Inquiry-Based Activities and Technology to Improve Student Performance on the Science Reasoning Portion of the ACT (American College Test)

J. E. Roldan, S. S. Stewart, J. N. DuBois, L. L. Ramsey, and D. K. Mills
GK-12 Teaching Fellows Program
Louisiana Tech University
P.O. Box 3179
Ruston, LA 71272

ABSTRACT

A six-week module to prepare Louisiana high school students from a small rural community for the science portion of the American College Test (ACT) was developed and taught by two graduate engineering students from Louisiana Tech University. The graduate students, in their role as Teaching Fellows in a National Science Foundation Graduate/K-12 Teaching Fellows Program (DGE-0231728), integrated ACTive Prep® software, inquiry based activities, analysis of science demonstrations, and reading of scientific literature into the program in an effort to develop the specific skills tested on the science portion of the ACT. Targeted skills included data interpretation/analysis, reading comprehension, and science reasoning. High school students interested in participating in the program were identified and placed in either an experimental or control group based solely on their ability to attend all program sessions. The experimental group of seven students met twice weekly for 1 ½ to 2 hours per session throughout the six week period and participated in all program components. Three students serving as the control group met only to take the practice ACT tests that were administered to both control and experimental group students at 0, 3, and 6 weeks. At the conclusion of the course, a slight increase in average composite and science scores was found for the experimental group; composite scores for the control group also increased slightly with no increase in scores on the science portion of the tests. The difference between the experimental and control groups was not statistically significant. Several factors may have contributed to this fact including small sample size, student motivation, and the sporadic attendance of students in the experimental group. Student input indicated that participants developed an improved confidence in their ability to score well on the science portion of the ACT. Finally, the course participants were not the only ones impacted; the graduate students responsible for the design and implementation of the course indicated that their involvement was personally and professionally rewarding.

INTRODUCTION

The ACT

As any college admissions advisor will tell you, a student's ACT (American College Test) score can have a profound impact on their college career. While an ACT score can not definitively indicate how well a student will perform in a college classroom, a good score can open many doors for success that a poor score cannot. ACT scores are used to determine college admissions, scholarship eligibility, and course placement [1]. When a student's score does not meet a college or university's desired criteria, it can often leave them to bear the cost of a higher education alone.

For the majority of students, the ever increasing cost of a college education alone deters them from attending but even more so when financial assistance is minimal or denied due to a low score on the ACT. Moreover, as many colleges and universities raise their admissions standards, at the minimum a satisfactory performance on the ACT is crucial.

Louisiana Performance on the ACT

As with many states, a growing concern in Louisiana is student performance on the ACT. Though student performance is at a ten year high, Louisiana's state average scores are still below the national average. In 2004, ACT scores in Louisiana improved by two tenths of a point after five years of holding steady at 19.6. Before this, the last improvement in scores was in 1999, when state scores increased by one tenth of a point from 19.5 [2, 3]. Since more than 85% of Louisiana high school graduates take the ACT, much focus is placed on test preparation. Within this same time frame, the average national scores have decreased a tenth of point, from 21 in 1999 to 20.9 in 2004 [2,3,4]. In the last few years several state-sponsored programs have been established to prepare students for the ACT. For example, the LA GEAR UP Program (funded by the U.S. Department of Education) aids teachers in the analysis of student performance on standardized tests developed by the American College Testing Program, such as the ACT, Explore, and Plan tests (administered in the 12^{th}, 10^{th}, and 8^{th} grades respectively) to determine how they can help their students better prepare for these tests. With so much focus being placed on these types of high-stakes standardized tests, it is clear that providing novel, interactive methods for preparing students is necessary.

