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Editorial

I want to take this opportunity to thank Stewart Townend for his contribution to the work of the journal over many years. Stewart has recently retired from his post at the University of Plymouth and will no longer be involved in the editing of the journal. Stewart has worked quietly behind the scenes assisting with the editorial work in a very significant way and his presence will be greatly missed by the editorial team here at Plymouth. I am looking at ways to fill the gap which Stewart has left and will be bringing in some new members of staff to help take on his role as we move into 2009.

The first paper in the current issue is Paul Laumakis and Marlena Herman. This is a particularly interesting and timely paper. In the past articles on the use of graphics calculators and other software have highlighted the need for teachers to be given thorough training in the use of the software from both an educational and personal competence perspectives. This paper looks at the impact of a training programme in the use of graphics calculators that was undertaken by a group of teachers. The performance of their students was then compared with a control group. The data presented in the paper suggests that the students taught by the teachers that had experienced the specific training programme gained significantly higher scores in their tests than the students in the control group. This paper does stress the importance of training of teachers to use technology effectively.

The second paper by Antonio Quesada, Richard Einsporn and Muserref Wiggins also concerns graphics calculators. In this case the graphics calculators were used as part of a graphical approach to teaching the formal definition of a limit. After some traditional instruction parts of the course were taught with the graphical approach. The performance of students using the graphical approach was compared with students who were taught the whole course in a traditional way. The authors used a number of pre-tests and post-tests to identify where the graphical approach made a difference to the students achievement and understanding. In their discussion the authors do make an interesting comment about how the students may not benefit from using the graphics calculator if they only work with them for a short time.

The third paper by Muhammad Abu-Naja continues the graphics calculator theme. His study was with Arab students in the Negev region of Israel. His study looked at how the students developed their understanding of the properties of some functions, particularly what the author refers to as the “positivity and negativity” of the functions. The work compares experimental groups who worked with the graphics calculators with control groups who worked on the same topics in a traditional way. The paper provides a detailed analysis of the responses of the students to a questionnaire designed to test their understanding. The authors conclude that the experimental groups demonstrated a better understanding of the concepts considered. The analysis of the responses used the ideas of pseudo-conceptual and pseudo-analytical thinking, and this found that these were less pronounced among the students in the experimental group. The author also speculates on the fact that the motivation of using the graphics calculators may contribute to the students engaging in a deeper way with the mathematics being studied.

The final paper by Rita Nagy-Kondor departs from the graphics calculator theme and considers a case of using a dynamic geometry package with students taking a course in descriptive geometry. In the paper the emphasis is on the results of a delayed post-test. From a consideration of this the author concludes that the use of the geometry package increases success and helps the students to create a proper conceptual structure, that the students seem to be better supported and more motivated, but the test has also allowed her to identify concepts that needed to be clarified with the students and that more time should be spent on. The approach of using a delayed test to identify what the author calls “weak spots” to guide future teaching is an interesting idea which could well be developed and used by more researchers.

Ted Graham
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The Effect of a Calculator Training Workshop for High School Teachers on their Students' Performance on Florida State-Wide Assessments

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This paper details the motivation, background, and analysis for studying the effect that an Increasing Achievement on Algebra Assessment (IAAA) workshop for a group of Florida high school teachers had on student performance in state-wide testing. The main focus of the workshop was to provide participating teachers with both instruction and activities related to problem-solving techniques using the TI-83 Plus handheld graphing calculator that the teachers could then use in an effort to better prepare their students for state-wide testing. Overall, students ($n = 328$) who were taught by IAAA-trained teachers between consecutive annual state-wide assessments had a greater gain in test scores than students ($n = 202$) who were taught by non-trained teachers. In particular, the data indicates a significant increase in scores for students taught by IAAA-trained teachers in a general mathematics course, as compared to no significant increase in scores for students taking that same course taught by non-trained teachers.

