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Affecting Attitudes towards Science, High School African American Students

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By

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Affecting attitudes towards science, high school African American students

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Racial minorities, women, and people with disabilities are underrepresented in the fields of Science, Technology, Engineering, and Mathematics (STEM). Attitude towards science has been shown to be a reliable predictor of science achievement. Project-Based Learning (PBL) has been shown to improve attitude towards a topic. The sample selected consisted of 113 African American high school students (68% to 32% female to male ratio) from Alabama, Louisiana, and Mississippi. A quasi-experimental research design which consisted of pre and post intervention measures of participants' attitudes towards science was utilized in this study. Overall, Phase 1, a week-long residential camp, saw greater increases with direct respect to time or gender due to the immersive nature of the camp, whereas Phase 2, an eight week long outreach, saw a more complex interaction of the two factors. PBL was shown to be an effective method of instruction to reach African American and women populations.

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STEM	Acronym for Science, Technology, Engineering, and Mathematics
TOSRA	Test of Science-Related Attitudes
Social	Scale name, Social Implications of Science (S)
Normality	Scale name, Normality of Scientists (N)
Attitude	Scale name, Adoption of Scientific Attitudes (A)
Enjoyment	Scale name, Enjoyment of Science Lessons (E)
Leisure	Scale name, Leisure Interest in Science (L)
Career	Scale name, Career Interest in Science (C)
GLMRM	General Linear Model repeated Measures
F	F statistic
df	degrees of freedom
p	statistical p-value
η^2	eta squared, proportion of total variance attributed to an effect
Std. Dev.	Standard deviation
PBL	Project-Based Learning

CHAPTER I

INTRODUCTION

The US government gave a call to the United States in 1983 (United States 1983) for the people of our nation to realize that staying a leader in a technologically progressive world was not something that would be easy to do, nor would it be a given. The times were extremely competitive especially in the fields of Science, Technology, Engineering, and Mathematics (STEM) and only hard work and determination would keep the USA a competitive global leader in these fields. Thirty-one years have passed since that call how are things looking now?

According to a recent study (Education 2008), the United States has not made significant gains nor significant improvements to its education system to meet the demand that was called for in 1983. “If [the United States was] ‘at risk’ in 1983, [the United States is] at even greater risk now” (Education 2008). In addition to the United States as a whole falling behind other countries in these technical fields, there exists specific groups within our population that are less involved in these fields than others. Racial minorities, women, and people with disabilities are underrepresented in the STEM fields. For example, in 2009, African Americans obtained 9% of all bachelor’s degrees awarded, but only 5.2% in mathematics and statistics, 6.3% in physical sciences, and 4.4% in engineering (Foundation 2009). Therefore, efforts into reaching and encouraging participation of underrepresented populations in STEM fields would benefit our nation as a whole by continuing to strive for our global leadership within those fields.

CHAPTER II

LITERATURE REVIEW

Much research has been done on the topic of retaining racial minority students during college, retaining racial minority students in STEM college programs, determining what methods are being used by successful minority-serving institutions, and identifying which predictors for STEM education completion are effective and present in high school students (Slovacek et al. 2011; Perna, Gasman, Gary, Lundy-Wagner, Drezner, 2010; LeBeau, Harwell, Monson, Dupuis, Medhanie, 2012; Whalen, Shelley II, 2010). However, there is little literature on effective methods of instructing racial minority high school students to encourage participation in STEM fields.

Retention and graduation at the collegiate level

Whalen and Shelly II studied retention and graduation of a Midwestern high-research university freshmen class of the year 2000, collecting data such as student demographic, academic grade and ability measures, whether or not the student stayed within their first declared major or switched, STEM or non-STEM majors, and financial aid. The study found that, among STEM majors, non-STEM majors, and initially STEM majors that switched out of the program, the STEM majors demonstrated the highest mean levels of ability than the other two groups at the time of surveying. However the students that began as STEM but switched to non-STEM demonstrated the lowest. In addition, the study found that the cumulative GPA the final semester of enrollment was the strongest positive predictor of 6-year retention and graduation, while aid in the form of loans, gifts, and work study as well as living on campus were also strong positive predictors of retention and graduation (Whalen, Shelley II, 2010).

Retention and graduation at the collegiate level for African Americans

The Minority Opportunities in Research (MORE), a division of the National Institute of General Medical Sciences (NIGMS), consists of several programs that target racial minorities. The programs are comprised of four components: research experience, mentoring and advisement, supplemental instruction and workshops, and financial support. Slovacek et al examined each of these components and determined their effectiveness in motivating and preparing a student to obtain or pursue a Ph.D. Variables that had a positive impact included communicating the students' research experience and findings through a poster or talk, having a faculty member research mentor, the student's own determination, and the students' undergraduate GPA (Slovacek et al. 2011).

Perna, Gasman, Gary, Lundy-Wagner, and Drezner studied Historically Black Colleges and Universities (HBCUs) in an attempt to identify what factors allowed these institutions to graduate a higher percentage of African Americans and African American women. Their findings included several interesting points, the first of which is that many students chose to attend HBCUs because of the schools' past success at graduating African Americans and women. The authors' stated that "Although researchers will not be able to replicate this reputation and other characteristics easily, other findings likely have greater transferability to other institutions." These other findings included: small class size, accessible faculty offices, cooperative peer culture, faculty encouragement in

STEM fields, "accessibility and use of academic support resources, and the availability and use of undergraduate research opportunities." (Perna, Gasman, Gary, Lundy-Wagner, Drezner, 2010).

