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Upward Bound Mythbusters Integrate Knowledge with Skill in Science and Mathematics

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Abstract: *Using an investigative curriculum, High school students in an Upward Bound Program were taught quantitative processes shared in science and mathematics. The mathematics content was limited to what is required in introductory college biology laboratory courses. The television show* "Mythbusters" *was used to present the scientific method to summer program participants. A laboratory activity that tested our ability to accurately predict adult human height was used to reinforce student understanding of linear metric units, calculation of averages, estimation of frequency, parts and notation of fractions, calculation of proportions and percentages, the relation between proportions and percentages, the interpretation of proportions and percentages, graphing data, and accepting or rejecting a scientific hypothesis. After instruction, students stated an increased understanding of this quantitative content*.

Keywords: Problem Based Learning, Mythbusters, Upward Bound, Science, Mathematics

Problem based learning (PBL) is one example of an active method of learning; it requires students to question, speculate, generate solutions, and use higher-order cognitive activities (Biggs, 1999). The goal of PBL is to get students to solve problems; the assessment is based on how well students solve these problems. In PBL, the problems are carefully selected and knowledge is acquired in a working context. In this study, to create a stimulating and relevant working context, we used the television show *Mythbusters* to both present and discuss the scientific method, and demonstrate the process of speculation, investigation, data collection, summation, presentation, and interpretation of evidence.

Mythbusters is now the longest running series on the Discovery Channel; this channel broadcasts to more than 100 million U.S. homes. *Mythbusters* is recognized as a scientific documentary series by the National Science Foundation and its hosts, Mr. Jamie Hyneman and Mr. Adam Savage, were invited to speak at the 2007 national meeting of the American Association of the Advancement of Science (Yikiligan, 2009). Mr. Hyneman and Mr. Savage are also included as co-authors in a peer-reviewed publication on their show's experimental investigation of the penetration of arrows with the shaft sharpened into a tip versus the arrow with an attached stone arrowhead (Waguespack et. al., 2009).

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Using the television show *Mythbusters* as a presentation of the scientific method has been adapted by other faculty teaching a variety of students at different levels of education. For example, Burkley and Burkley (2009) successfully used video clips from *Mythbusters* to present multiple research methods in an undergraduate course in psychology. They found that *Mythbusters* helped their students better understand course concepts, apply their knowledge to real-world research projects, and provided an enjoyable educational experience (Burkley & Burkley, 2009). Astall and Bruce (2010) reviewed how the Mentos and Diet Coke demonstration (highlighted on *Mythbusters* in 2006), where a fountain of froth spews upward for meters, was successfully used by teachers to demonstrate the process of science with an open-ended experiment with undergraduate physics students. This same activity was also used in several undergraduate chemistry courses to engage students in an activity with authentic science focus (citations given in Astall & Bruce, 2010). Howarth and Woollhead (2008, cited in Astall & Bruce, 2010) described the use of the Mentos and Diet Coke demonstration with 12 and 13-year old students as a model for volcanic eruption in an earth science class. Astall and Bruce (2010) extended the use of this same activity to primary-school students. Madsen (2011) described his successful effort to teach science to undergraduate students in non-science majors. "Adventures in Physics: Mythbusters" was explicitly based by Madsen on the television program *Mythbusters*; in this course, students make projects to learn about science as a process. Lastly, Zavrel (2011) describes how high school science teachers can use *Mythbusters* as an engagingly accurate cultural representation of science and engineering, and motivate students to enroll in STEM majors at college.

In spring 2009, the Director of the Upward Bound program at Saint's College asked one of the authors to teach a six-week science course. After discussion about the academic background of the students, the instructor developed a course focusing on data analysis and presentation shared in science and mathematics. This course was taught during the Summers of 2009 and 2013. We present "mythbusting" as an effective practice suited for use by high school and college faculty teaching science and mathematics to the diversity of students in today's classrooms. Here we summarize this investigative, instructional approach designed to follow the principles of Biggs (1999) and Resier et al. (2003). We report a positive outcome on student's perceived learning; afterward, students report that they are knowledgeable in the topics taught.

THE UPWARD BOUND PROGRAM AT SAINT'S COLLEGE

Upward Bound is a competitive grant-funded program administered by the United States Department of Education. Upward Bound began in 1965 as part of the Higher Education Opportunity Act. The mission of the Saint's College (SC) Upward Bound program is to provide academic and social support, on a year-round basis, to educationally and socio-economically disadvantaged high school students from a local partner school. They are targeted because their community-specific exposure to information about college education, and individuals with college degrees, is below the national average for secondary school students. To participate in the SC Upward Bound program, a student (grades 9-12) must be a U.S. citizen, permanent resident, or provide evidence of intent to become a permanent resident, and: (a) come from a family meeting the federal low-income guidelines, and/or (b) be a potentially first-generation college student, and/or (c) have a high risk for academic failure – this may

include evidence of low performance on state-mandated standardized tests, a GPA of 2.5 or below (out of 4.0), and low educational aspirations[1] – at the time of application.