1 FOUNDATION OF STUDY

The use of graphing calculators has been a source of interest for mathematics educators since the time that the calculators first made their way into mathematics classrooms. A surge of research occurred during the 1990's, with many studies showing that use of the graphing calculator does not hinder student achievement on paper-and-pencil items at a procedural level and instead enhances student understanding at a conceptual level (see overviews in Burrill, Allison, Breaux, Kastberg, Leatham and Sanchez, 2002; Dunham and Dick, 1994; Dunham, 2000; The McKenzie Group, 2001; Waits and Demana, 2000). Research today tends to focus on specific uses of the graphing calculator in various settings. For example, one focus area has been the study of functions in algebra, precalculus, and calculus classrooms, particularly in terms of multiple representations of functions that the graphing calculator offers. Many articles, dissertations, and books (e.g., Romberg, Fennema, and Carpenter, 1993) have been devoted to this topic. Burrill et al. (2002) point out that further research on the use of graphing calculators is needed in other major areas of focus, such as student attitudes and beliefs; comparisons with respect to gender, ethnicity, geographic, and socio-economic conditions; teacher knowledge, beliefs, and experiences; curriculum implications; and relationships to high stakes assessments.

In general, as a result of positive effects on student learning found in a large number of studies, national organizations (National Council of Teachers of Mathematics, 2000; National Research Council, 2001) currently strongly support the use of graphing calculators in middle school, high school, and university classrooms, and other

organisations have followed suit. The TI-83 Plus family of graphing calculators, manufactured by Texas Instruments, is the most widely used type of calculator used in the United States. More than 80 percent of high school mathematics teachers surveyed in a national survey in 2000 claimed to use such handheld graphing technology in their classrooms (Weiss, Banilower and Smith, 2001). The popularity and widespread use of the TI-83 Plus calculator has led to its being allowed for use on standardized exams such as the PSAT, the SAT Reasoning Test, SAT Subject Tests and Math Level 1 and 2 Tests, and AP Calculus, Physics, and Chemistry exams in the United States. On the other hand, use of the TI-83 Plus graphing calculator is not permitted on many state assessments, even in states that do support the use of the calculator in the classroom.

This study focuses on the effects of a specific type of professional development on the use of handheld graphing calculators in terms of the impact of teacher training on student performance on Florida's state assessment. Florida was targeted as a state that promotes the use of graphing calculators such as the TI-83 Plus in secondary classes, but does not allow use of graphing calculators on its state assessments. Further information about Florida, the professional development experienced by Florida teachers, and effects on student achievement is described in the following sections of this paper.

2 FLORIDA TESTING

The Florida Comprehensive Assessment Test (FCAT) is administered to students in grades 3-11, satisfying the No Child Left Behind (NCLB) mandate that annual testing in reading and mathematics occur in each of grades 3-8 and at least once in grades 10-12. The FCAT contains two basic components: criterion-referenced tests (CRT), measuring selected benchmarks in Mathematics, Reading, Science, and Writing from the Sunshine State Standards (SSS); and norm-referenced tests (NRT) in Reading and Mathematics, measuring individual student performance against national norms. This study focuses on students' mathematics achievement from year to year and thus the following discussion will focus on the Mathematics portion of the CRT only. (Florida Department of Education, 2005)

The FCAT mathematics test questions focus on five content areas that match Florida state standards, including Number Sense, Concepts, and Operations (making up approximately 18% of the test); Measurement (16 - 17% of the test); Geometry and Spatial Sense (24 - 25% of the test); Algebraic Thinking (23% of the test); and Data Analysis and Probability (18% of the test). As with many states, the

Florida standards are aligned with those measured on the National Assessment of Educational Progress (NAEP) national assessments and those promoted by the National Council of Teachers of Mathematics (NCTM), i.e., number sense, properties, and operations; measurement; geometry and spatial sense; algebra and functions; and data analysis, statistics, and probability.