High school factors affecting retention and graduation at the collegiate level

A study by LeBeau, Harwell, Monson, Dupuis, and Medhanie explored the relationship "between various student and high-school characteristics and completion of a STEM major in college." Although a discussion of underrepresented groups in STEM fields was made, the sample used was predominately Caucasian with a slight majority male. The study found that the type of high school mathematics curriculum is unrelated to completing a major in mathematics or engineering. In addition, characteristics of the high school such as type of mathematics class taught and schedule did not increase the likelihood of completing a STEM major. Predictors of STEM major completion were found to include gender (more males completed STEM majors), high school GPA of the student, and ACT score of the student. (LeBeau, Harwell, Monson, Dupuis, Medhanie, 2012).

Attitude toward science as an effective predictor in achievement

According to Oliver and Simpson (1988), attitude towards science is an effective predictor of achievement. If STEM interest could be increased, then achievement and participation in these fields might also increase. Research has been performed to determine what types of curriculum have led to increased preference towards these subjects. Of particular interest to high school students are STEM-pedagogy (a method of integrating STEM subjects into a single class), Project-Based Learning (PBL), and constructivism (a system that promotes hands-on learning through construction-based projects) methods. (Lou, Liu, Shih 2010). PBL can be used to combine constructivism and STEM-pedagogy. Because PBL has been used independently by several groups across the globe (Lou, Liu, Shih 2010; Lou, Shih, Diez, Tseng 2010; Hayden, Ouyang, Scinski, Olszewski, Bielefeldt, 2011; Barak, Zadok 2009) as well as because it combines the STEM-pedagogy method and constructivism approach, PBL was selected as the method of instruction for this research.

Curriculum that affects attitude towards science

Areas in which studies of similar design and type have been conducted possess different properties than the area selected for this study. Areas of previous studies include Taiwan (Lou, Liu, Shih 2010; Lou, Shih, Diez, Tseng 2010), California (Hayden, Ouyang, Scinski, Olszewski, Bielefeldt, 2011; Slovacek et al. 2011), Iowa (Whalen, Shelley II, 2010), Georgia (Perna, Gasman, Gary, Lundy-Wagner, Drezner, 2010), New Mexico (Slovacek et al. 2011), Isreal (Barak, Zadok 2009), and Minnesota (LeBeau, Harwell, Monson, Dupuis, Medhanie, 2012). The location selected for this study includes Louisianna, Alabama, and Mississippi, locations that differ from previous research areas in at least one of the following: culture, language spoken, racial minorities present, and population.

Framework outline of previous research

From the different studies that used PBL, there arose a similar outline or pattern for research design (Lou, Liu, Shih 2010; Lou, Shih, Diez, Tseng 2010; Hayden, Ouyang, Scinski, Olszewski, Bielefeldt, 2011; Barak, Zadok 2009). First, the instructor lectured to the students about the given topic (robotics, how speakers work, solar powered cars, etc.) and taught them about the fundamental principles. Students were then split into groups of approximately six participants. They were given a period of time (ranging from four to more than eight weeks) to work on the project. At the end of this time, the students were required to give a presentation in front of their instructors and peers about their project, what they had learned, what challenges they had and how they were overcome, how the group worked together, etc.

TOSRA

Designed to measure seven distinct science-related attitudes among secondary students, the Test of Science-Related Attitudes (TOSRA) was developed first in 1978 in Australia (Fraser, 1981). Based on the comprehensive classification scheme for science education by Klopfer, the TOSRA aims to alleviate semantics problems attached to the term "attitude to science" by the use of six conceptually different categories of attitudinal aims (Klopfer, 1971; Fraser 1981). These six categories, listed in Figure 1 and taken from Fraser in 1981, involve distinctions between attitudes to science and scientists (H. 1), attitude to inquiry (H. 2), adoption of scientific attitudes like curiosity and open-mindedness (H. 3), enjoyment of science learning experiences (H. 4), interest in science apart from learning experiences (H. 5), and interest in a career in science (H. 6). Because H. 1 measures two similar sub-categories, manifestation of favorable attitudes towards science and manifestation of favorable attitudes towards scientists, the TOSRA has dedicated two separate scales to adequately measure the Klopfer classification. The Social Implications of Science scale measures primarily social benefits and problems which accompany scientific progress while the Normality of Scientists scale primarily measures an appreciation that scientists are normal people rather than the eccentrics often depicted in the mass media. The Attitude to Scientific Inquiry scale measures attitude to scientific experimentation and inquiry as a way of obtaining information about the natural world. The fourth scale of the TOSRA, Adoption of Scientific Attitudes, measures attitudes such as open-mindedness, willingness to revise opinions, etc. The last three scales of the TOSRA, Enjoyment of Science Lessons, Leisure Interest in Science, and Career Interest in Science measure what their name specifies, identical to H. 4 through H. 6 respectively (Fraser, 1981).

Research questions

Because there are underrepresented groups in STEM fields and the research suggests that methods of instruction may improve attitude towards the STEM component subjects, research to determine the influence of PBL on high school African American students' attitudes towards science is worthwhile and beneficial. The study investigates four research questions:

1. What are students' attitudes towards science as measured by the TOSRA?
2. Do TOSRA scores increase after participating in the PBL intervention?
3. Do TOSRA scores differ by gender?
4. Is there a difference in change of TOSRA scores by gender?

The hypothesis of this research is that PBL will improve the sample's attitude towards science for both genders over the time of the intervention, and that male and female attitude as measured by the TOSRA will be different.

