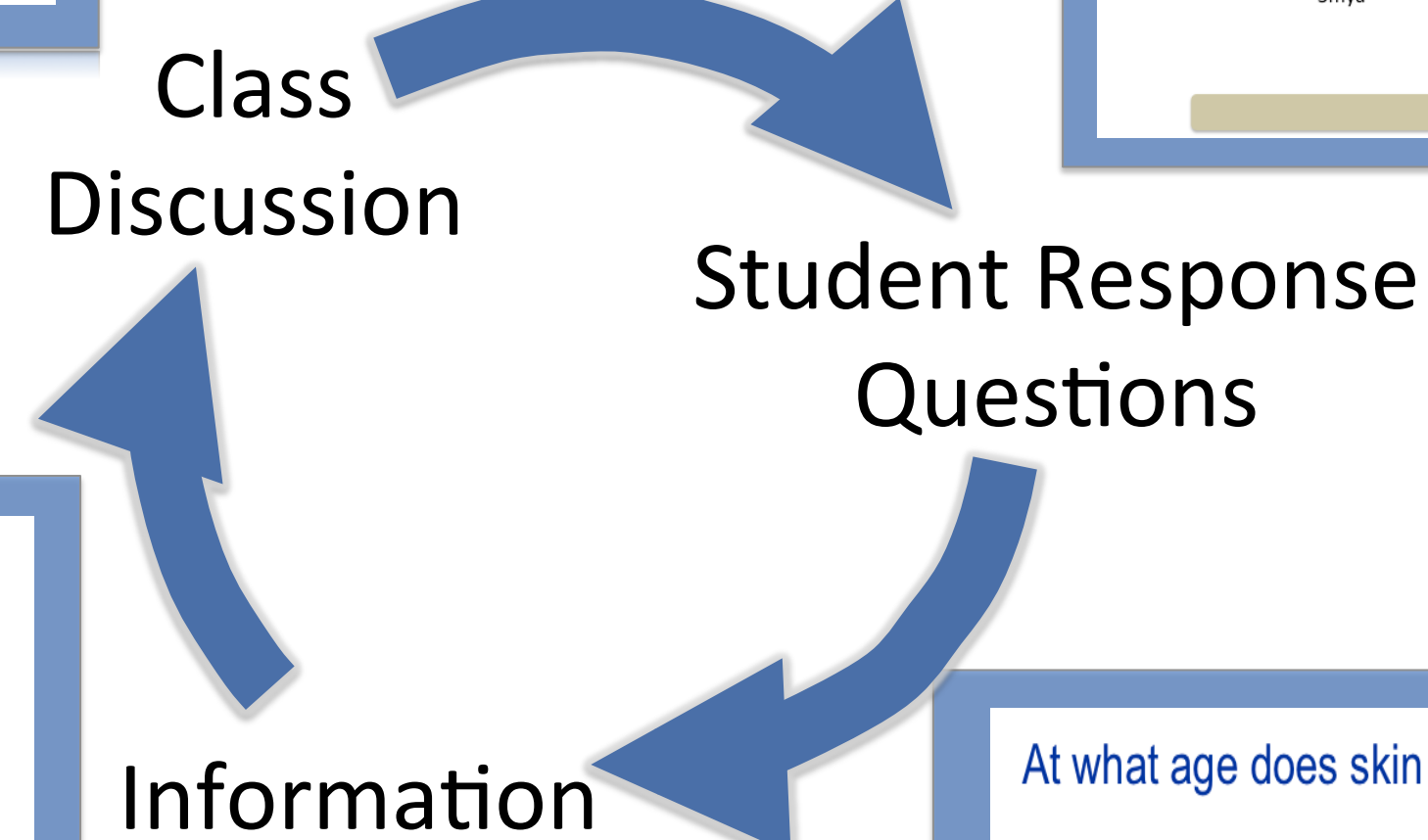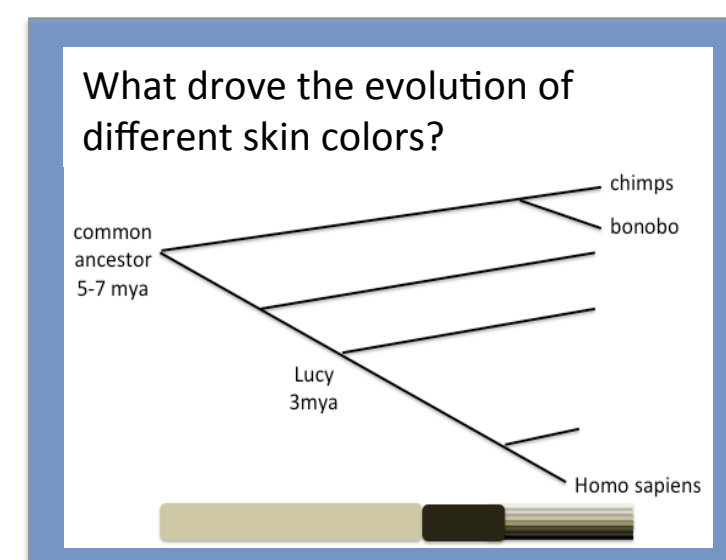- Assessment tool was modified and study repeated