The Louisiana Tech GK-12 ACT Prep Course

Supported by a National Science Foundation grant, the Louisiana Tech University GK-12 Teaching Fellows Program hosts a mini-grant program through which Teaching Fellows working with nearby partnering schools can fund a variety of innovative classroom and after school activities. With the available resources, two Graduate Teaching Fellows from the College of Engineering and Science wrote a proposal for and received funds to support a six week pilot course that would prepare high school students from a nearby rural school for the science portion of the ACT. The nearby K-12 school of Simsboro with a student enrollment of 560 was chosen as the target because of its existing involvement with the Louisiana Tech GK-12 Program [5]. Furthermore, the school had already developed a math ACT prep class which students could receive credit for; thus it appeared as an opportune setting when maximum impact could be made. The GK-12 ACT course would serve as a means of strengthening the existing program, while giving students an opportunity to seek further assistance. The objective of the course was to effectively develop the specific skills tested on the ACT, while at the same time arming the participants with viable test-taking strategies, which would allow them to approach the ACT with confidence. Few questions in the science portion of the ACT require specific scientific knowledge; instead, specific skills such as data interpretation/analysis, reading comprehension, and science reasoning are tested. Therefore, technology, student-centered activities, and demonstrations were integrated to facilitate the participants' development of the aforementioned skills. The course structure was based on didactic research which has shown that a student-centered type of instruction is generally more effective at developing critical-thinking as opposed to the classical lecture style [6]. In conjunction, ACTive Prep ® software was used to supplement activities, because it provided personalized test preparation with content specific test-taking strategies [7].

GK-12 ACT PREP COURSE

Selection of Participants

For this investigation, students were randomly selected to participate in the ACT prep course from a list of interested students. To determine the effectiveness of the course, the study included two groups of students for comparison: the experimental and control groups. The experimental group was given access to all test preparation materials, activities, and practice tests, while the control group received only the scheduled practice tests. Students were placed in either the experimental or control group based solely upon whether the student would be able to participate in all six weeks of the course. The experimental group consisted of 7 students and the control group consisted of 3 students. Practice test performance was then compared between the groups at weeks 0, 3, and 6.

Student Survey

The day prior to the first practice test, all students were given a survey in which they were asked to disclose general biographical and educational information, their opinions about standardized tests, plans for the future including those at institutions of higher learning, and information pertaining to their normal study habits. This information was gathered for the purpose of determining whether educational or socio-economical differences amongst the students played any role on ACT performance. The same survey was then administered at the end of six weeks to determine if [students'] attitudes about the ACT and studying had changed. Finally, students were asked to evaluate the course as a whole including suggestions on how improvements could be made for future classes. Figure 1 shows student reactions during an informal group discussion.

Figure 1: Perplexed participants during an afternoon ACT prep session

Administration of Practice Tests

All students were given a practice test before the start of the course to have a baseline measure of their performance on the ACT. For two students, scores from an actual ACT test were used in lieu of the practice test because the practice test was administered on the same day as the ACT test, for which they had already registered. Students were given a total of three practice tests. The practice tests were administered at the same time and in the same manner as the actual ACT. The

practice tests began at 8 a.m. and students were given only the time allotted by the ACT to complete each section of the practice test. This was done so that the students could become accustomed to the testing conditions. The students' tests were then scored and appropriate statistical analysis was conducted. For the third and final practice test, the order of the test was exactly reversed. That is, the Science Reasoning section was administered first followed by the Reading, Mathematics, and English sessions, to determine if the superior performance noted on the early sections of the ACT was due to stronger Math/English skills as opposed to Reading/Science skills or lack of endurance on the part of the students.

Course Layout

Students were asked to spend a minimum of one half hour each week working with the ACTive Prep ® software to individually review practice materials. Each student was given a personal copy of ACTive Prep and was allowed to take it home if they so chose, on the condition that they would document the time spent using it. The software was used to provide additional study materials and to allow the students to have access to further help with test-taking strategies for the sections of the ACT that were not reinforced in this course. The software set came with an interactive study module and two full length practice tests [7]. Students first took a short test to determine which areas they would need to particularly focus. Afterwards, interactive personalities guided the student through section specific test strategies. The program also provided students with test-taking tips and variety of information about college admissions. The ACTive Prep® program was used during the initial weeks of our program but was seldom if ever used after the 2nd week. Figure 2 shows a screenshot of the ACTive Prep® welcome screen [7].