Scale name		Klopfer (1971) classification
Social Implications of Science (S) Normality of Scientists (N)	H.1:	Manifestation of favourable attitudes towards science and scientists
Attitude to Scientific Inquiry (I)	H.2:	Acceptance of scientific inquiry as a way of thought
Adoption of Scientific Attitudes (A)	H.3:	Adoption of 'scientific attitudes'
Enjoyment of Science Lessons (E)	H.4:	Enjoyment of science learning experiences
Leisure Interest in Science (L)	H.5:	Development of interest in science and science-related activities
Career Interest in Science (C)	H.6:	Development of interest in pursuing a career in science

Figure 1 Name and classification of each scale in the TOSRA

CHAPTER III

METHODOLOGY

Description of sample

The sample that was selected consisted of a total of approximately 180 African American high school students (68% to 32% ratio female to male, overall) enrolled in JROTC in Alabama, Louisiana, and Mississippi public schools. This sample was chosen out of convenience as these students are within relative easy access to the researcher both in geographic proximity and previous contact with the schools. By using this sample, with racial and geographic status properties different than those of previous studies, this research will contribute to the knowledge base of the subject.

Phase 1 description

This research design consisted of two phases. Phase 1 consisted of a week-long summer camp in which the sample traveled from their hometowns to the campus of Mississippi State University. The 113 (71% to 29% female to male ratio) students stayed in a residence hall on campus. Throughout the week, the students were exposed to several small STEM and PBL-related projects, went on high tech industry tours in Mississippi and Alabama (Mercedes Benz and Nissan production plants as well as Raspet Flight Research Laboratory), listened to speakers discuss topics of leadership, college enrollment, and time management, as well as spoke with currently-enrolled graduate and undergraduate students about competitive engineering teams. In addition to the smaller projects throughout the week, there was a larger project at the end of the week that encompassed topics and fundamentals learned from the previous projects and experiences. Throughout the week, several presentations were given by the participants to their peers. The students were given an instrument to measure their attitudes towards science at the beginning of the week when they first arrived and then again at the end of the week before their departure from Mississippi State University. The instrument was administered and taken up by the researcher.

Phase 2 description

Phase 2 consisted of an intervention at some of the same students' schools. During the fall following Phase 1, the researcher traveled to seven Jackson, Mississippi public schools and followed a similar approach as that outlined from other PBL studies. The researcher gave a lecture to the 60 (68% to 32% ratio of female to male, of which 7 participated in Phase 1) students on a chosen topic that is STEM-related (CO_2 effects on the environment on a large and small scale) and then left the students with directions for their project. Groups were formed consisting of four to six students. The students had approximately six to eight weeks to work on their project. During this time the students did not receive additional instruction from the researcher but could contact the researcher with any clarifications or questions the students may have. At the end of this timeframe, the researcher returned to these schools and each group gave a presentation of their project in front of their peers, their instructors, and the researcher. The students were given an instrument to measure their attitudes towards science before the initial instruction, after the lecture, and then after their presentations were completed.

An incentive was used during Phase 2. Each groups' presentation was scored based on a predetermined rubric including presentation skills, knowledge of the topic, accuracy of the information presented, and group participation. The group from each school with the highest cumulative score was invited to the campus of Mississippi State University to watch a college basketball game, tour the campus, listen to speakers on leadership and engineering, and eat two meals. This incentive was offered to compete with other school obligations and activities. The students were not required or forced to participate in the study, nor did they have a copious amount of free time on which to spend on a project like this. For that reason, an incentive was be used to encourage participation over the course of the six to eight week-long project.

The decision to use two Phases was made because the majority of existing research (Lou, Liu, Shih 2010; Lou, Shih, Diez, Tseng 2010; Hayden, Ouyang, Scinski, Olszewski, Bielefeldt 2011; Barak, Zadok 2009) consisted of single phases. By using two phases with extremely different lengths, additional information might be gleaned from the study as opposed to a single-phase study. This research improves upon past research by including two phases of varying duration.

Instrument design and description

The instrument selected to be used in this research is the TOSRA (Fraser 1981). The instrument has seventy questions, with ten questions devoted to each scale. Each question is a five-point Likert scale design ranging from Strongly Agree to Strongly Disagree. The intent of the instrument is not to obtain an overall measure of attitude, but rather seven separate attitude measures, one for each scale. For this reason, scores from each question will be added to all other question scores for a given scale, obtaining a scale score for each student. The minimum score of a scale is ten (a response of one to all ten questions) with the maximum score being fifty (a response of five to all ten questions). Although originally developed to measure the attitudes of secondary school students living in Australia, the TOSRA has been cross-validated in the United State of America. Concerning reliability, the TOSRA has been shown to have a mean test-retest score for all scales being .78 and a Cronbach's alpha score of .82 (Fraser, 1981). Concerning validity, discriminate validity was used to show that intercorrelations between different scales ranged from .10 to .59 (Fraser, 1981).

Analysis type

Data was collected and measured multiple times in each phase. For this reason, a repeated-measure method of data analysis was been selected. Names were collected, with the permission of the IRB, such that linking surveys across times as well as phases was possible. In addition to name, race, gender, and school information was collected. Once the data was collected and entered into the computer, the sum of each scale was calculated for all times. Then, a General Linear Model Repeated Measures (GLMRM) test was performed in a statistical analysis software package to determine if there was a significant difference between the scale scores of the different times. Assumptions of the GLMRM were tested as well.

Limitations of the study

There was no concern about the instrument being valid or reliable because of how extensively and how widely it has been used. However, there are other concerns or limitations to note. The largest limitation to this study is that of the characteristics of the sample. All of the participants are in JROTC (Junior Reserve Officer Training Corps) at their high schools. This is a necessary characteristic of the sample because it was a requirement to obtaining the sample. The research was, in part, funded by the United State Army. The Army funded the summer camp during Phase 1 as well as some expenses during the fall intervention in Phase 2. Because of this, the Army had limited participants to only those in high school JROTC programs. While this does limit the number of conclusions that can be drawn from the sample and applied to other groups, the sample still falls within underrepresented groups in STEM fields (for both race, African American, and primarily female, roughly 70%) and therefore can be used in meaningful research in regards to this situation.