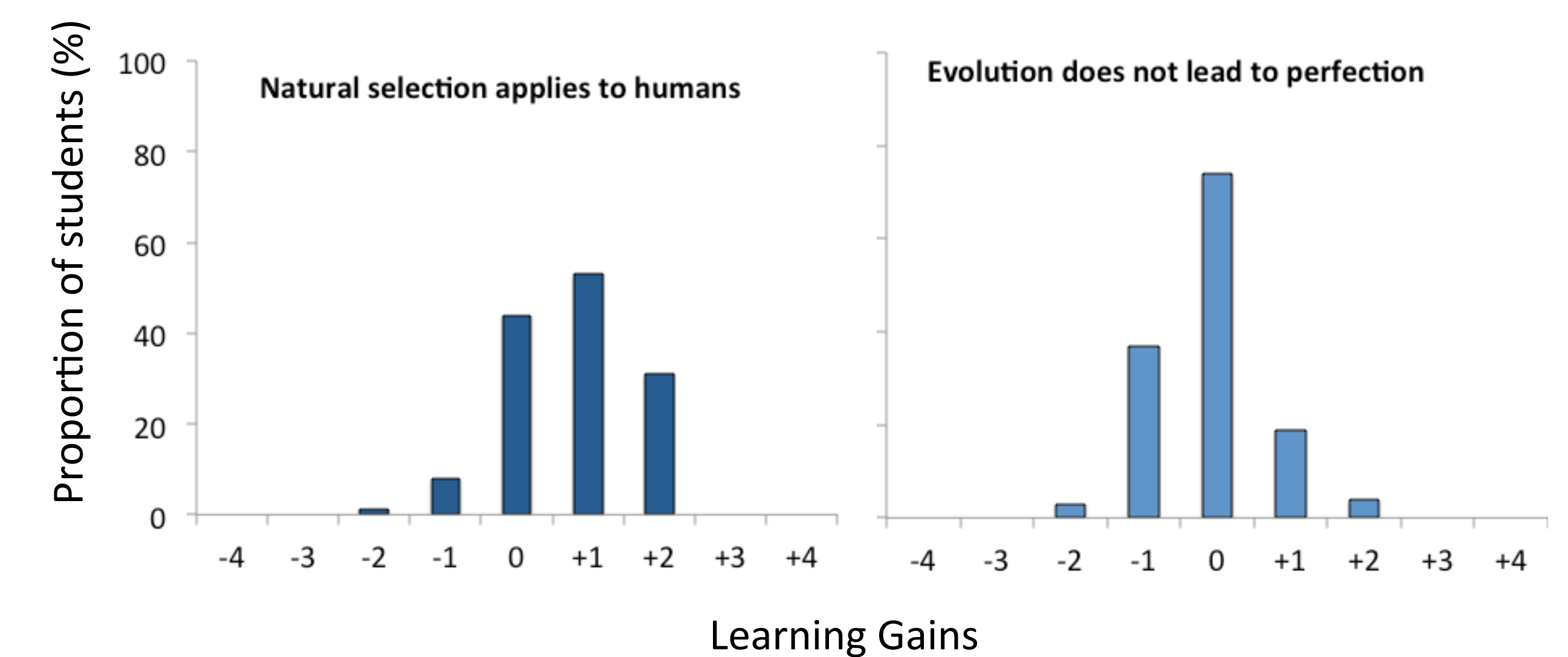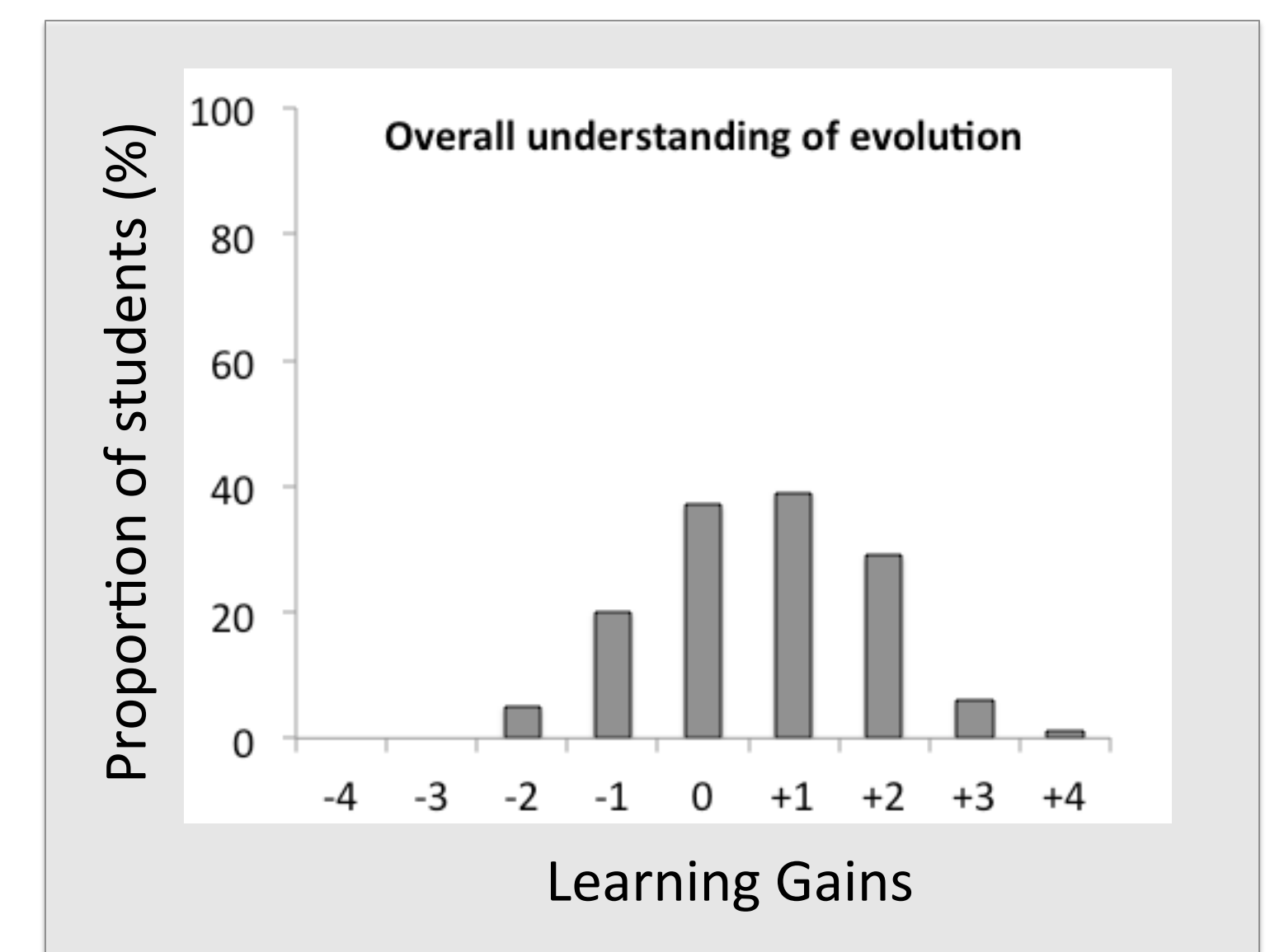
Major Findings

