Science requires the ability to think critically, which needs to be learned in science class if students are to graduate from college with more than a superficial and marginal understanding of the natural world (Boyer Commission on Educating Undergraduates in the Research University, 1998). Preliminary data suggest that UGA science-majors tend to be reluctant to accept critical thinking as a valuable learning skill, and are performing significantly worse on exam questions that test critical thinking (N=26: 55% correct) compared to questions that test remembering and basic understanding (N=100: 72% correct; Chi2; df=1: Pearson's= 15.864; p< 0.001). It was the goal of this project to determine whether the inclusion of short answer/essay questions on exams makes students (a) less resistant to critical thinking, and (b) better critical thinkers.

The subjects in this study were students in BIOL 1108 (Principles of BIOL II) for science majors. Most of these students (>65%) aspire a career in the health professions. BIOL 1108 is a 4-credit class with 3 lecture hours per week and a weekly 90-minute lab period. The major focus of this class is organismal biology (emphasis on animal and plant physiology and ecology), which is taught from an evolutionary perspective.

During Spring 2009, two BIOL 1108 classes were taught by the investigator. The two classes differed only in exam format (multiple choice only in the 9am class versus multiple choice + short essay in the 2:30pm class), all other assessments (student attitudes, student demographics and study activities, as well as pre- and post-tests) were the same. Most assessments had been previously tested for reliability (IRB #2007-10197-2), the four study surveys were specifically designed for the purpose of this study. One graduate student assistant attended all the classes, worked with the instructor on question design, and graded the short essay questions on the four lecture exams and the final exam.
direct comparison. The exams were administered in the two classes on the same day, and all exams were collected in both classes. To ensure that the difficulty level of the exams in the two classes were equivalent, question variants were created on the same Bloom levels. In addition, the relative contribution of questions from different Bloom levels was the same.

**Study Strategies:**
As part of their class grade, students completed four study surveys (e.g. how they studied, when, and how much). In addition, they submitted two samples of their study notes (along with study survey 2 and 4), which illustrated typical study notes (sample 1) or study notes for critical thinking (sample 2).

**Student Attitudes:**
Student demographics, their attitudes towards learning, their motivation and engagement were assesses with five extra-credit learning surveys.

**Data Analysis:**
I am presently compiling all the data for the analysis. In the MC group (9am class), 260 students were in class and >90% consented to participate in this study. In the MC+short essay group (2:30pm class), 180 students were enrolled and >90% consented to participate in this study. For all exams (four lecture exams and one cumulative final exam) student performance will be scored for all questions by question type (MC or short essay), and by learning level: Remember & Understanding (Bloom levels 1&2) or Critical Thinking (Bloom levels 3-6).

Statistical analyses will test for differences in attitudes, study strategies, and exam performance by learning levels (with pretests and student demographics accounting for pre-existing variation, and pre-posttest comparisons measuring learning gains).

**Findings:** Describe your findings and how the research project impacted student learning.

The data have not been analyzed yet. However, I was very surprised by how poorly students did on the writing portion of their exams. Not only writing itself (e.g. sentence structure) was poor, but also the content was lacking and so were reasoning skills. A detailed quantitative analysis of the exam answers, will serve to test this first (subjective) impression, and whether/how the outcome of this analysis is related to study habits and student learning. It will also serve to assess potential differences in learning outcomes and attitudes towards critical thinking between the two treatment groups (classes).

**Conclusions/Recommendations:** Describe any conclusions and recommendations based on findings and overall study (not already covered in your findings section).

Not available yet.

**Dissemination:** Include information concerning presentation proposals you have submitted this year (e.g., seminars, conference presentations, roundtable presentations) and/or articles submitted to journals.
The results will be published in a Life Science Education journal. They will also be shared with colleagues at UGA (seminars, Faculty Learning Community on Critical Thinking, Educator discussion group) and beyond.