Additionally, during both Phase 1 and Phase 2 there were numerous other activities that took place that were not specifically Project-Based Learning. In Phase 1, these activities included the speakers, the high tech industry tours, and several other activities. In Phase 2, these activities could have included anything from sports to other school projects because of the duration of the phase. There is not a practical method for isolating the sample from non-PBL-related activities; however, both Phases were designed with PBL in mind and attempted to emulate the PBL design found in other studies within the constraints present for this research.

Also, for Phase 2, the students were administered the survey a total of three times, the first two of which will be administered within two hours of one another. Because of the fact that the students are administered the same survey multiple times, two of which are within a short period of time, there exists a possibility of the students becoming familiarized with the survey and, thus, is a limitation of the study.

Significance of the study

The researcher hypothesizes that the combination of PBL and STEM will positively affect the sample's attitudes towards science. This is based upon the findings of Lou, Liu, Shih 2010, Lou, Shih, Diez, Tseng 2010, and Mahoney, 2010. If this is true, then the impact of the findings would be significant. This information could encourage school systems with primarily African American student bodies to adopt a PBL and STEM approach to teaching STEM component subjects. In addition, these findings could point towards similar research being successful with other minority groups (Hispanics, women, persons with disabilities, etc.).

CHAPTER IV

RESULTS

The following results have been coded as follows: Gender is either F (female) or M (male), time and scale are represented such that abbreviations for each scale are ended with suffixes that denote when the scale was taken with “pre” and “post” for times for the Phase 1, whereas Phase 2 times are numerical starting from 1 and range to 3.

Testing assumptions of analysis, Phase 1

Assumptions for the summer camp analysis are included in Table 1 and were tested for pre and post responses broken down by scale. There were instances of outliers for some scales, and for several scales, the data was not normally distributed; however, the variance between groups was not statistically significant. The outliers did not contribute greatly to the mean score of the data. The mean of all available data points (M) and the mean without the top and bottom 5% of all available data points, or trimmed mean (TM), can be found in Table 2. Because the mean and trimmed mean are very similar (seen in the % Diff. column, which is the percentage of difference between M and TM), it can be concluded that the outliers do not influence the data greatly and the analysis can proceed without additional consideration. Given a large enough sample size, one would expect normal data to occur, but it would seem that the 113 participants in Phase 1 were not enough to achieve this normality. Also worth noting is that the nature of a Likert-based survey would lend itself to be skewed in one direction or the other, especially for smaller sample sizes. Table 3 shows which specific times, scales, and by what gender the data was either normal or non-normal.

Testing assumptions of analysis, Phase 2

Assumptions for Phase 2 analysis are included in Table 4 and were tested for all three responses (pre lecture, post lecture, and post project) broken down by scale. There were instances of outliers for some scales, as well as some slight divergences from the assumptions of normality and sphericity. The outliers did not contribute greatly to the mean score of the data. The M column for Table 5 is the true mean of all available data points, whereas the TM column is the trimmed mean and disregards the top and bottom 5% of available cases to calculate a new mean. Because the mean and trimmed mean are very similar (seen in the % Diff. column), it can be concluded that the outliers do not influence the data greatly and the analysis can proceed without additional consideration. The reasons explaining the non-normality of Phase 1 data are still applicable with regards to scale N of Phase 2 data, especially since Phase 2 had fewer participants than Phase 1. Table 6 explains in detail what specifically was non-normal in scale N. The errors in the sphericity assumption can be corrected using the Greenhouse-Geisser correction method, and this was done for the analysis of the data.

Results, Phase 1

Results from Phase 1 can be gleaned by looking first at the descriptive of the scales in Table 7. The difference in mean is positive in all but two cases (Female Enjoyment and Male Social), thus the mean of almost each scale rose from pre to post survey. To determine the significance of these increases, a GLMRM test was used, investigating the effect of gender, in addition to time. Results for this analysis can be found in Table 8.

Statistically significant results for time include Normality of Scientists, having the largest effect size of the significant results for Phase 1 at an eta squared of .19, and Career Interest in Science. Statistically significant results for gender include Social Implications of Science, Enjoyment of Science Lectures, Leisure Interest in Science, and Career Interest in Science. Of these four scales, male mean score is higher in every case. There are no significant results for an interaction effect between time and gender.

Results, Phase 2

Obtaining results from Phase 2 is not as straightforward of a process. Descriptive statistics for the data are found in Table 9. The differences of means between post lecture and pre lecture as well as post project and pre lecture are calculated for each scale in the Totals Difference column of Table 9. The means of the Social scale stayed constant before decreasing slightly. The scales of Normality and Career increased at each time, whereas the scales of Inquiry and Adoption decreased at each time. In addition, the scales of Enjoyment and Leisure decreased initially but then rose to an overall increase. To determine the statistical significance of those changes, a GLMRM test was used, investigating the effect of gender as well as time. Results from this analysis can be found in Table 10.

Statistically significant results for time include the one scale Enjoyment. Statistically significant results for an interaction effect include the scales Social, Normality, with the largest effect size of significant results for Phase 2 at an eta squared of .11, and Adoption. There are no significant effects for gender.