- Modules were effective at promoting a better understanding of evolution, particularly applying natural selection to human health
- Majors showed greater gains as compared to non-majors (possibly due to prior exposure to evolution concepts?)
- Students, particularly non-majors, struggled with the concept that evolution does not lead to perfection

Learning Module: Evolution of Skin Color

Re-think your hypothesis. Do you think that protection from UV-damage could drive the evolution of skin color? Why or why not?

What drove the evolution of different skin colors?

Class Discussion → Student Response Questions → Information →

Figure 2. Relationship of skin reflectance to latitude.

At what age does skin cancer typically occur?
a) Infancy
b) Early childhood (teen years)
c) Early adult hood (20-30)
d) Later in life (>40 years)

Assessment Tool: Pre- & Post Test

- Pre- & Post-tests were vignette-style multiple choice questions delivered through D2L at the beginning & end of each semester
- Each learning goal was evaluated with at least two questions
- Distractors were common misconceptions
- To decrease pre-test questions influencing students' answers on the post-test, different sets of questions were used
- Item difficulty & discrimination were used to evaluate assessment tool
- Gain scores were calculated as averages of individual student learning gains

Item difficulty (correct answer).

Below 20%	Unacceptable – revision to be more attractive or others less attractive
Between 20-47%	Needs revision to be more attractive
Between 47-78%	Acceptable (62% is optimal for correct answer) Needs revision to be less attractive, or other distractors need revision to be more attractive
Above 78%	

Item Discrimination.

Negative	Unacceptable: check item for error
0-24%	Unacceptable: item should be improved
25-39%	Good question
40-100%	Excellent question

Individual learning gains formula:

$$\frac{(post\text{-}assessment - pre\text{-}assessment)}{(100\%^* - pre\text{-}assessment)} \times 100\%$$

*If a student scores 100% on the pre-assessment, then must record 99% as pre-assessment scores.

*If same student scores 100% on both pre- and post-assessment, record 99% for both

Where do we go from here?

- Continued assessment of student learning gains
- Development of a new module to reinforce the concept of evolution not leading to perfection
- We have developed smaller "mini-modules" to address different learning goals for the second of the A&P series course
- Comparison of extensive modules (described here) with shorter, less active modules to foster deeper understanding of impact of evolution on human health and disease

Acknowledgements