On notification of its first grant award in 2006, the Upward Bound Program at Saint's College began to work with teachers and staff from President High School (PHS) to identify fifty eligible participants. President High School was selected because it was one of the lowest performing high schools in the school district. In an accountability status report from the state's Department of Education in 2006, the school had been designated "School in Need of Improvement" and "School Under Registration Review." Over 80% of the families in the area had household incomes below the poverty level[2], and about 10% of the parents in this population had obtained a four-year degree. In addition, more than 90% of the 9th grade students at PHS had been identified as being at "high academic risk for failure;" they did not meet the proficient level on one or both of the state assessments in reading/language arts and math in grade eight.

The school's low performance prompted the school district to begin a process to redesign and adopt a "school in a school" model in 2007. The original secondary school was thus converted into a preparatory school, Multinational Secondary School (MSS), to serve grades 5-12[3]. Currently, the MSS population includes students from more than 15 countries, with as many different native languages. Approximately 35% of students at MSS are English Language Learners (ELLs) and have been designated as "Limited English Proficient" (LEP) by the school district[4].

During the 2008-2009 academic year, 60 students (grades 9-11) from MSS received services through the SC Upward Bound Program. Of these 60 students, 91.7% met two TRIO Upward Bound eligibility requirements by being both low-income and potentially first-generation college students. Just 6.7% of these 60 students were eligible for the Upward Bound program only as low-income students, and just 1.7% were eligible only as potential first-generation college students. Of these 60 students 61.7% were female and 38.3% were male. In terms of race and ethnicity, 48.3% of these 60 students were Black or African American, 20% were Hispanic or Latino, 16.7% were Asian, 3.3% were White, and 1.7% American Indian/Alaskan Native; 10% of these students reported more than one race or ethnicity. The academic needs of these 60 students was indicated by the fact that 33.3% had limited English proficiency, 11.7% had low achievement test scores, 8.3% had low grade point average, 26.7% had both low grade point average and low achievement test scores, 3.3% had diagnosed learning disabilities, and 1.7% had both low grade point average and low educational aspirations.

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[1] Low educational aspiration is determined by a student interview and survey. A student who self-identifies that they want to attend college but does not believe they can achieve this goal, or does not aspire to it because of perceived circumstances in their life, has low educational aspiration.

[2] In 2006, the poverty threshold for a family of four was $20,614 (Poverty Thresholds 1959-2013, United States Census Bureau).

[3] The full conversion to the new Multinational Secondary School into a College Board School was in 2011-2012.

[4] Limited English Proficient (LEP) describes a student whose native language is not English and who has sufficient difficulty speaking, reading, writing, or understanding English that this student cannot successfully learn in a classroom where English is the language of instruction. At MSS the school district is responsible for determining if a student qualifies as LEP.

During 2012-2013, 55 students (entering grades 9-11) from MSS received services through the SC Upward Bound Program. Of these 55 students, 91% met two TRIO Upward Bound eligibility requirements by being both low-income and potentially first-generation college students; 7% of these 55 students were eligible for the Upward Bound program only as low-income students, and 2% were eligible only as potential first-generation college students. Of these 55 students 57% were female and 43% were male. In terms of race and ethnicity, 44% were Asian, 40% were Black or African American, and 16% were Hispanic or Latino. The academic needs of these Upward Bound students is indicated by the fact that 56% have limited English proficiency, 3.6% have both low grade point average and low achievement test scores, 7.3% have low achievement test scores, 3.6% have low grade point average, and 3.6% have both low grade point average and low educational aspirations.

THE SUMMER ACES PROGRAM

In the partnership between SC Upward Bound and MSS, college students act as tutors and mentors for Upward Bound participants. In addition, MSS teachers and SC staff/faculty participate in the program as mentors and instructors. During the academic year (September-June) and the six-week summer component (July-August), Upward Bound provides instruction in math, laboratory science, composition, literature, and foreign language through its academic coursework and enrichment services (ACES) program.

In spring 2009, the Director of the SC Upward Bound Program asked one of the authors to teach a six-week science course as part of that summer's ACES program; this instructor developed a course focusing on data analysis and presentation shared in science and mathematics. The knowledge and skills taught in this ACES course were limited to content required in introductory college biology laboratory courses: an introduction to the scientific method, linear metric units, calculation of simple averages, estimation of frequency, parts and notation of fractions, the calculation of proportions and percentages, the relation between proportions and percentages, the interpretation of proportions and percentages, graphing data, and accepting or rejecting a scientific hypothesis.