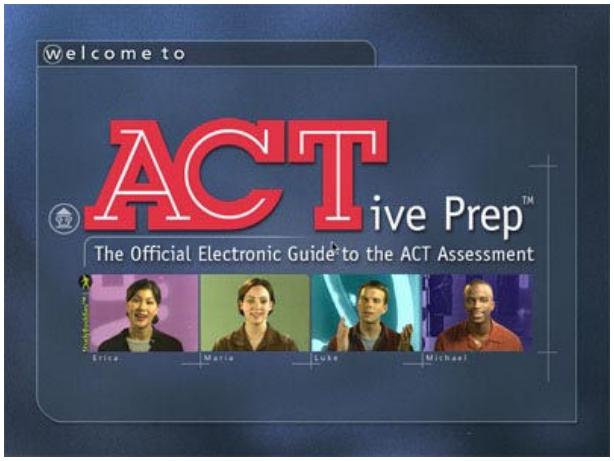

Figure 2: Screenshot of the ACTive Prep®

Beginning in mid-October, two sessions (Monday and Thursday afternoons) of the ACT course were held each week after school. Each session typically lasted an hour and a half with no session lasting more than two hours. A typical week is as follows. On Mondays, students were given a reading assignment usually from a scholarly science journal or from a science project report and were asked to critique and summarize it by the following Monday. On Thursdays, students were asked to obtain a science related newspaper or magazine article of their choosing to summarize by the following Thursday. The summaries generated by the students were discussed in an open floor format, allowing each participant to contribute his/her thoughts on

what he/she felt the article contained and what the data indicated. The participants were occasionally given sample ACT science questions for homework, due on the next meeting.

The remainder of each session primarily focused on presenting the students with questions similar to those asked by the ACT. Each week a new scientific concept was introduced with an interactive PowerPoint presentation; students were given short passages to read and data tables/graphs to analyze, and were then given questions to answer in an allotted time period. Informal group discussions were often held to discuss the best approach to each question and how to determine the correct answer from the data tables/graphs. The main idea for each session was not to present specific scientific concepts but to show the students how to obtain the most appropriate information from the data tables/graphs as quickly as possible. Session topics were various and were centered on themes such as electromagnetism, the Doppler Effect, and the cardiovascular system.

RESULTS

Mean scores for both groups have been provided in Table 1. For all who were administered the second practice test, the average science score was 19.7 and the average composite score was a 20.7. As with the pre-test, the mean score for the control group was slightly higher than that for the experimental group. For the final practice test, only those students in the experimental group were available to be tested. The mean score on the post-test for this group was 19.3 and 20.3 for the science and composite scores, respectively.

PRACTICE TEST 1	SCIENCE	COMPOSITE
EXPERIMENTAL	18.9	19.6
CONTROL	20.7	20.3
PRACTICE TEST 2		
EXPERIMENTAL	19.5	20.3
CONTROL	20.7	20.7
PRACTICE TEST 3		
EXPERIMENTAL	19.3	20.3
2004 LA STATE AVG	**19.7**	**19.8**

Table 1: Average science and composite scores from all practice tests

To summarize, there was an observed increase in mean science and composite scores for the experimental group (+0.6 science, +0.7 composite). The control group showed no change in their mean science score and a +0.4 change in mean composite score. Figure 3 illustrates the above data.