A score called the *developmental scale score*, falling between 86 and 3000, is used to determine a student's annual progress from grade to grade. The developmental scale score is equated to the base year (1998 for Grade 10 Mathematics) so that scores from year to year can be compared in such a way that, even though a grade-level test may contain different questions each year, students who perform at the same skill level in different years will earn the same developmental scale score. The developmental scale score is also identified as the FCAT score and is the type of score reported in this study. (Florida Department of Education, 2003)

The high school students ($n = 569$) in this study took the FCAT two times, once in March of 2003 and then again in March 2004. The March 2003 Mathematics test serves as a pre-test in the study, and the March 2004 Mathematics test serves as a post-test in the study. While the pre-test and post-test were not the exact same test, the two tests were comparable in content with parallel questions and thereby functioned equivalently. In general, the test contained 50 questions in multiple choice (MC), gridded-response (GR), short-response performance task (SR), and extended-response performance task (ER) formats. Overall, the majority of the test was MC and GR questions (approximately 88%), with few SR and ER questions.

Between the pre-test and the post-test, the students in this study continued their mathematics coursework, all at the same Florida high school. Many students ($n = 530$) completed a substantial portion of one mathematics course during the school year prior to the March 2004 post-test. All of these students took a geometry course, an algebra course, or a general course entitled Explorations in Mathematics during the 2003-04 school year. During the same time period, the remaining students ($n = 39$) took two mathematics courses under the school's 4 by 4 block scheduling which enabled some students to complete a course in December of the school year and begin a second course prior to the March post-test. These students took various combinations of courses.

Also between the pre-test and the post-test, some of the mathematics teachers at the high school completed training in an Increasing Achievement on Algebra Assessment (IAAA) workshop program sponsored by Texas Instruments (TI). The IAAA workshop focused on specific methods of using a TI-83 Plus graphing calculator to build student understanding of a variety of mathematical concepts, described in more detail in the next section below. After participating in the IAAA training, teachers used IAAA techniques with the graphing calculator in their classrooms during the 2003-04 school year. While students used the graphing calculator for class, they were not permitted to use

it on the FCAT pre-test and post-test. Instead, they were permitted to use a non-scientific calculator that offered only basic arithmetic operations ($+$, $-$, \times , \div , $\sqrt{\quad}$, $\%$, \pm) such as the Casio HS10 electronic calculator.

This study focuses on academic progress made by students between the pre-test and the post-test in courses taught by IAAA-trained teachers, as compared to student progress made between the pre-test and the post-test in similar courses taught by teachers who did not take part in the IAAA training. As such, the study investigates the effects of the IAAA training on student achievement in mathematics content areas related to Florida's state standards as measured by FCAT scores. The following paragraphs describe the IAAA training, student test results, and findings in more detail.

3 DESCRIPTION OF IAAA TRAINING

National and state standards encourage the use of technology such as graphing calculators for teaching and learning mathematics, and the use of graphing calculators is now common in many secondary classrooms. However, as mentioned above, some states do not allow the use of the technology on their state mathematics assessments. Hence, the need arose for specific teacher training on ways to incorporate the use of graphing calculators for purposes of deepening student understanding and enhancing skills targeted on state assessments. The Teachers Teaching with Technology (T^3) program, known for the principle of "teachers teaching teachers" whereby T^3 instructors are trained to teach others how to use calculators and computers in appropriate ways to enhance the teaching and learning of mathematics and science, sought to address this need. As a result, after identifying some states that allow the use of graphing calculators in the classroom but not on the state assessments, a group of T^3 instructors reviewed these states' mathematics assessments for secondary school and developed a set of activities around topics tested on the assessments, particularly those considered algebra concepts. This set of activities became the IAAA training manual used to train Florida teachers in a professional development setting modelled after traditional T^3 institutes in this study.

The training manual was comprised of nine sections, each addressing a different aspect of the TI-83 Plus graphing calculator's functionality with regard to helping students solve a diverse collection of problems. The first section was an introduction that provided a blueprint for the pedagogical techniques used for problems typically encountered in high school algebra classes involving concepts such as numerical processes, algebraic processes, tables, variables, graphs, and problem solving. The second section on number sense included activities that provided opportunities to explore the various computational capabilities of the TI-83 Plus calculator, such as basic arithmetic operations, fractions, and exponents. The third section on percentages and discounts addressed the calculator's features used to compute various sales pricing with an emphasis on pattern recognition through the use of lists. The fourth section on relationships and variables was motivated by a geometric application and

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describes how to use expressions in lists to relate length, width, perimeter, and area of a rectangle.