To produce the data students needed for associated calculations, graphical presentation, and interpretation, we used a published laboratory activity that tested our ability to accurately predict adult human height as a mathematical product of another measured body part (Leupold, 2006). The knowledge and abilities associated with this ACES course were in the context of the investigative model illustrated by the television show *Mythbusters* (Table 1). The same ACES course in science and mathematics was also used with Upward Bound students in summer 2013.

In both summers, we showed an episode of *Mythbusters* (Season 1, Episode 9, "Chicken Gun, Octopus Egg Pregnancy, Killer Washing Machine"). This episode first aired in 2004; it is available on DVD and can be found online. We highlighted the *Mythbusters* investigation of the question "Can a woman give birth to an octopus after swallowing an octopus egg?" because the *Mythbusters* explicitly design and present a controlled biology experiment while investigating this question (Hyneman & Savage, 2004).

Table 1: Schedule of Upward Bound Mythbusting Science and Mathematics Activities

2009	2013
Jul. 7 - Looking Beyond Stereotypes **Jul. 9 - Introductions to each other & the summer plan** • Survey given **Jul. 14 - *Mythbusters* DVD** **What do the *Mythbusters* do? How do they do it?** • Viewed episode 9, season 1 • Students write notes on what Mythbuster team members do to test a myth • Students share observations with classmates • Instructor prompts student contribution and summarizes different student observations **Jul. 16 - Busting a myth - Collecting information.** • Working with a partner, each student follows a protocol to measure head size and height, and predict height from head size • Discussion - is the "myth": Busted, plausible, or confirmed based on individual results • Introduction to the meter, decimeter, centimeter, and millimeter **Jul. 21 - Summarizing information** • Calculation of average height and average predicted height for class, all females, and all males • Discussion on the "myth": Busted, plausible, or confirmed based on average results • Estimating frequency of females and males by fraction • Introduction of terms numerator and denominator • What a proportion is • Calculating the proportion as numerator divided by denominator • What a percent is • Conversion of the proportion into a percent **Jul. 23 - Presenting information** • Graphing frequency data as a pie chart • Graphing actual and predicted heights as an x-y line graph • Explanation of terms variable, independent variable, dependent variable, x-axis, and y-axis **Jul. 28 - Interpreting information – is the myth busted?** • Introduced the concept of variation around the average • 95% certainty in science and difference between averages (actual and predicted heights) greater than ± 4.25 cm **Jul. 30 - What new myth can we bust?** • Students identify and discuss possible myths to test **Aug. 4 - What information do we need?** • Students identify and discuss the information needed to test their myths • Survey given	**Jun. 25 – Survey given** • Looking Beyond Stereotypes: • Introduction to each other & the summer plan **Jul. 2 - *Mythbusters* DVD** **What do the *Mythbusters* do? How do they do it?** • Viewed episode 9, season 1 • Students write notes on what Mythbuster team members do to test a myth • Students share observations with classmates • Instructor prompts student contribution and summarizes different student observations **Jul. 11 - Busting a myth - Collecting information** • Working with a partner, each student follows a protocol to measure foot size and height, and predict height from foot size • Discussion - is the "myth": Busted, plausible, or confirmed based on individual results • Introduction to the meter, decimeter, centimeter, and millimeter • Calculation of average height and average predicted height for class, all females, and all males • Discussion of the "myth": Busted, plausible, or confirmed based on average results ***Jul. 18 – power outage, activities cancelled*** **Jul. 25 – Summarizing information** • Estimating frequency of females and males by fraction • Introduction of terms numerator and denominator • What a proportion is • Calculating the proportion as numerator divided by denominator • What a percent is • Conversion of the proportion into a percent **Jul. 26 - Presenting information** • Graphing frequency data as a pie chart • Graphing actual and predicted heights as an x-y line graph • Explanation of terms variable, independent variable, dependent variable, x-axis, and y-axis • Survey given

During the approximately one hour of time a student spent in class on a given day, each student worked with a self-selected partner to complete scheduled activities and calculations (Table 1). Because few numbers were used in the calculations, and the operations required addition and subtraction, or multiplication and division, students used paper and pencil for all calculations. During class the instructor circulated through the room to interact with students and evaluate their work. This allowed him to confirm that students understood what to do and how to do it, to identify mistakes and prompt students to recalculate, and to confirm right answers. When needed, the instructor also gave brief presentations and led class discussion in support of that day's work. The activities (Table 1) were ordered so that the outcome of each day's work was the basis for the next class's activities. For example, in order to summarize information students learned to estimate the frequency of females and males by fraction, fractions led to the introduction of the terms numerator and denominator, students were then taught to calculate the proportion as the numerator's value divided by denominator's value, and in turn this proportion was converted into its percent. On the following day students graphed their frequency data as a pie chart.