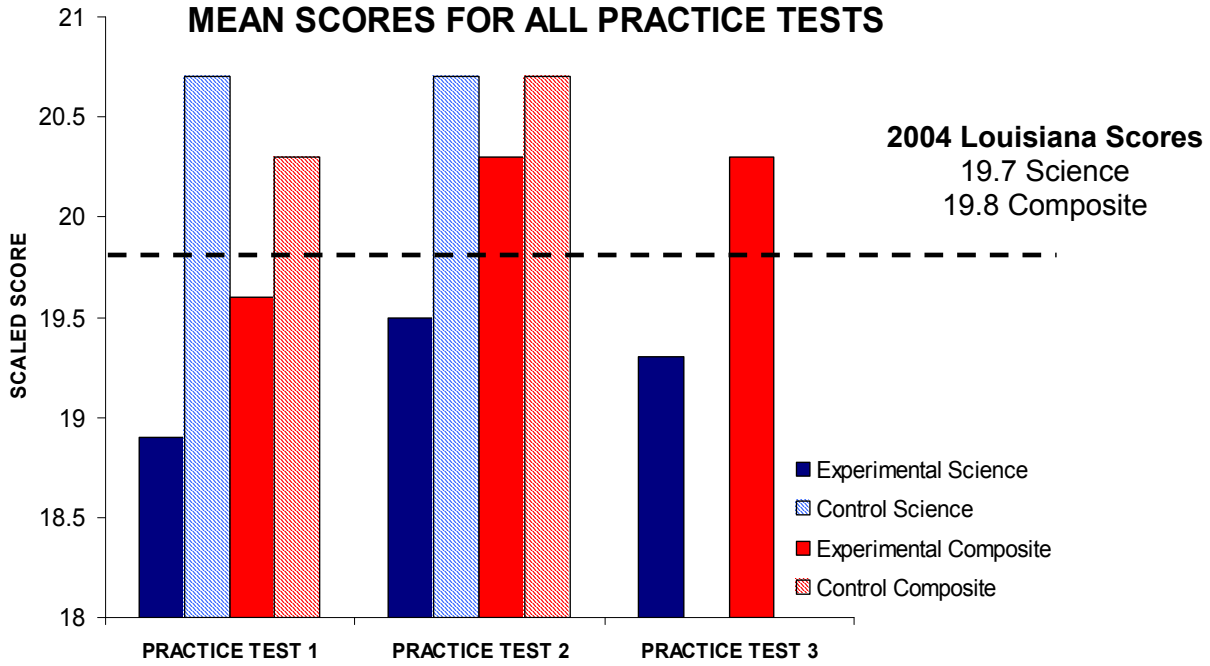

Figure 3: The mean scores for both experimental and control groups for all three tests are compared to the 2004 Louisiana student mean scores

The SAS (Statistical Analysis Software) package accessible via the Louisiana Tech University's mainframe was used to analyze the collected data. A linear model of the form

$$Y_{it} = \mu + \tau_i + \varepsilon_{it}$$

was used to represent the pilot experiment, relating the resulting scores to the test sequence. In order to address the differences in scores obtained from the tests at 0, 3, and 6 weeks, a one-way analysis of variance (ANOVA) was computed at α=.05 to test the null hypothesis, versus the alternative hypothesis that the effects of at least two of the tests differ [8].

The results of the ANOVA determined that at the .05 level, there was no statistically significant difference between any of the tests. Additionally, 95% confidence intervals for the pairwise differences of the τ_i were calculated using Tukey's method indicated the same [8]; small as it may be the experimental groups' score increase is promising.

From the beginning, attendance for the after-school sessions was tracked. The following table and graph show the effects of attendance on practice test performance. Table 2 shows the actual changes for each student that participated in the program. From the table, the correlation between score improvement and attendance appears to be strong. On average, those students which attended more than 80% of the time show an improvement of 5.25 and 2 points, science and composite score, respectively. It can be seen from the graph that a significant increase in science scores occurs when participants attended more than 80% of all sessions.

STUDENT GROUP	% Attendance	Best Increase in Science Score	Best Increase in Composite Score
CONTROL	0.0	0	1
	0.0	0	0
	0.0	0	0
EXPERIMENTAL	41.7	0	2
	50.0	0	1
	75.0	0	0
	83.3	7	1
	83.3	3	2
	91.7	7	0
	91.7	4	5

Table 2: The greatest increase in science and composite score from the first practice test as it compares with attendance