The fifth section presented the classical maximizing-volume-of-a-box problem, starting with actually forming boxes from standard graph paper with scissors and tape, and progressing to using the TI-83 to set up lists, equations, and graphs relating the dimensions of the box with its volume. The sixth section on linear functions provided guidance on building equations, inequalities, and systems of equations for solving real-world problems with numerical guess-and-check, symbolic, and graphical approaches. The seventh section provided an overview of both the meaning of the intercepts of a function and the solutions of linear equations. The eighth section presented an activity to help participants explore lines with varying slopes and y -intercepts. The ninth and final section of the training manual integrated the notions of coordinate graphing, characteristics of polygons, and geometric transformations.

Of the seventeen mathematics teachers involved in this study, ten teachers received the IAAA training on a volunteer basis. These ten participants attended a class taught by two T³ instructors for six hours per day over a three-day period during the summer of 2004. Workshop activities included both lecture and demonstrations by the T³ workshop leaders on uses of the TI-83 Plus calculator as a tool for developing and bolstering deep comprehension (as encouraged by NCTM, 2000). Additionally, workshop

participants had ample hands-on activities to deepen their understanding of the methods of using the calculator. Follow-up from the summer workshop was provided to the participants in the form of a one-day mid-year training session, access to online teacher resources provided by Texas Instruments, and ready-made activities for the classroom in a book entitled "Activities for Algebra with the TI-83 Plus" (Newman-Turner and Goodman, 2001).

4 ANALYSIS OF TEST RESULTS

There were a total of 569 students who took part in this study. Of the total number of student participants, 360 were taught by teachers who had received IAAA training, with the remaining 209 students being taught by teachers who had not received the IAAA training. As shown in Table 1, the students who were taught by IAAA-trained teachers were further grouped into Group 1 (G1) for students who took one high school mathematics course between the pre-test and the post-test and Group 3 (G3) for students took two high school mathematics courses during that same time period. Students who were taught by teachers who had not received IAAA training were similarly grouped into Group 2 (G2) and Group 4 (G4). Due to the many variations of courses taken by students in G3 and G4 and due to the small size of G3 and G4, these two groups are not compared in this study. Comparisons made between G1 and G2 are discussed below, first as whole groups and then by subgroups.

	IAAA-trained	Not IAAA-trained
Students who took 1 mathematics course between tests	Group 1 (G1) 328	Group 2 (G2) 202
Students who took 2 mathematics courses between tests	Group 3 (G3) 32	Group 4 (G4) 7
Total	360	209

Table 1 Numbers of students in four groups between pre-test and post-test.

In terms of whole groups, the first two groups compared in this study are G1, the group of students that had been taught by IAAA-trained teachers and had taken one high school math course between the pre-test and the post-test, and G2, the group of students that had been taught by teachers that had not received IAAA training and had also

taken one high school math course between the pre-test and post-test. In terms of subgroups, Table 2 shows a breakdown of the numbers of students who took different high school mathematics courses between the pre-test and post-test for both G1 and G2.

Course Taken	G1	G2
Geometry	71	59
Algebra I	160	110
Algebra II	60	7
Explorations in Math	37	26
Totals	328	202

Table 2 Numbers of students taking different courses between pre-test and post-test.

Table 3 shows the mean FCAT scores for G1 and G2 for both the pre-test and the post-test, along with pertinent p -values. The mean FCAT score for G1 is significantly higher

at the 0.05 level of significance than the G2 mean for both the pre-test ($p = 0.0039$) and the post-test ($p = 0.0040$). These p -values were computed using the unequal variance

assumption, in part due to the appreciable difference in sample size between G1 and G2. Examination of the means reported in Table 3 seems to indicate that G1 has academically stronger students than G2, which is further supported by the fact that sixty students in G1 took Algebra II in the year between the pre-test and the post-test, as compared to only seven G2 students taking Algebra II during

that time period, as shown in Table 2. Using a matched-pair t -test for both G1 and G2, the post-test means for both groups are significantly higher at the 0.05 level of significance than the pre-test means. Finally, the increase in mean score for G1 from pre-test to post-test was 52.6 points as compared to an increase of 48.7 points for the G2 mean, showing a larger gain for G1.