During the summer of 2009, the number of students participating in SC's Upward Bound program dropped from 60 to 33. Upward Bound scholars that graduated from high school did not participate in the summer program; nor did students who were out-of-town over the summer break. The schedule that we followed during the 2009 Upward Bound summer program is in Table 1. Initially there were two sections of Upward Bound students. A section with 16 students, met from 9-10:30 AM on Tuesdays and Thursdays. A second section met from 10:30 AM – noon on Tuesdays and Thursdays and had 17 students. Altogether, 59.4% of these 33 students were female and 40.6% of the students were male.

In the state where this study was conducted, to receive a high school diploma, a public school student must pass at least five subject specific tests in the areas of English, mathematics, global history and geography, United States history and government, and science; a passing score is 65 or above. After not passing one or more of these standardized exams (June, 2009), 26 of the 33 Upward Bound students were scheduled by their school to use mornings to prepare for and repeat these state examinations in mid-August (2009). Ultimately, seven Upward Bound students (four males and three females) completed the entire ACES course in science and mathematics (completion rate was 21%).

Similarly, the number of students participating in SC's summer 2013 Upward Bound program dropped from 55 to 36. Upward Bound students that graduated from high school, as well as those who were out-of-town during the summer break, did not participate in the summer program. The schedule that we followed during the 2013 Upward Bound summer program is also in Table 1. There were three sections of Upward Bound students. These sections were scheduled in the afternoon so that students who had not passed state exams (June, 2013), could use mornings to prepare for and repeat them in mid-August (2013). One section with 13 students, met as scheduled from 1-2 PM on Tuesdays and/or Thursdays. A second section with 11 students met from 2-3 PM on Tuesdays and/or Thursdays as scheduled. The third section of 12 Upward Bound students met on Tuesdays and/or Thursdays from 3-4 PM. Altogether, 66.7% of these 36 students were female and 33.3% of the students were male. Ultimately, 24 Upward Bound students (18 females and six males) completed the entire instructional program in science and mathematics (completion rate was 62%).

STUDY DESIGN

The survey created for this study was written before instruction by one of the authors. The survey presented the student with 31 questions to self-report their familiarity of: Linear metric units, calculation of simple averages, estimation of frequency, parts and notation of fractions, the calculation of proportions and percentages, the relation between proportions and percentages, the interpretation of proportions and percentages, and graphing data. Students participating in this instructional program were surveyed twice, before instruction and after instruction. In 2009, we gave and collected the "before" survey on July 9th (N=33). We gave and collected the "after" survey to the remaining students at the end of the summer program, August 4th (N=7). In 2013, we gave and collected the "before" survey on June 25th (N=36) and gave the same survey to the remaining students at the end of the summer program, July 26th (N=24).

Contingency table analysis was done to determine if there is a relationship between categorical variables. Categorical variables identify group membership (e.g. yes, maybe, or no) instead of a quantity (McDonald, 2014, pp. 8-9). Contingency table analysis showed that the frequency of the survey responses for each item (Appendix 1), before this summer ACES course, was statistically equivalent in 2009 and 2013 for all but two of the 31 survey items. Similarly, contingency table analysis showed that after students completed the summer ACES course (2009 and 2013), the frequency of their survey responses was statistically equivalent for all 31 survey items (Appendix 2). Consequently, survey responses from Summer 2009 and Summer 2013 were combined before statistical analyses (McDonald, 2014, pp. 87-88); the combined raw survey responses were then grouped by topic to increase the sample size of the frequencies being compared (Table 2), and to reduce the number of statistical analyses done and reported from 31 to seven (Table 3).

The observed survey responses before any of the work was done were compared to the survey responses given after completing these instructional activities. The null hypothesis was that the activities the students performed during this summer ACES course would not change the survey responses given by students "before" instruction in comparison to survey responses "after" instruction. The hypothesis of interest was that the activities the students performed during the six-week instructional course would increase the number of positive survey responses (yes) and reduce the number of uncertain responses (maybe and no) given by students at the end in comparison to the beginning. All of the probability values associated with the statistical test of the null hypothesis are one-tailed to identify the benefit of this instructional approach.