Table 1 Assumptions of analysis, Phase 1

Scale	Outliers[1]	Normality	Homogeneity
Social	None	Non-normal[2]	Homogenous
Normality	2	Non-normal[2]	Homogenous
Inquiry	1	Non-normal[2]	Homogenous
Adoption	5	Non-normal[2]	Homogenous
Enjoyment	1	Non-normal[2]	Homogenous
Leisure	1	Normal	Homogenous
Career	2	Normal	Homogenous

1 Number of outliers in data set
2 For at least one time or gender

Table 2 Descriptive statistics for scales with outliers, Phase 1

Scale	Gender	Mean	Trim. Mean	% Diff.
Normality Pre	F	32.71	32.79	.33
	M	34.21	34.00	.34
Inquiry Pre	F	38.74	39.00	.39
Adoption Pre	F	38.89	38.90	.39
	M	39.64	39.71	.40
Enjoyment Pre	F	34.56	34.72	.35
Leisure Pre	M	33.21	33.55	.33
Career Pre	F	31.13	31.21	.31

Table 3 Normality Violations, tested using Shapiro-Wilk Test, Phase 1

Scale	Gender	Statistic	df	Sig.
Social Pre	F	.96	80	**.02**
Social Post	F	.96	80	**.01**
Normality Pre	M	.92	33	**.02**
Normality Post	F	.94	80	**.001**
Inquiry Pre	F	.97	80	**.03**
Inquiry Post	F	.96	80	**.01**
Adoption Pre	M	.93	33	**.04**
Enjoyment Pre	M	.93	33	**.03**

Table 4 Assumptions of analysis, Phase 2

Scale	Outliers[1]	Normal	Sphericity	Correction
Social	None	Normal	Yes	n/a
Normality	6	Non-normal[2]	Yes	n/a
Inquiry	3	Normal	No, $\chi2(2)=6.61$, $p=.04$	Greenhouse-Geisser, .90
Adoption	None	Normal	No, $\chi^2(2)=11.57$, $p=.003$	Greenhouse-Geisser, .85
Enjoyment	6	Normal	Yes	n/a
Leisure	8	Normal	No, $\chi^2(2)=7.18$, $p=.03$	Greenhouse-Geisser, .90
Career	5	Normal	No, $\chi^2(2)=7.39$, $p=.03$	Greenhouse-Geisser, .90

1 Number of outliers in data set
2 For at least one time or gender

Table 5 Descriptive statistics for scales with outliers, Phase 2

Scale	Gender	Mean	Trim. Mean	% Diff.
Normality 1[1]	F	35.69	35.33	.36
Normality 2[2]	F	36.11	35.88	.36
	M	34.47	34.30	.34
Inquiry 1[1]	F	40.80	40.83	.41
Inquiry 2[2]	F	40.11	39.98	.40
Inquiry 3[3]	M	37.73	37.81	.38
Enjoyment 1[1]	F	37.34	37.44	.37
	M	40.67	40.80	.41
Enjoyment 3[3]	F	38.83	38.98	.39
	M	40.13	40.04	.40
Leisure 1[1]	F	33.06	33.08	.33
Leisure 2[2]	F	33.37	33.42	.33
Career 1[1]	M	35.20	35.56	.35
Career 2[2]	F	34.26	34.17	.34
Career 3[3]	F	34.86	34.69	.35

1 Pre Lecture
2 Post Lecture
3 Post Presentation

Table 6 Normality Violations, tested using Shapiro-Wilk Test, Phase 2

Scale	Gender	Statistic	df	Sig.
Normality 2	F	.94	41	**.03**
	M	.89	19	**.03**

Table 7 Descriptive statistics, Phase 1

		N		Std. Dev.		Mean		
	Scale	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Diff.**
Female	Social	80	80	5.19	6.56	36.64	37.95	1.31
	Normality	80	80	4.58	4.71	32.71	35.26	2.55
	Inquiry	80	80	5.09	7.26	38.74	39.51	0.78
	Adoption	80	80	4.35	6.00	38.66	38.89	0.23
	Enjoyment	80	80	5.24	8.99	34.56	34.34	-0.23
	Leisure	80	80	4.91	9.14	28.65	28.89	0.24
	Career	80	80	7.45	8.18	31.13	31.73	0.60
Male	Social	33	33	4.24	5.24	39.58	39.48	-0.09
	Normality	33	33	3.59	4.91	34.21	35.79	1.58
	Inquiry	33	33	7.13	6.54	37.85	38.70	0.85
	Adoption	33	33	4.71	5.51	39.00	39.64	0.64
	Enjoyment	33	33	7.26	7.49	38.36	39.27	0.91
	Leisure	33	33	4.75	8.06	33.21	33.33	0.12
	Career	33	33	7.04	7.29	34.21	35.85	1.64

Table 8 General linear model repeated measures results, Phase 1

	Interaction of Time and Gender			Main Effect of Time			Main Effect of Gender		
Scale	**F(df)**$_{inter}$	p_{inter}	η^2_{inter}	**F(df)**$_{time}$	p_{time}	η^2_{time}	**F(df)**$_{gender}$	p_{gender}	η^2_{gender}
Social	F(1,111)=2.33	**.13**	.02	F(1,111)=1.77	**.19**	.02	F(1,111)=4.41	**.04**	.04
Normality	F(1,111)=1.425	**.24**	.01	F(1,111)=25.6	**<.001**	.19	F(1,111)=1.43	**.24**	.01
Inquiry	F(1,111)=.00	**.95**	.00	F(1,111)=1.74	**.19**	.02	F(1,111)=.41	**.52**	.00
Adoption	F(1,111)=.12	**.73**	.00	F(1,111)=.51	**.48**	.00	F(1,111)=.28	**.60**	.00
Enjoyment	F(1,111)=.94	**.33**	.01	F(1,111)=.34	**.56**	.00	F(1,111)=7.1	**.01**	.06
Leisure	F(1,111)=.01	**.91**	.00	F(1,111)=.13	**.72**	.00	F(1,111)=6.93	**.01**	.06
Career	F(1,111)=.991	**.32**	.01	F(1,111)=4.61	**.03**	.04	F(1,111)=5.61	**.02**	.05