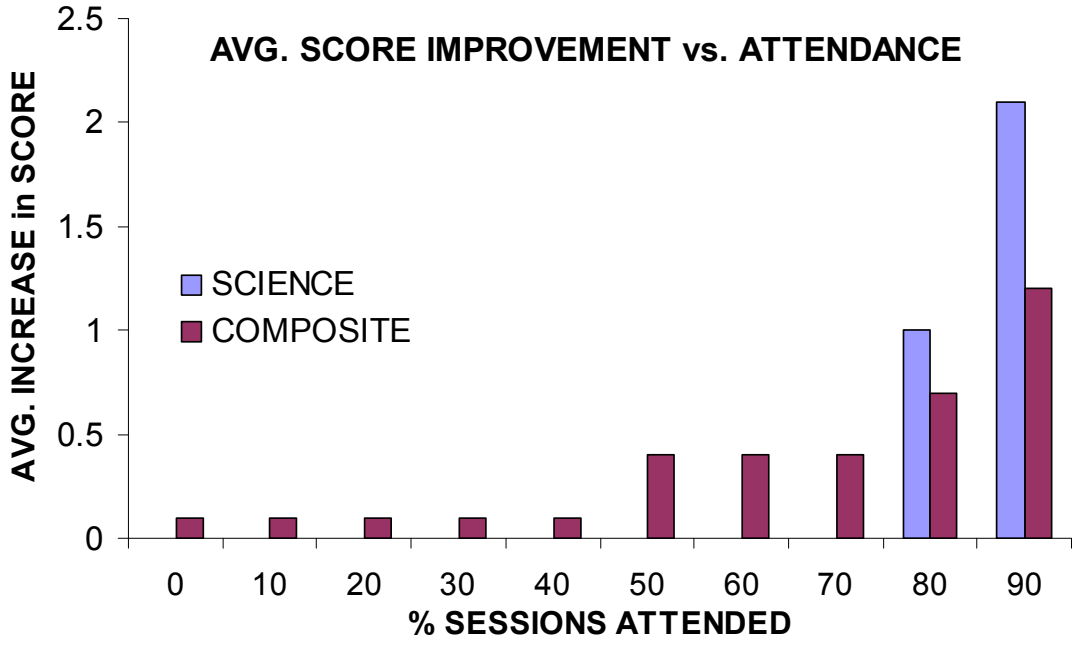

Figure 4: Improvement in science and composite scores as session attendance increases

DISCUSSION

Course Assessment

Assessment of the program was based upon practice test scores as well as feedback from the students via informal discussions during sessions and at the conclusion of the course. As previously mentioned, statistical analysis indicated that there was no significant difference between the scores of the experimental and control groups. However, as documented in the results, there was an overall improvement in student scores, with the greatest overall improvement on the second test. During the initial design of the course it was decided that student feedback would play a key role in determining the success of our program. Based on previous experience, we felt that helping the students gain confidence in their ability to do well was just as important as how many more points they actually scored. Much of our course design was based on providing the students with the strategies needed to perform well, but also calm their fears of standardized tests. According to student surveys, this goal was accomplished as the majority of students felt an increased confidence in their ability to score well on the Science Reasoning portion.

We hypothesize that several factors may have attributed to the fact that no statistically significant difference was noted between the scores of the two groups, one major aspect being the small sample size of ten students. We were unable to have as many participants as originally anticipated, and with such a small sample size it is difficult to determine whether the results are truly meaningful. Additionally, we tried to distribute the two groups so that the students in each had fairly similar backgrounds. It turned out, however, that the majority of the students in the experimental group were those students who truly needed the extra help to prepare for the ACT. According to the Louisiana State Board of Regents and the Louisiana State Department of Education, improvements in scores have been noted despite the disproportionate number of poor students taking the test in the state (15%) when compared to the national average (9%) [3]. The fact that our pilot study was carried out in the Village of Simsboro, a rural and economically poor community in north central Louisiana may have had an impact on the minimal, but noteworthy increase in scores during our experiment. Rural schools typically have many fewer students than their urban counterparts and thus more individual attention can be given to each student, especially when it comes to standardized test preparation. Finally, attendance of all seven students in the experimental group was rare and this certainly had great impact on science scores in that those students who did not attend regularly were not as familiar with the test-taking strategies as opposed to those students who consistently attended.

ACTive Prep®

It was decided that the interactive software, ACTive Prep®, would benefit the students since it was designed by the makers of the ACT and would allow them to work at their own pace, while offering additional practice materials for the sections not covered by our course. Unfortunately, we were not allowed to preview the program before purchasing and to our disappointment, the software was essentially useless. Before allowing the students to use ACTive® Prep, the program was evaluated; navigation through the menu was difficult and aside from the diagnostic tests, no practice questions which specifically addressed students' weaknesses were provided. The ACTive Prep® technical sheet stated it was designed to run on Windows® 95, 98, or Millennium editions and not intended for use with Windows® XP. Though the school computers

exceeded technical specifications, the software functioned poorly [7]. The students' disliked the program, felt it was boring, and in their own words, "cheesy." The software was not as interactive as anticipated and its use was discontinued after a short time. Needless to say, our experience was much different from what was advertised for this "award winning" software.