Fisher's exact test of independence was used for preliminary data analysis (McDonald, 2014, pp. 77-79). This statistical test is used with categorical variables (McDonald, 2014, pp. 8-9). A categorical variable classifies observations into categories. Our categories were when the survey was given (before or after instruction) and student responses (yes, maybe, and no). The data in this analysis were summarized in a table where R is the number of rows and C is the number of columns. In this case our RxC table was 2x3. Since Fisher's exact test of independence was originally limited to a 2x2 contingency table, the Freeman-Halton extension of the Fisher exact probability test for a contingency table with two-rows and three-columns was used (Lowry, 2013).

The chi-square test of independence was performed on tabled data (Table 2; Lowry, 2013). When the probability level associated with the calculated value of chi-square was less than 0.05, we rejected the null hypothesis and accepted the hypothesis of interest. The hypothesis of interest was that the activities the students performed in this integrated course of math and science instruction would increase the number of positive survey responses (yes) and reduce the number of uncertain responses (maybe and no) given by students.

FINDINGS

Before and After Surveys

In the first survey of the students (before the summer ACES course) the responses indicate how unsure these students are about their knowledge and ability with regard to linear metric units, calculation of simple averages, estimation of frequency, parts and notation of fractions, the calculation of proportions and percentages, the relation between proportions and percentages, the interpretation of proportions and percentages, and graphing data (Table 2). On average only 45.4% of the students responded "yes" to any survey item, 30.5% of the students responded "maybe", and 24.1% of the students responded "no". This indicates that less than half of the time, students were certain in their knowledge and ability. Their lowest certainty is about the numerator and denominator in a fraction equivalent to a percent. For example, only 11 out of 68 students (16.2%) were certain that the fraction equivalent to 16.2% is 16.2 per 100. In contrast, their highest certainty is associated with knowing what an x-y line graph is. Here 57 out of 68 students (83.8%) answered yes to the statement "I know what an x-y line graph is".

In the second survey of the students, after this summer ACES course, every response indicates how much more certain these students were about linear metric units, calculation of simple averages, estimation of frequency, parts and notation of fractions, the calculation of proportions and percentages, the relation between proportions and percentages, the interpretation of proportions and percentages, and graphing data (Table 3). On average 70.8% of the students responded "yes" to any survey item, 23.2% of the students responded "maybe", and only 6.1% of the students responded "no". This indicates that more than two-thirds of the time, students were certain of their knowledge and ability. After this set of integrated science and math activities, their lowest certainty continued to be about the value of the numerator and denominator in a fraction equivalent to a percent; only 16 of 31 students (51.6%) were certain that the fraction equivalent to 51.6% is 51.6 per 100. In contrast, their highest certainty is associated with knowing what an x-y line graph was; here 29 of 31 students (93.5%) answered "yes" to the statement associated with their knowing what an x-y line graph was.

DISCUSSION

It is evident that the students who completed this summer ACES course in science and mathematics modeled on the *Mythbusters* were much more certain of their knowledge and abilities about quantitative processes shared in science and mathematics (Table 3). Students who completed this integrated set of activities were 1.5 times more likely to answer "yes" to a survey question after instruction. We assisted the students in skill development, and moved the students into the next higher

Table 2: Survey Responses Grouped across Years and by Topic, Before and After the Mythbusting Activity

	Before			After		
	Yes	**Maybe**	**No**	**Yes**	**Maybe**	**No**
Knowing about the meter and its subunits	57 (44.2%)	34 (26.4%)	38 (29.5%)	83 (67.5%)	32 (26.0%)	8 (6.5%)
Knowing how to calculate averages and frequencies	59 (45.0%)	45 (34.4%)	27 (20.6%)	89 (72.4%)	28 (22.8%)	6 (4.9%)
Knowing about fractions	54 (41.2%)	38 (29.0%)	39 (29.8%)	80 (64.5%)	27 (21.8%)	17 (13.7%)
Knowing how to convert fractions into proportions and percentages	40 (30.3%)	54 (40.9%)	38 (28.8%)	86 (73.5%)	31 (26.5%)	0 (0%)
Knowing what a percent is as a fraction	15 (22.7%)	19 (28.8%)	32 (48.5%)	32 (44.4%)	23 (31.9%)	7 (9.7%)
Knowing about graphs	178 (61.6%)	72 (24.9%)	39 (13.5%)	224 (80.3%)	43 (15.4%)	12 (4.3%)
Knowing about dependent and independent variables	40 (41.2%)	35 (36.1%)	22 (22.7%)	57 (62.0%)	29 (31.5%)	6 (6.5%)

Table 3: Chi Square Test Results Comparing Student Survey Responses Grouped Across Years and by Topic, Before and After the Mythbusting Activity

Survey Topic	X^2	*df*	*p*
Knowing about the meter and its subunits	24.33	2	0.0000025
Knowing how to calculate averages and frequencies	23.17	2	0.0000045
Knowing about fractions	15.33	2	0.00023
Knowing how to convert fractions into proportions and percentages	60.33	2	0
Knowing what a percent is as a fraction	22.45	2	0.0000065
Knowing about graphs	26.70	2	0.000001
Knowing about dependent and independent variables	12.56	2	0.000937

level of skill, a process called scaffolding (Vygotsky, 1997). The incremental sequence of information and activities we followed served as the scaffold (see Table 1). Our scaffolded learning materials helped to reduce complexity, and highlighted concepts and inquiry (Reiser, Krajick, Moje, & Marx, 2003). The incremental sequence of information and activities we followed also helped students who were not native-English speakers, or had other language difficulties (Karp & Howell, 2004)[5].