	Sample Size	Pre-test Mean	Post-test Mean	p -value
G1	328	1901.2	1953.8	$\sim 10^{-45}$
G2	202	1863.2	1911.9	$\sim 10^{-43}$
p -value		0.0039	0.0040	

Table 3 FCAT means and associated p -values for G1 and G2.

Subgroup comparisons can be made across courses in terms of matching groups of students who took Geometry, Algebra I, and Explorations in Math. The very small sample of students in G2 who took Algebra II makes it difficult to make comparisons across the Algebra II course alone. Differences between G1 and G2 across Geometry, Algebra I, and Explorations in Math are described below.

A comparison of the scoring for students in G1 who took a Geometry course (G1 GEOM) between the pre-test and the post-test with the students in G2 who also took a Geometry course (G2 GEOM) between tests is illustrated in

Table 4. Note that the students in G1 GEOM scored significantly higher than students in G2 GEOM on both the pre-test and the post-test under the assumption of unequal variances. Using matched-pair t -tests, both groups significantly increased their scoring from pre-test to post-test, with an increase of 68.2 points in mean scoring for G1 GEOM as compared to an increase in mean score of 55.0 for G2 GEOM. As with the whole group comparisons, differences between G1 and G2 across Geometry show a larger gain from pre-test to post-test results for G1.

	Sample Size	Pre-test Mean	Post-test Mean	p -value
G1 GEOM	71	2061.8	2130.0	$\sim 10^{-42}$
G2 GEOM	59	1944.2	1999.2	$\sim 10^{-35}$
p -value		$\sim 10^{-2}$	$\sim 10^{-7}$	

Table 4 FCAT means and associated p -values for G1 GEOM and G2 GEOM.

The next two groups compared are the students in G1 that took an Algebra I course (G1 ALG I) between the pre-test and the post-test and the students in G2 who also took an Algebra I course (G2 ALG I) during that same time period. As shown in Table 5, there was no significant difference in the scoring on both the pre-test and the post-test between

these two groups using unequal variance assumptions, as evidenced by the p -values of 0.0724 and 0.0681 on the pre-test and post-test, respectively. However, using matched-pair t -tests, both G1 ALG I and G2 ALG I show significant increases in scoring from pre-test to post-test.

	Sample Size	Pre-test Mean	Post-test Mean	p -value
G1 ALG I	160	1829.5	1873.6	$\sim 10^{-7}$
G2 ALG I	110	1853.5	1901.1	$\sim 10^{-7}$
p -value		0.0724	0.0681	

Table 5 FCAT means and associated p -values for G1 ALG I and G2 ALG I.

The final two groups compared in this study are the students in G1 who took the Explorations in Math course (G1 EXP) between the pre-test and the post-test and the students in G2 who also took the Explorations in Math course (G2

EXP). Like the earlier tables, Table 6 shows the mean FCAT scores for these groupings, along with the relevant p -values.

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	Sample Size	Pre-test Mean	Post-test Mean	<i>p</i> -value
G1 EXP	37	1678.2	1733.8	0.0125
G2 EXP	26	1690.2	1720.2	0.1167
<i>p</i> -value		0.3670	0.3780	

Table 6 FCAT means and associated *p*-values for G1 EXP and G2 EXP.

