REVEALING GENERATION 1.5 STUDENT AWARENESS OF ACADEMIC SELF-EFFICACY TO LEARN BIOLOGY THROUGH INQUIRY

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ABSTRACT from Original Proposal for Preliminary Study in Spring of 2011

College non-major Biology classes require students to have academic self-efficacy to be successful. However, many students come to Biology courses with inadequate self-efficacy. The purpose of this study is to determine a method for Generation 1.5 students to accurately detect their academic self-efficacy and take appropriate action to advance their conceptual understanding of Biology. This study has two phases. The first phase, a preliminary study, was completed with 16 students in spring 2011 using BSCS *Biological Perspectives* as the inquiry-based curriculum. The second phase of the study will be conducted in summer of 2011. Three instruments are used: 1) a student self-efficacy questionnaire, 2) scientific understanding tests, and 3) individual interviews. One scale of the SMTSL Student Motivation Towards Science Learning questionnaire measures self-efficacy. It was found to have a high correlation with achievement scores (Tuan et al., 2005). Most findings from phase one of this study have not risen to the level of statistical significance. However, there is some hint that the results may be educationally meaningful and may substantiate the findings of Tuan. For this reason, the authors will broaden the study in the second phase to another 64 students to determine whether results might be more generalizable.

CONCLUSIONS from Follow-Up Study in Summer of 2011

Paired Samples *t*-tests were conducted on the data to evaluate the change in self-efficacy. Pre and post scores were compared for each student on each of the 12 questions on the self-efficacy questionnaire. The authors found no significant difference between student ideas from the pretest compared to the posttest on questions 1 through 8 and 10 through 12. Only question 9 showed a statistically significant increase in self-efficacy scores from pretest (M=3.0444, SD=1.107) to posttest (M=3.3466, SD=0.908), t (45) = 2.145, $p<0.05$ (two-tailed). The mean increase in SBSEQ scores was 0.311 with a 95% confidence interval ranging from 0.60339 to 0.01888.

Paired Samples *t*-tests were conducted on the data to evaluate the change in conceptual understanding. Comparing classes by instructor, the authors found no significant difference between the two classes in student performance from the pretest compared to the posttest. In a comparison by gender of data combined from the two classes, females showed a statistically significant increase in scores from the pretest (M=4.06, SD=1.600) compared to the posttest (M=4.67, SD 1.451), t (32) = 2.07, $p<0.05$ (two-tailed). The mean increase in conceptual understanding scores was 0.606 with a 95% confidence interval ranging from 1.200 to 0.012. There were more females than males in the study (females = 32, males = 14).

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ORIGINAL PROPOSAL TO NABT

Introduction

Colleges and universities require that all students take a science lecture and lab. Many students choose Biology. This requirement provides an important hurdle for students to cross. College non-major Biology classes require students to have academic self-efficacy to be successful. Zimmerman (1995) defines academic self-efficacy as personal judgments of one's capabilities to organize and execute courses of action to attain designated types of educational performances.

Many students come to Biology courses with inadequate self-efficacy. Further, instructors have no formal means of diagnosis and relevant intervention. Research shows that students who are self-efficacious are more successful in persisting and engaging in activities that lead to conceptual change, a key skill in learning Biology through inquiry. With an understanding of students' levels of academic self-efficacy, particularly as it relates to Biology, instructors can intervene appropriately to foster self-efficacy.

Subject/Problem

Research in academic self-efficacy draws attention to the importance of fostering self-belief and self-regulatory capabilities in students (Zimmerman, 1995). The purpose of this study was to determine a method for students to accurately detect their own academic self-efficacy and take relevant action to advance their conceptual understanding of Biology. The goal is to enable students to improve in their ability to assess their own capabilities as either sufficient or insufficient to achieve a pertinent academic outcome.

Students in both a four year state university and a community college take equivalent courses for non-majors in Biology in their freshman or sophomore year. The authors noted a mismatch between the students' perceived self-efficacy and instructor expectations of the behaviors associated with academic success and engagement. In addition, students' generally had less prior knowledge and experience with Biology concepts and skills than would be expected for these courses. Thus, they tended to not be successful.

The majority of the authors' students are from a demographic background that is currently being described in the literature as Generation 1.5. This term refers to the increasing number of U.S. high school graduates that enter college while still in the process of learning English. The label 1.5 is derived from the shared characteristics of both first- and second-generation immigrants (Rumbaut & Ima, 1988).

The authors follow a constructivist theory (Mintzes et al. 1998, Von Glaserfield 1998) for teaching and learning Biology. Students must take an active role in constructing new knowledge in order to connect their prior knowledge with the laboratory experiences. Otherwise, they will not achieve the anticipated deeper understanding required at the college level. These students are unprepared for rigorous science inquiry due to reasons explained in the literature on Long Term English Learners. These LTELs are defined as:

> English Learners who have been in the United States 7+ years, are orally fluent in English, but reading and writing below grade level, and have low literacy in the home language, if any (Olsen & Jaramillo, 1999).