A concern raised by the data is that our conclusions are based only on the responses of students who completed this program of instruction (2009: 7 of 33 students and 2013: 24 of 36 students). The difference in completion rates is due to changes in scheduling made in 2013 in response to 2009. In summer 2009, both ACES instruction and the school district's remedial education was scheduled in the morning. This caused 26 of the 33 students who received less than a 65 on one or more of the standardized state exams to withdraw from the ACES course integrating science and mathematics and opt for the school's remedial education. Consequently, in 2013, summer ACES instruction was scheduled in the afternoon so that any Upward Bound student who received less than a 65 on one or more on the standardized state exams, could participate in the school district's scheduled remediation during the morning and ACES instruction in the afternoon. While there is concern that our conclusions are based only on the responses of the 31 students, recall that the survey responses from 2009 and 2013 were combined and that the combined raw survey responses were then grouped by topic to further increase the sample size of the frequencies being statistically compared (Table 2). The number of responses per survey topic, from students who completed this program of instruction, ranged from 62 to 279 (average = 131.4, s=69.0). While the concern that our conclusions are based on the responses of the 31 students is real, we believe that some of this should be offset by the larger number of responses per survey topic analyzed.

The activities that the students performed during the five-week instructional course significantly increased the perceived certainty of response given by students after instruction. While this survey provides insight to a student's sense of knowledge and ability (both before and after instruction), questionnaires answered by adolescent students have been shown to include inaccurate and/or invalid responses (Fan, Miller, Park, Winward, Christensen, Grotevant, and Tai, 2006). Fan et al. (2006) found that it was unusual or exceptional response options (e.g. false adoption status, false non-U.S. born, and inaccurate response to having an artificial limb) that tended to attract inaccurate and/or invalid responses; and then, that the frequency of inaccurate and/or invalid responses was extremely low (e.g. false adoption status = 0.6%, false non-U.S. born = 1.5%, and inaccurate response to having an artificial limb = 1.8%). Given these observations by Fan et al. (2006), we consider that our student survey responses were accurate since none of our response options (yes, maybe, and no) were unusual or exceptional. In addition, while this survey provides insight to a student's sense of knowledge and ability (both before and after instruction), this study would benefit from data provided by a test to confirm the student's gain in understanding and skills due to instruction. We recognize this important limitation to our data-based generalizations.

A significant issue that we cannot address, because we lack the data, is the impact that demographic heterogeneity might have had on the students' perception of learning. The school that our

[5] In 2009, 33% of the Upward Bound students were LEP; in 2013, 56% of the Upward Bound students were LEP.

Upward Bound program draws all of its students includes children of immigrant refugee families from more than 15 countries, with as many different native languages. We know that in terms of race and ethnicity, 48.3% of our Upward Bound students (2009) were Black or African American, 20% were Hispanic or Latino, 16.7% were Asian, 3.3% were White, 1.7% American Indian/Alaskan Native, and 10% of these students reported more than one race or ethnicity. Similarly, we know that in 2013, 44% of our Upward Bound students were Asian, 40% were Black or African American, and 16% were Hispanic or Latino. However, the survey used in this study with students participating in the summer ACES program did not contain any demographic variables (Appendix 1). This is unfortunate because students' social, cultural, and demographic background may influence the pace at which they learn and acquire new concepts. We think that it is very important to explore if demographic factors like these could influence student learning in the same instructional environment. We recommend that other investigators broaden their assessments to include descriptive, demographic variables to include in analysis.