Table 9 Descriptive statistics, Phase 2

		N			Std. Dev.			Mean				
	Scale	1[1]	2[2]	3[3]	1[1]	2[2]	3[3]	1[1]	2[2]	3[3]	Diff. (2-1)[4]	Diff. (3-1)[5]
Female	Social	44	44	44	4.57	5.22	5.16	38.34	38.30	38.93	-.05	.59
	Normality	44	44	44	4.59	5.21	5.08	35.37	35.66	37.71	.29	2.34
	Inquiry	44	44	44	4.33	4.00	5.05	40.31	39.55	39.31	-.76	-1.00
	Adoption	44	44	44	4.24	4.65	4.01	39.74	39.56	40.26	-.19	.51
	Enjoyment	44	44	44	6.93	7.88	6.29	37.12	36.61	38.32	-.51	1.20
	Leisure	44	44	44	8.10	7.92	7.75	32.65	32.98	34.14	.33	1.49
	Career	44	44	44	7.43	6.80	6.19	33.19	33.79	34.09	.60	.91
Male	Social	20	20	20	4.84	5.08	5.23	40.35	40.45	38.75	.10	-1.60
	Normality	20	20	20	4.54	4.69	5.12	35.37	34.89	34.11	-.47	-1.26
	Inquiry	20	20	20	4.42	5.36	4.56	39.24	37.94	38.06	-1.29	-1.18
	Adoption	20	20	20	5.15	5.79	5.06	40.05	39.00	37.45	-1.05	-2.60
	Enjoyment	20	20	20	7.32	6.71	4.82	39.60	38.55	39.90	-1.05	.30
	Leisure	20	20	20	7.39	7.64	6.54	36.32	35.37	35.79	-.95	-.53
	Career	20	20	20	6.15	6.30	5.11	34.53	33.95	33.89	-.58	-.63

1 Pre Lecture
2 Post Lecture
3 Post Presentation
4 Difference between mean of Post Lecture and Pre Lecture
5 Difference between Post Project and Pre Lecture

Table 10 General linear model repeated measures results, Phase 2

	Interaction of Time and Gender			Main Effect of Time			Main Effect of Gender		
Scale	**F(df)**$_{inter}$	p_{inter}	η^2_{inter}	**F(df)**$_{time}$	p_{time}	η^2_{time}	**F(df)**$_{gender}$	p_{gender}	η^2_{gender}
Social	F(2,124)=3.49	**.03**	.05	F(2,124)=.73	**.48**	.01	F(1,62)=1.18	**.28**	.02
Normality	F(2,116)=7.40	**.001**	.11	F(2,116)=.95	**.39**	.01	F(1,58)=1.38	**.25**	.02
Inquiry	F(1.9,107)=.10	**.89**	.00	F(1.9,107)=2.12	**.13**	.04	F(1,59)=1.37	**.25**	.02
Adoption	F(1.8,108)=4.56	**.02**	.07	F(1.8,108)=1.95	**.15**	.03	F(1,61)=.86	**.36**	.01
Enjoyment	F(2,118)=.27	**.76**	.00	F(2,118)=3.16	**.046**	.05	F(1,59)=1.34	**.25**	.02
Leisure	F(1.9,112)=1.94	**.15**	.03	F(1.9,113)=1.20	**.31**	.02	F(1,60)=1.59	**.21**	.03
Career	F(1.9,112)=1.02	**.36**	.02	F(1.9,112)=.04	**.95**	.00	F(1,60)=.07	**0.8**	.00

CHAPTER V

CONCLUSIONS

Phase 1

Of significant results obtained during Phase 1, the Normality of Scientist scale is the largest effect size of all significant results, has the smallest *p* value, and is the largest increase of means. This could be interpreted as the students becoming more familiar with scientists and viewing them as more normal after spending an intensive week with the scientists. No longer are scientists viewed as eccentric TV figures or “mad scientists”, but as normal every-day people, going as far as to possibly view themselves as a scientist after working on STEM-themed PBL projects. The significant increase in Career Interest in Science with regards to the main effect time could be explained as interesting some of the students of both genders, who are near making decisions that will influence what they study at the collegiate level, in the field of science. Due to the inclusion of industry tours and speakers, the students could interact with people who had careers in the STEM fields and therefore explain the influencing of Career Interest in Science.

The significant differences that are seen due to gender are Social Implications of Science, Enjoyment of Science Lessons, Leisure Interest in Science, and Career Interest in Science. Males were seen to manifest more favorable attitudes towards science for the Social Implications of Science scale, meaning that, according to the Klopfer classification used in the TOSRA, they were seen to be more interested, than females, in science as a whole (Fraser, 1981; Klopfer, 1971). This is in line with current literature that states that males are more involved and interested in STEM than females (Whalen, Shelley II, 2010; LeBeau, Harwell, Monson, Dupuis, Medhanie, 2012). The Leisure Interest in Science scale was the lowest average mean score of all scales, but did witness a significant result when investigating the gender main effect. Results saw a higher mean score in males than females, suggesting that males were more likely to enjoy science in their leisure time or time not dedicated to traditional learning (Fraser, 1981). This is important to note because many of the PBL projects were constructed using materials that would be readily available in the average home and could therefore be recreated by the students if they so desired. Career Interest in Science was significant for both time and gender, without an interaction effect. Males were seen to have a higher mean score than females by nearly 11.5 percent. While this shows that the intervention was shown to be effective at increasing attitudes of both males and females, it does also show that males possess a higher starting, ending, and absolute value increased than females in Career Interest in Science, which was to be expected if current literature was to be believed (Whalen, Shelly II, 2010; LeBeau, Harwell, Monson, Dupuis, Medhanie, 2012). Because females possess lower initial attitudes towards science, it is important that African Americans and women become interested and fill roles within the STEM community to further encourage and connect with future generations of both underrepresented populations.