Science First

Analysis of the previous test data and test day observations led to the hypothesis that students' decreased scores in the reading and science sections might be attributed to mental fatigue towards the conclusion of the exam. To investigate this hypothesis the order of the third test was reversed. Unfortunately, there was little difference when comparing science scores from tests 2 and 3. The mean scores actually indicated a 0.2 point drop when the science portion was given first. Although, one student's score did increase by seven points, there was no indication that this difference was statistically significant. A likely contributor to the greater increase in Math and English scores was the participants' concurrent involvement in school-sponsored Math and English ACT prep classes; they had been enrolled in these classes since the beginning of August. In addition, some of the participants were not enrolled in a science course due to block scheduling.

Student Feedback

In discussing the strengths and weaknesses of our course with the participants, it was determined that holding two sessions a week was a greater problem than originally anticipated. Our original concern was finding times when all the students would be able to attend. However, having solved that problem we noticed that attendance for consecutive sessions was still low. The students indicated that other after-school activities made it difficult for them to attend both and still have enough energy to participate. The majority of the participants were members of at least one organization that required weekly, after-school participation. Moreover, since our course was held in the middle of the basketball season, many students had previous commitments to the team that did not allow them to attend every session. It was also indicated by the students that their attention span just was not large enough for 2 sessions and that the next time we held the course we should do only one session per week. On the other hand, the students felt that the session length of 1 ½ to 2 hours was appropriate.

Impact on Teaching Fellows

In reflecting upon the impact of this course, it is clear that we learned as much from this experience as did the students who participated. Foremost, educational research of this type vastly differs from the typical laboratory research we as graduate engineering students have become accustomed to. For example, when conducting educational research investigators must understand that working in a K-12 environment requires a higher degree of flexibility, patience, and tolerance of unexpected chaos. An important outcome derived through the implementation of this program was that it provided an avenue through which communication skills were improved, a necessity for future professionals. As engineers, designing this course and overcoming its intermittent obstacles provided an opportunity to apply our problem-solving skills to a situation atypical of that within an engineering text. Moreover, the additional workload and close contact with the students made us appreciate how personally rewarding and fulfilling the teaching profession can be. Fortunately, the impact of this program was not limited to ACT scores.

CONCLUSION

A novel, six-week course was designed to aid high-school students for the science reasoning portion of the ACT. Using an interactive approach, students developed the necessary data analysis and interpretation skills needed to perform well in science reasoning section. During that time frame, student performance on practice tests was tracked and compared to a control group that was not receiving any additional test preparation. At the conclusion of the course, there was an observed increase in the science score of the participants while no change was observed for the control group. Students remarked that they confident in their ability to answer the types of questions found on the ACT at the conclusion of the course. Since the sample size of our investigation was so small, statistical analysis of the scores is inconclusive and it is clear that another course, with more students, is needed to determine the true impact of this module. What is more, the graduate students found that the design of and involvement in this course provided a novel venue through which design and problem-solving skills could be applied; the unexpected chaos of this investigation provided a new perspective the typical engineer does not experience.

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BIOGRAPHICAL INFORMATION

JORGE E. ROLDAN is a graduate student in Molecular Science and Nanotechnology at Louisiana Tech University. His current research involves applications of nanotechnology for drug delivery and cartilage tissue engineering. This is Jorge's second year with the GK-12 Program and assisting in teaching high-school mathematics and science at Weston High School.

SKYLAR S. STEWART is a graduate student in Biomedical Engineering at Louisiana Tech University. Her most current research project involves near ultra-violet light for wound healing applications. Through the GK-12 Program, Skylar is a currently assists in teaching high-school biology, physical science, and chemistry at Simsboro High School.

JULIE N. DuBOIS is the Science Department at Simsboro High School. She currently teaches high-school biology, physical science, chemistry, and physics. This is Julie's second year with the GK-12 Program.

LINDA L. RAMSEY serves as the Director of CATALyST (Center for Applied Teaching and Learning to Yield Scientific Thinking), Louisiana Tech University's K-12 science and mathematics education center. Linda also serves as the Co-Principal Investigator for the GK-12 Program at Louisiana Tech.

DAVID K. MILLS is an Associate Professor of Biological Sciences and the Institute for Micromanufacturing. His research interests are varied and include TMJ structure & function, tissue engineering, and nanobiotechnology. David is the Principal Investigator for Louisiana Tech's GK-12 Program.