In their K-12 education, LTELs have been unnoticed and their needs have gone unmet. Over the course of many years in school, they have “amassed gaps in language development that have impacted their access to and achievement in academic content areas” (Olsen, 2010, p. 26.) To be successful in college they need to be made aware of the inadequacies of their mental schema for science inquiry. They graduated from high school following a paradigm for learning based on memorization of material for recall. They “developed habits of non-engagement, learned passivity and invisibility” in the classroom (Olsen, 2010, p. 24.). They will need to understand that this paradigm must shift to meet their general education college requirements.

For all students, especially in science, self-efficacy is important in influencing them to construct and reconstruct their conceptions toward more scientific understanding (Pintrich et al., 1993). By linking awareness of academic self-efficacy with progress toward scientific conceptions, the authors hope to demonstrate what Tuan et al. (2005) found:

> . . . when students perceived that they are capable, and that they think the conceptual change tasks are worthwhile to participate in, and their learning goal is to gain competence, then students will be willing to make a sustained effort and be engaged in making conceptual change.

Design/Procedure

This study has two phases. The first phase, this preliminary study, was completed with16 students in the spring of 2011. The second phase will be implemented with at least 64 additional students in at least two course sections during the summer of 2011. The study uses three instruments: 1) a student self-efficacy questionnaire, 2) scientific understanding tests, and 3) individual interviews. Each of these is briefly described below along with the overall design, timeline, and procedures used.

1) <u>Self-Efficacy Questionnaire</u>: The self-efficacy tool used in this study tested the factor of students’ belief in their own ability to perform well in science learning tasks. This tool had seven questions. The items were constructed using a five-point Likert scale from 1 Strongly Disagree to 5 Strongly Agree (Tuan et al., 2005). This questionnaire was administered twice, a pretest one third of the way through the 16 week course and again as a posttest at the end. Five of the seven questions were worded in reverse form. This tool was selected because of its confirmed validity and reliability as a scale in the SMTSL Student Motivation Towards Science Learning questionnaire. Among six scales of SMTSL, self-efficacy had a high correlation with achievement scores (Tuan et al., 2005).

2) <u>Scientific Understanding Tests</u>: Administered along with this instrument was a tool for evaluating scientific understanding. This tool was selected from the research-based curriculum used as the course textbook, *Biological Perspectives* by BSCS (Biological Sciences Curriculum Studies, 2006). This college text for non-majors presents active, collaborative, and inquiry-based

instruction by providing a variety of experiences that challenge students to think, discuss, and write about information they are learning. This curriculum uses innovative learning strategies. Students are actively engaged in learning from each other, encouraging joint intellectual effort. The pretest and posttest were different in topic and appropriate to the prior instructional unit, but were equivalent in response type and number of items. Content validity of this instrument was achieved by comparing responses from several instructors of the equivalent Biology course at the four year state university and community college. A total score from one to six was calculated for each test, Pre- and Post-, of this instrument.

3) Individual Interviews: Interviews were conducted at the end of the semester by one of the authors with eight (one half of the sample of 16) students. These students were chosen because they had scored from two to four points differently on the Likert scale for one or more items from Pre- to Post- self-efficacy questionnaire. Their reasons for the change in their scores were recorded and compiled in a table for review.

Some revisions or additions to the instruments and procedures are anticipated for use in the second phase of the study. Data will be collected from students in at least two additional classes during the summer session. These sessions will have 32 students each, for an expected minimum total of 64 students. This higher number of subjects will enable an increased sample size and may contribute to more generalizable conclusions. Effect size, which is a measure of the magnitude of the observed effect or strength of the observed relationship, will be assessed for significant findings by calculating the Cohen's *d* value. (Cohen, 1988). Effect sizes will not be computed when using a paired samples *t*-test, however, per the warning issued by Becker (2000).

Using information gleaned from the interviews, reverse items will be reworded and a few additional items will be added to the self-efficacy questionnaire. Revisions in the wording of some items on the self-efficacy questionnaire and the additional items will then be validated. The analysis of the revised self-efficacy survey will use a Cronbach alpha reliability coefficient with the individual student as the unit of analysis. The authors may also revise the conceptual understanding tool to be equivalent in topic as well as response type and number of items. This should facilitate the detection of any changes in depth of understanding.