In addition, while we believe in the strong academic benefit derived from our instructional approach, where mathematics and science are presented and used together, it must be recognized that the significant increase in certainty of response given by students after instruction may also be explained by teacher immediacy. Teacher immediacy (verbal or non-verbal) occurs when a teacher behaves in a way that reduces the physical and/or psychological distance between the teacher and their students (Witt, Wheeless, & Allen, 2004). In our work, the instructor reduced the psychological distance between him and his students by first trying to establish rapport and cultivate a culture of mutual trust and respect. To "surmount the "us and them" syndrome" the first myth busted was "Looking beyond Stereotypes". We discussed the stereotypes we know and have, and identified how each of us doesn't fit the "myth". In addition, everyone shared simple, personal information as a way to see each other as an individual. To reduce the physical distance that separated teacher and students, during class this instructor continually circulated through the room to interact with students and evaluate their work. In a review of 81 published studies, Witt, Wheeless, and Allen (2004) confirmed that teacher immediacy has a substantial and positive relationship with student attitudes and perceptions of their learning. A teacher's nonverbal immediacy was positively correlated with a student's perceived learning ($r=0.51$); a teacher's verbal immediacy was positively correlated with a student's perceived learning ($r=0.49$) (Witt, Wheeless, & Allen, 2004).

IMPLICATIONS FOR PRACTICE

We are pleased to have been early adopters of *Mythbusters* as a way to have Upward Bound students experience science and mathematics in an integrated, investigative way (Seki & Menon, 2007 Tobias, 1985). Though the advantages of interdisciplinary curriculum units are present in the educational literature, designing an interdisciplinary unit (based on student needs) remains a challenge (McGehee, 2001). Our study provides evidence for the benefits of integrated science and mathematics instruction with students that have limited English proficiency, demonstrate low academic performance and achievement, and overwhelmingly are both low-income and potentially first-generation college students (Dunn, 2004; Karp & Howell, 2004). Here we outline the steps we followed to create this interdisciplinary curriculum in a way that other faculty can easily adapt or adopt:

- To help "at risk" students, the teacher must establish rapport and cultivate a culture of mutual trust and respect (Dunn, 2004; Littky, 2004, p. 55). Before we completed any of the academic activities associated with this instructional program, we first discussed the stereotypes we know and have, and identified how each of us doesn't fit the "myth"; everyone shared simple, personal information as a way to see each other as an individual beyond apparent race, ethnicity, culture, or religion. We created an environment where diversity was respected and welcomed (Littky, 2004).

- Use assessment driven design (AKA backwards design). First identify the learning objectives, these objectives guide the design of the associated curriculum and activities (Reiser et al., 2003). A curriculum organized so that objectives are aligned to learning activities is likely to achieve understanding (Biggs, 1999).

- Collaborative and cooperative learning have been shown to be successful teaching and learning strategies (Verdugo & Flores, 2007). Couple explicit instruction with cooperative learning to improve student learning. Another benefit that can be derived from cooperative learning is that students with academic or language deficits can use another student's resources, skills, and knowledge to improve their learning (Verdugo and Flores, 2007).

- If appropriate, use *Mythbusters* as a model for the scientific method to demonstrate the process of speculation, investigation, data collection, summation, presentation, and interpretation of evidence.

- Use a form of active learning (like Problem Based Learning, PBL) that that requires students to question, speculate, generate solutions, and use higher-order cognitive activities (Biggs, 1999). In PBL, the instructor must carefully select the problem. The problem creates the working context for students to acquire skills and knowledge.
- To explore if demographic factors influence student learning in the same instructional environment, it is necessary that other investigators broaden their assessments to include descriptive, demographic variables.

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Appendix 1: Student Survey Responses Before the Mythbusting Activity