While the differences between groups in the pre-test mean and in the post-test mean are not statistically significant at the 0.05 level under the unequal variance assumption, it is interesting to note that the pre-test mean for G1 EXP is lower than the pre-test mean for G2 EXP, but the post-test mean for G1 EXP is higher than the post-test mean for G2 EXP. Hence, the increase in the mean FCAT score (55.6 points) for students who were taught by IAAA-trained teachers is larger than the increase in mean FCAT score (30.0 points) for students who were taught by teachers not IAAA-trained. Furthermore, using matched-pair *t*-tests, the increase in mean FCAT score for G1 EXP is statistically significant ($p = 0.0125$), whereas the increase in the mean FCAT score for G2 EXP is not statistically significant ($p = 0.1167$). In light of this phenomenon, there may be an underlying relationship that could be used to predict a post-test result from a pre-test result under IAAA-trained teaching techniques in the Explorations in Math course.

In order to investigate the relationship, if any, between the pre-test and post-test scores for the students in G1 EXP, a scatterplot of the data is shown in Figure 1, along with the least-squares regression line. The FCAT pre-test score is plotted against the FCAT post-test score for all 37 students in the group. The linear regression model coefficients and statistics are shown in Table 7. At the 0.05 level of significance, the slope coefficient is significantly different from zero ($p = \sim 10^{-6}$), while the intercept coefficient does not significantly differ from zero ($p = 0.0565$). The correlation coefficient for this data is 0.68, indicating a moderately strong positive association between pre-test and post-test scoring for G1 EXP students. Note that when the single outlier data point corresponding to a pre-test score of 1594 and post-test score of 1068 is removed from the analysis, the correlation coefficient increases to 0.79, indicating an even stronger positive association between the pre-test and post-test scores for this group of students taught by IAAA-trained teachers.

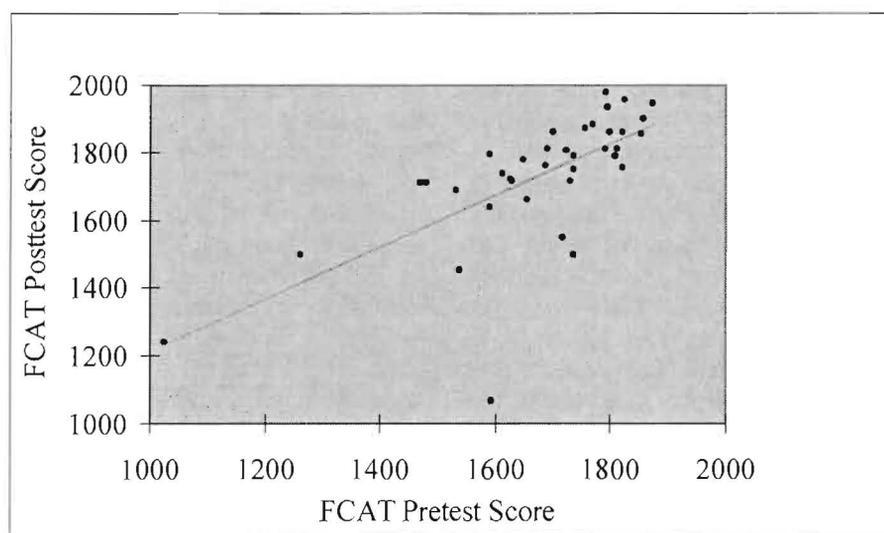


Figure 1 Scatterplot of G1 EXP pre-test and post-test scoring.

	Regression Coefficients	<i>p</i> -value
Intercept	457.8	0.0565
Pre-test Score (Slope)	0.76	$\sim 10^{-6}$

Table 7 Regression model coefficients and statistics for predicting G1 EXP post-test scores from pre-test scores ($n = 37$).

5 DISCUSSION AND SUMMARY OF RESULTS

The results of the statistical analysis reported in the preceding section of this paper seem to indicate that the IAAA training program is an effective way for teachers in the state of Florida to better prepare their students for state-wide assessment testing. Although the increase in test scores was significant for both students who were taught by IAAA-trained teachers as well as for students who were taught by non-trained teachers, overall there was a larger difference in increased scores for students of trained teachers.