Analysis and Findings

In an initial analysis using MS Excel®, increases in scores showed that almost two thirds of the class, ten out of 16 students, improved in conceptual understanding from pretest to posttest. Half of those who improved in conceptual understanding also improved in self-efficacy. The other five students did not appear to improve according to increases in their self-efficacy scores. However, two of these students were included in the individual interviews. These students explained changes in their responses in such a way that the changes could be considered to show increases rather than decreases in their self-efficacy. The other three students who improved in conceptual understanding were not interviewed because their Pre- Post- self-efficacy scores did not differ by more than one point in either direction on any of the seven items. The six students who did not improve in conceptual understanding also did not improve in self-efficacy.

In further analysis using IBM SPSS v19® statistical software, Paired Samples *t*- tests of the pretest and posttest scores showed no significant difference in self-efficacy. Paired Samples *t*-tests of the pretest and posttest scores showed no significant difference in conceptual understanding of Biology. Pearson Correlation test showed a significant correlation only between the pretest conceptual understanding score and the pretest self-efficacy score. No significant correlation was found between posttest conceptual understanding score and the posttest self efficacy score.

Analysis of the interview data found that some of the reasons, such as change in the perceived difficulty of the Biology content or lab activities, could be linked to items on the self-efficacy questionnaire. However, others related more to changes in factors such as: amount of studying done outside of class, comfort in reading the textbook, level of participation in cooperative groups, ability to do more challenging writing assignments, and depth of learning from researching and giving presentations to the class.

Interviews with students who scored two or more points differently on their posttest versus pretest self-efficacy scores uncovered two important problems with question interpretation:
1) <u>Reverse Items</u>: Some students did not understand the way the question was worded in reverse items. The authors speculated that their unique linguistic background as LTELs, mostly from Spanish-speaking homes, could explain this failure to understand the use of the (double) negative in English.
2) <u>Item Mis-Interpretation</u>: Some students provided unexpected explanations for changes in their responses on the Likert scale. For example, one student reversed his score on item six. On the pretest, he interpreted the item as contrasting independent thought with peer dependence. On the posttest, he interpreted the item as contrasting working in isolation with working in collaborative groups.

Thus far, most findings from phase one of this study have not risen to the level of statistical significance. However, there is some hint that the results may be educationally meaningful and may substantiate the findings of Tuan. For this reason, the authors will broaden the study in the second phase to another 64 students during summer 2011 to provide a broader basis upon which to generalize findings. They will present results for the preliminary study with this initial group from phase one of the investigation and for the extended study with additional student groups from phase two.

In the second phase of the study, the authors plan to clarify directions and interpretations to the students for self-efficacy items whose wording was confusing to the students. Additional items may be added to address factors not included in the seven items from the SMTSL used in the first phase of the study. This may produce a more robust instrument capable of determining whether there is a strong or weak or any correlation between gains in conceptual understanding and self-efficacy.

The authors also intend to further increase content understanding by incorporating some techniques from the literature on Generation 1.5 students and Long Term English Learners. These strategies should improve the effect of the intervention, the inquiry-based BSCS curriculum.

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Contribution

This study contributes valuable insights into learning of Biology on the part of Generation 1.5 students. It revealed changes in how students perceive science and its relevance to their lives. The study also influenced their attitudes toward effective strategies for science learning. In addition, the study showed progress in making them aware of their academic inadequacies for learning science through inquiry. This study may also have important implications for other students who are not LTELs but who too need support in Biology classes for non-majors.

General Interest

This study builds on the research done by Tuan et al. (2005) extending the use of one scale of their SMTSL questionnaire to college students. Assessing student self-efficacy has been found to be a key affective component in effecting conceptual change. This study could be expanded by other researchers in additional courses for non-majors such as Biology for Future Teachers and Physiology for Physical Therapists and Occupational Therapists. This could provide much needed answers to the problems of enhancing science literacy across diverse cultural and educational backgrounds.

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FOLLOWUP STUDY

Methodology

1) Academic Self-Efficacy Pre- Post- Test: The authors revised the Student Science Self Efficacy Questionnaire in three ways from the preliminary study for use with the two summer sessions. First, the word "science" was changed to "Biology" in the title and in the questions. Thus, the instrument became the SBSEQ Student Biology Self Efficacy Questionnaire. Second, the original questions that were presented in a negative format were restated in a positive format. Negatively formatted questions had caused difficulty in comprehension for the participants in the preliminary study who were mostly English Learners. The authors changed the wording so that the intended ideas would be understood. Third, the authors added five questions to the survey for a new total of 12 questions.

The added questions were designed to reveal: 1) Whether students perceived their role in the classroom as working alone rather than sharing ideas with their peers in small groups, 2) Whether students preferred to get ideas from other students rather than think for themselves, 3) Whether students preferred to learn through memorization of facts rather than to figure out concepts through class participation, 4) Whether students would answer a question in class even when they were not confident of their understanding , and 5) Whether the students felt the teacher should just "tell students what they should know" instead of asking students about their ideas. Students self-rated how confident they were about their own Biology learning on a Likert scale of 1 to 5, from Strongly Disagree to Strongly Agree with the statements.