		July 9, 2009			June 25, 2013		
	Survey Item	**Yes**	**Maybe**	**No**	**Yes**	**Maybe**	**No**
1.	I know what a meter is	18	8	7	23	8	5
2.	I know how a decimeter relates to a meter	10	11	11	6	15	14
3.	I know how a centimeter relates to a meter	15	9	9	13	12	10
4.	I know how a millimeter relates to a meter	14	6	11	12	11	12
5.	If I use pencil and paper, I know how to take a set of numbers and calculate the average	19	10	4	20	12	4
6.	If I use a calculator, I know how to take a set of numbers and calculate the average	18	11	3	25	10	1
7.	If I use pencil and paper, I know how to take a set of numbers and calculate the frequency of a group of numbers in that set	10	12	11	16	13	6
8.	If I use a calculator, I know how to take a set of numbers and calculate the frequency of a group of numbers in that set	12	12	9	16	12	7
9.	In a fraction, I know what the numerator is	18	6	9	22	8	6
10.	In a fraction, I know what the denominator is	18	5	9	23	4	9
11.	I know what the line in a fraction represents in words	7	15	11	19	9	8
12.	I know what the line in a fraction represents in math	11	12	10	18	11	7
13.	If I use pencil and paper, I know how to take a fraction and calculate the proportion it represents	8	16	9	15	13	8
14.	If I use a calculator, I know how to take a fraction and calculate the proportion it represents	12	11	10	15	11	10
15.	If I use pencil and paper, I know how to take a proportion and calculate the percent it represents	7	17	9	11	16	9
16.	If I use a calculator, I know how to take a proportion and calculate the percent it represents	9	18	6	13	12	10
17.	If a frequency is written as a percent, I know what the numerator is in an equivalent fraction	9	9	15	3	16	6
18.	If a frequency is written as a percent, I know what the denominator is in an equivalent fraction	6	10	17	4	16	15
19.	I know what a "pie chart" is	18	10	5	25	10	1
20.	If I am given a set of values showing the size of different groups in a set, I know how to use this information to draw a pie chart	8	15	8	14	13	9
21.	I know what a "line graph" is	25	4	3	29	6	1
22.	If I am given a set of 2 related values, I know how to use this information to draw a line graph	18	9	3	21	11	4
23.	I know what an "x-y line graph" is	26	4	2	31	1	4
24.	If I am given a set of 2 related values, I know how to use this information to draw an x-y line graph	21	7	4	26	6	4
25.	In math, I know what the term variable means	15	11	6	28	5	3
26.	If I am given a set of 2 related values, I know how to use this information to decide which variable is the dependent variable	13	11	9	17	9	10
27.	If I am given a set of 2 related values, I know how to use this information to decide which variable is the independent variable	12	13	7	14	14	8
28.	For an x-y line graph, I know what the term axis refers to	23	7	3	23	10	3
29.	In an x-y line graph I know which axis is the x-axis	22	7	4	28	4	4
30.	In an x-y line graph I know which axis is the horizontal-axis	17	9	7	22	12	2

Appendix 2: Student Survey Responses After the Mythbusting Activity

		August 4, 2009			July 26, 2013		
	Survey Item	**Yes**	**Maybe**	**No**	**Yes**	**Maybe**	**No**
1.	I know what a meter is	7	0	0	17	6	1
2.	I know how a decimeter relates to a meter	6	1	0	12	10	1
3.	I know how a centimeter relates to a meter	6	1	0	15	6	3
4.	I know how a millimeter relates to a meter	6	1	0	14	7	3
5.	If I use pencil and paper, I know how to take a set of numbers and calculate the average	7	0	0	19	3	2
6.	If I use a calculator, I know how to take a set of numbers and calculate the average	6	1	0	21	2	1
7.	If I use pencil and paper, I know how to take a set of numbers and calculate the frequency of a group of numbers in that set	6	1	0	12	12	0
8.	If I use a calculator, I know how to take a set of numbers and calculate the frequency of a group of numbers in that set	5	1	0	13	8	3
9.	In a fraction, I know what the numerator is	5	2	0	16	3	5
10.	In a fraction, I know what the denominator is	5	2	0	16	4	4
11.	I know what the line in a fraction represents in words	5	2	0	14	5	5
12.	I know what the line in a fraction represents in math	5	2	0	14	7	3
13.	If I use pencil and paper, I know how to take a fraction and calculate the proportion it represents	4	3	0	16	6	1
14.	If I use a calculator, I know how to take a fraction and calculate the proportion it represents	5	2	0	17	6	1
15.	If I use pencil and paper, I know how to take a proportion and calculate the percent it represents	6	1	0	16	5	3
16.	If I use a calculator, I know how to take a proportion and calculate the percent it represents	5	2	0	17	6	1
17.	If a frequency is written as a percent, I know what the numerator is in an equivalent fraction	2	5	0	13	7	4
18.	If a frequency is written as a percent, I know what the denominator is in an equivalent fraction	3	4	0	14	7	3
19.	I know what a "pie chart" is	7	0	0	18	5	1
20.	If I am given a set of values showing the size of different groups in a set, I know how to use this information to draw a pie chart	6	1	0	15	6	3
21.	I know what a "line graph" is	7	0	0	21	3	0
22.	If I am given a set of 2 related values, I know how to use this information to draw a line graph	6	1	0	18	4	2
23.	I know what an "x-y line graph" is	7	0	0	22	2	0
24.	If I am given a set of 2 related values, I know how to use this information to decide which variable is the dependent variable	6	1	0	20	3	1
25.	In math, I know what the term variable means	5	2	0	17	6	1
26.	If I am given a set of 2 related values, I know how to use this information to decide which variable is the dependent variable	3	4	0	13	7	3
27.	If I am given a set of 2 related values, I know how to use this information to decide which variable is the independent variable	5	2	0	14	8	2
28.	For an x-y line graph, I know what the term axis refers to	6	1	0	17	6	1
29.	In an x-y line graph I know which axis is the x-axis	6	1	0	19	3	2
30.	In an x-y line graph I know which axis is the horizontal-axis	6	1	0	16	5	2