Phase 2

For Phase 2, the significant result for time was Enjoyment of Science Lessons. Looking at the descriptive statistics for this scale, the difference from survey 1 to 2 is negative while the overall difference between survey 3 and 1 is positive. This could be explained as disliking the traditional lecture on science, but after having completed the project and final presentation, the subjects gain a better appreciation and enjoyment of science lessons. This points towards further investigation on what types of lectures receive the most favorable feedback, as well as what types of lectures are most beneficial. It also speaks to the effectiveness of PBL relative to the lecture as the lecture was documented by negative enjoyment while PBL was documented by positive enjoyment.

Three interaction effects were significant for Phase 2. In every case males were higher in mean scale score than females with the significant scales following in order of greatest absolute difference of mean scale score from pre lecture to post project between genders: Normality of Scientists (3.6), Adoption of Scientific Attitude (3.11), and Social Implications of Science (2.19). The Normality of Scientists scale decreased overall, decreased with regard to males, and increased with regards to females by approximately 7% of the original value; thus, females seem to have manifested more favorable attitudes towards scientists than males (Fraser, 1981). Subjects were exposed to only a male researcher during this phase of the intervention. The Adoption of Scientific Attitude scale exhibited an initial decrease for females before increasing overall, while males decreased overall. Because this scale describes the adoption of scientific attitudes like critical thinking, logic, open-mindedness, etc. it could be said that females were willing to adopt a more critical mindset after completing the project and presentation, while males seem more resistive to a critical mindset overall (Fraser, 1981). The Social Implications of Science scale showed a similar increased and decreased with regards to gender as the Normality of Scientist scale showed. This suggests that females and males do not respond the same way to PBL, in particular to the manifestations of favorable attitudes towards science.

Overall, Phase 1 saw greater differences with direct respect to time or gender, possibly due to the immersive nature of the camp, whereas Phase 2 saw a more complex interaction of the two factors. To address the matter of underrepresentation of not only African Americans but women in STEM, PBL has been shown to be an effective method of instruction to reach these populations.

Research questions addressed

Addressing the posed research questions:

1. What are students' attitudes towards science as measured by the TOSRA?
2. Do TOSRA scores increase after participating in the PBL based intervention?
3. Do TOSRA scores differ by gender?
4. Is there a difference in change of TOSRA scores by gender?

The answer to the first question was determined through the administering of the TOSRA at the initial time for Phase 1 and Phase 2. These were treated as the "baseline" scores and used to compare the other survey responses in determining any change. The answer to the second question was determined to be "yes" for the specified statistically significant scales with respect to the main effect of Time, Normality of Scientists and Career Interest in Science for Phase 1 and Enjoyment of Science Lessons for Phase 2. The answer to the third question was determined to be "yes" for all scales, but statistically significant for Social Implications of Science, Enjoyment of Science Lessons, Leisure Interest in Science, and Career Interest in Science for Phase 1. The answer to the fourth question was determined to be "yes" for all scales but statistically significant for specifically Social Implication of Science, Normality of Scientists, and Adoption of Scientifics Attitudes during Phase 2.

Suggestions for future research

Future research related to this could include repeating the study but with a different sample (different location, non-JROTC, or different age group), conducting a modified version of the research to address different groups of underrepresented persons in STEM fields, including multiple races in the surveying, or using different time lengths in the Phases based upon then-current research. A study involving a control group of a "traditional" instructional method such as a lecture, homework, and tests, would also be beneficial to contrast survey responses between the control and PBL group.

In addition, understanding the relationship between significant main effects and short duration/high intensity and significant interactions of main effects and longer duration/lower intensity would prove interesting and beneficial. These findings could point towards PBL used in conjunction with Transformative Learning accompaniment to obtain a short duration/high intensity experience with the outcome of changing the basis of how the participants view STEM being the goal.

Further, research investigating the cost effectiveness of both phase designs compared to the efficiency of influencing attitude towards science would not only be a practical next step to implementing PBL on a larger scale, but also be necessary to reach these underrepresented populations, many of which attend school systems with not much, if any, extra money to spend on new curriculum.

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APPENDIX A

SAMPLE OF TEST OF SCIENCE RELATED ATTITUDES SURVEY

Test of Science Related Attitudes (TOSRA)
(Fraser, 1981)

Directions:

1. This test contains a number of statements about science. You will be asked what you think about these statements. There are no "right" or "wrong" answers. Your opinion is what is wanted.
2. For each statement, draw a circle around the specific numeric value corresponding to how you feel about each statement. **Please circle only ONE value per statement.**

5 = Strongly Agree (SA)
4 = Agree (A)
3 = Uncertain (U)
2 = Disagree (D)
1 = Strongly Disagree (SD)

Statement	**SA**	**A**	**U**	**D**	**SD**
1. Money spent on science is well worth spending.	5	4	3	2	1
2. Scientists usually like to go to their laboratories when they have a day off.	5	4	3	2	1
3. I would prefer to find out why something happens by doing an experiment than be being told.	5	4	3	2	1
4. I enjoy reading about things that disagree with my previous ideas.	5	4	3	2	1
5. Science lessons are fun.	5	4	3	2	1
6. I would like to belong to a science club.	5	4	3	2	1
7. I would dislike being a scientist after I leave school.	5	4	3	2	1
8. Science is man's worst enemy.	5	4	3	2	1
9. Scientists are about as fit and healthy as other people.	5	4	3	2	1
10. Doing experiments is not as good as finding out information from teachers.	5	4	3	2	1