2) Conceptual Understanding Pre- Post- Test: The authors also revised the test for conceptual understanding of the content from the preliminary study for use with the two summer sessions. The test still required students to interpret textual and graphic information. It still asked students to interpret any claims made from the evidence. However, the authors decided to use a pretest that would be identical to the posttest, rather than only similar as in the preliminary study. They selected a topic commonly used during the study of Evolution in Biology classes for non-majors: Natural Selection and the Case of the Peppered Moth. An English geneticist, Henry Bernard David Kettlewell (1907-1979), first noticed industrial melanism in the peppered moth.

This four question test asked students to interpret three short paragraphs of background information, a data table, and a set of three graphs. In between the pretest and the posttest, this experiment was studied in more detail with a simulation activity in the lab. Students pretended to be predator birds eating the moths as their prey. Questions 1 and 2 were completion items scored with one point each. Questions 3 and 4 were short answer items scored with zero to two points each. Total scores ranged from 0 to the maximum possible of six points. The authors had an inter-rater reliability of 3.8% (from initial disagreement on only seven of 184 variables from 45 subjects with four scored variables each.)

3) Individual Interviews: The author/interviewer for the Preliminary Study was out of town at the end of the summer session. Therefore, interviews were conducted by the other author who was not one of the instructors for the summer session. This time the students self-selected for interviews because there was not time to score the posttests before conducting interviews. The

interviewer prompted the students to volunteer for an interview based on a prompt: “If you feel that you have changed your confidence and/or study habits during this intensive summer Biology course, please place a green dot on your posttest. Then I will call you up individually to discuss your ideas.” Their reasons students gave for their perceived changes in confidence or study habits were recorded. They were later compiled in a table for review.

Analysis and Findings

1) Academic Self-Efficacy Pre- Post- Test: Paired Samples *t*-tests were conducted on the data to evaluate the change in self-efficacy on the SBSEQ. Pre and post scores were compared for each student on each of the 12 questions on the self-efficacy questionnaire. The authors found no significant difference between student ideas from the pretest compared to the posttest on questions 1 through 8 and 10 through 12. Only question 9 showed a statistically significant increase in SBSEQ scores from pretest (M=3.0444, SD=1.107) to posttest (M=3.3466, SD=0.908), t (45) = 2.145, $p<0.05$ (two-tailed). The mean increase in SBSEQ scores was 0.311 with a 95% confidence interval ranging from 0.60339 to 0.01888.

Question 9 asked students to disagree or agree with the statement: “I never answer a question in class unless I am positive of having the correct answer.” Students disagreed with this statement more strongly at the end of the semester than at the beginning. Possibly they were more confident of their learning. Perhaps they were more willing to risk giving an incorrect answer in order to check for their own understanding.

2) Conceptual Understanding Pre- Post- Test: Paired Samples *t*-tests were conducted on the data to evaluate the change in conceptual understanding of Natural Selection and the Peppered Moth. Comparing classes by instructor, the authors found no significant difference between the two classes in student performance from the pretest compared to the posttest. In a comparison by gender of data combined from the two classes, females showed a statistically significant increase in scores from the pretest (M=4.06, SD=1.600) compared to the posttest (M=4.67, SD 1.451), t (32) = 2.07, $p<0.05$ (two-tailed). The mean increase in conceptual understanding scores was 0.606 with a 95% confidence interval ranging from 1.200 to 0.012. There were more females than males in the study (females = 32, males = 14).

3) Individual Interviews: Students in the follow up study that were interviewed revealed some strategies that were used to achieve success. One student said "Our instructor gave us extra credit for flashcards, lecture notes. She showed me how to make terms more understandable by simplifying the definitions to five words. My study habits changed. I used the same amount of time only I used my study time more effectively.” Another student commented, “I found better ways to study by isolating myself from others. Quiet or music but no distraction. I use highlighting, and conceptual imagery in my head.”

Next Steps

The authors propose to first clearly define the paradigm of Generation 1.5 student perception of self-efficacy to learn Biology through inquiry. Then, they would like to clearly define the paradigm of instructor expectation of student academic efficacy to compare with the student paradigm. Then they will expand their search for a more refined instrument to measure academic self-efficacy for this population. Finally, they will test the new instrument for reliability and validity with additional classes of students at community colleges such as Santa Ana College. They have received permission to broaden their study to include students in equivalent courses at four year universities such as CSU Fullerton. This latter population will likely require Institutional Board Review for Human Subjects Research.

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