Looking more closely at students in specific courses, the same trend holds true for Geometry students. That is, for the students who took a Geometry course between the pre-test and the post-test, a higher increase in scoring was achieved by students taught by IAAA-trained teachers than by students taught by non-trained teachers. Students taking Geometry taught by IAAA-trained teachers increased their scores, on average, 13.2 points more than students taking Geometry taught by non-trained teachers. Given that 24 - 25% of the pre-test and post-test problems are geometry questions, one might expect a comparable significant increase in scoring, regardless of whether a geometry student is taught by a trained or non-trained teacher, but this is not the case. Perhaps students taught by an IAAA-trained teacher gained a larger repertoire of techniques for solving geometry problems, including algebraic methods such as those typically associated with analytic geometry, and hence were better able to solve the problems on the geometry portion of the test. Or, students may have performed similarly on the geometry portion of the test while scoring differently on other portions of the test. In particular, as the majority of the content of the IAAA training focused on algebra topics, it seems logical that students taking a geometry course taught by an IAAA-trained teacher may have performed better on problems that fall within the algebra portion of the test.

There was a comparable significant increase in scoring for the students who took Algebra I between the pre-test and the post-test, regardless of whether they were taught by trained or non-trained teachers. As the IAAA training concentrated on algebra topics, students taught by IAAA-trained teachers may have simply learned different approaches to solving algebra problems than students taught by non-trained teachers. Given that 23% of both the pre-test and the post-test contain algebra questions, it should not be surprising that all students who take an Algebra I course between tests would learn some techniques for solving algebra problems and hence should be able to increase their scores. Thus, this result is reasonably expected.

The IAAA training seems to be most beneficial for students who take a general course that does not specifically focus on one of the content areas being tested on the state-wide assessments as does a geometry or algebra course. The Explorations in Math course in this study uses multiple texts and different course materials covering elementary mathematical topics in an attempt to lay the foundation for Algebra I. As such, the content of this course does not

specifically prepare the student for success in any one of the five strands tested on the FCAT. A comparison of the pre-test and post-test scoring for the students who took the Explorations in Math course between the tests shows a significant increase in scoring for students taught by IAAA-trained teachers and no significant increase in scoring for students of non-trained teachers. The increase in average score from pre-test to post-test was 25.6 points more for students taught by trained teachers, and the correlation between pre-test and post-test scoring for these students is moderately strong with a significant nonzero slope coefficient. These differences in student performance seem to be attributable, in part, to the IAAA training program.

As is the case with most studies of this type, the presence of certain confounding variables may impact conclusions drawn from the analysis. In this study, variables such as teacher quality, innate student intellectual ability, and student academic maturity may indeed be contributing factors affecting student improvement on the FCAT. However, it has been shown that students taught by IAAA-trained teachers significantly improve their performance on the FCAT, and, of particular note, they do so when taking a general mathematics course such as Explorations in Math.

It would be interesting to find out whether or not similar trends occur in other locations, including other Florida school districts and other states, such as California and Ohio, in which students regularly use graphing calculators in the classroom but not on state assessments. Of particular curiosity is whether or not data on students in courses similar to Explorations in Math would stand out the way it does in this study. It would also be of interest to study more information from students in courses which were not analyzed in this study due to small sample size, such as Algebra II and other upper level courses. While this study focused on particular uses of the TI-83 graphing calculator on the achievement of high school students, it would be intriguing to consider uses of calculators and other technology commonly used at lower levels of schooling in terms of achievement of grade school and middle school students on state assessments administered in grades 3-8. Further research in these areas is recommended.

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BIOGRAPHICAL NOTES

Paul Laumakis and Marlena Herman are faculty members in the Department of Mathematics at Rowan University in Glassboro, New Jersey, USA.

Paul earned his B.S. in Mechanical Engineering from Drexel University, his M.A. in Mathematics from Villanova University, and his Ph.D. in Applied Mathematics from Lehigh University. Paul's current interests include the creation and dissemination of application-oriented projects used in teaching engineering mathematics courses. He is also involved with implementing and studying the effect of

use of data collection devices with graphing calculator technology in middle school science classrooms.

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