Statement	SA	A	U	D	SD
11. I dislike repeating experiments to check that I get the same results.	5	4	3	2	1
12. I dislike science lessons.	5	4	3	2	1
13. I get bored when watching science programs on TV at home.	5	4	3	2	1
14. When I leave school, I would like to work with people who make discoveries in science.	5	4	3	2	1
15. Public money spent on science in the last few years has been used widely.	5	4	3	2	1
16. Scientists do not have enough time to spend with their families.	5	4	3	2	1
17. I would prefer to do experiments rather than to read about them.	5	4	3	2	1
18. I am curious about the world in which we live.	5	4	3	2	1
19. School should have more science lessons each week.	5	4	3	2	1
20. I would like to be given a science book or a piece of science equipment as a present.	5	4	3	2	1
21. I would dislike a job in a science laboratory after I leave school.	5	4	3	2	1
22. Scientific discoveries are doing more harm than good.	5	4	3	2	1
23. Scientists like sports as much as other people do.	5	4	3	2	1
24. I would rather agree with other people than do an experiment to find out for myself.	5	4	3	2	1
25. Finding out about new things is unimportant.	5	4	3	2	1
26. Science lessons bore me.	5	4	3	2	1
27. I dislike reading books about science during my holidays.	5	4	3	2	1

Statement	SA	A	U	D	SD
28. Working in a science laboratory would be an interesting way to earn a living.	5	4	3	2	1
29. The government should spend more money on scientific research.	5	4	3	2	1
30. Scientists are less friendly than other people.	5	4	3	2	1
31. I would prefer to do my own experiments than to find out information from a teacher.	5	4	3	2	1
32. I like to listen to people whose opinions are different from mine.	5	4	3	2	1
33. Science is one of the most interesting school subjects.	5	4	3	2	1
34. I would like to do science experiments at home.	5	4	3	2	1
35. A career in science would be dull and boring.	5	4	3	2	1
36. Too many laboratories are being built at the expense of the rest of education.	5	4	3	2	1
37. Scientists can have a normal family life.	5	4	3	2	1
38. I would rather find out things by asking an expert than by doing an experiment.	5	4	3	2	1
39. I find it boring to hear about new ideas.	5	4	3	2	1
40. Science lessons are a waste of time.	5	4	3	2	1
41. Talking to my friends about science after school would be boring.	5	4	3	2	1
42. I would like to teach science when I leave school.	5	4	3	2	1
43. Science helps to make life better.	5	4	3	2	1
44. Scientists do not care about their working conditions.	5	4	3	2	1
45. I would rather solve a problem by doing an experiment than be told the answer.	5	4	3	2	1

Statement	SA	A	U	D	SD
46. In science experiments, I like to use new methods which I have not used before.	5	4	3	2	1
47. I really enjoy going to science lessons.	5	4	3	2	1
48. I would enjoy having a job in a science laboratory during my school holidays.	5	4	3	2	1
49. A job as a scientist would be boring.	5	4	3	2	1
50. This country is spending too much money on science.	5	4	3	2	1
51. Scientists are just as interested in art and music as other people are.	5	4	3	2	1
52. It is better to ask a teacher the answer than to find it out by doing experiments.	5	4	3	2	1
53. I am unwilling to change my ideas when evidence shows that the ideas are poor.	5	4	3	2	1
54. The material covered in science lessons is uninteresting.	5	4	3	2	1
55. Listening to talk about science on the radio would be boring.	5	4	3	2	1
56. A job as a scientist would be interesting.	5	4	3	2	1
57. Science can help to make the world a better place in the future.	5	4	3	2	1
58. Few scientists are happily married.	5	4	3	2	1
59. I would prefer to do an experiment on a topic than to read about it in science magazines.	5	4	3	2	1
60. In science experiments, I report unexpected results as well as expected ones.	5	4	3	2	1
61. I look forward to science lessons.	5	4	3	2	1
62. I would enjoy visiting a science museum on the weekend.	5	4	3	2	1
63. I would dislike becoming a scientist because it needs too much education.	5	4	3	2	1
64. Money used on scientific projects is wasted.	5	4	3	2	1

Statement	SA	A	U	D	SD
65. If you met a scientist, he/she would probably look like anyone else you might meet.	5	4	3	2	1
66. It is better to be told scientific facts than to find them out from experiments.	5	4	3	2	1
67. I dislike other peoples' opinions.	5	4	3	2	1
68. I would enjoy school more if there were no science lessons.	5	4	3	2	1
69. I dislike reading newspaper articles about science.	5	4	3	2	1
70. I would like to be a scientist when I leave school.	5	4	3	2	1

APPENDIX B

IRB APPROVAL LETTER

April 23, 2013

Charles Anderton

ASE

RE: HRPP Study #13-073: Affecting Attitude Towards Science, High School African American Students

Dear Mr. Anderton:

This email serves as official documentation that the above referenced project was reviewed and approved via administrative review on 4/23/2013 in accordance with 45 CFR 46.101(b)(1). Continuing review is not necessary for this project. However, in accordance with SOP 01-03 Administrative Review of Applications, a new application must be submitted if the study is ongoing after 5 years from the date of approval. Additionally, any modification to the project must be reviewed and approved by the HRPP prior to implementation. Any failure to adhere to the approved protocol could result in suspension or termination of your project. The HRPP reserves the right, at anytime during the project period, to observe you and the additional researchers on this project.

Please note that the MSU HRPP is in the process of seeking accreditation for our human subjects protection program. One of these changes is the implementation of an approval stamp for consent forms. The approval stamp will assist in ensuring the HRPP approved version of the consent form is used in the actual conduct of research. Your stamped consent form will be attached in a separate email. You must use copies of the stamped consent form for obtaining consent from participants.

Please refer to your HRPP number (#13-073) when contacting our office regarding this application.