

**USING INSTRUCTIONAL TECHNOLOGIES OUTSIDE THE CLASSROOM:
GRAPHING CALCULATORS AND THE TEXAS FFA AGRICULTURAL MECHANICS
CAREER DEVELOPMENT EVENT**

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Abstract

This study was designed to describe student performance in the Texas FFA agricultural mechanics career development event (CDE) by access to, experience with, and use of a graphing calculator. A census of CDE participants was conducted. Findings of this study show that most participants had access to a graphing calculator. Students in this study perceived that the use of a graphing calculator improved their achievement in mathematics, agricultural science, and science. Students overall, however, did not perceive that they were experts in using a graphing calculator for mathematics, agricultural science, and science. Student classification and graphing calculator ownership were positively associated with higher agricultural mechanics CDE scores.

Introduction

Career development events (CDE's) are an important part of agricultural education. These educational events are organized by the National FFA Organization and state FFA associations, and sponsored by postsecondary education, business and industry, and individuals (Texas FFA, 2009). State rules generally follow national rules, with adaptations for conditions in each state. State CDE activities are based on competencies suggested by the National FFA Organization (National FFA, 2002). Each state association is represented in at least one National FFA CDE. Forty-six states competed in the National Agricultural Mechanics CDE in 2008 (Brown, 2009). Twenty-nine chapters competed in the 2008 Texas FFA Agricultural Mechanics CDE at the state level (Edney, 2009).

Career development events are an opportunity to perform real-world assessment of student skills. Students must develop abilities to solve complex problems to be successful in the workplace (Texas Education Agency, 2003). Career development events in agricultural mechanics are designed to identify students who have developed the competencies and skills needed for success in the constantly changing workplace. Career development events are designed to incorporate the most current teaching technologies. Students must apply a wide range of technologies to be successful in the workplace (Instructional Materials Service, 2002). Ozgün-Koca (2001) stated that instructional programs should enable students to use representations to interpret physical and mathematical situations. The use of technology-based tools in career development events improves student success by enhancing the instructional process (National Research Council, 1988).

Current educational technology includes graphing calculators that are mandatory in Texas for use by high school students in mathematics courses. In addition to access for testing and classwork, students must have access to graphing calculator for homework and extra curricular activities. Nelson (2002) directed school districts to ensure that adequate numbers of graphing calculators are made available to students for high-stakes testing situations. The state education agency has already provided significant funds to districts for the purchase of graphing calculators. Students should have multiple opportunities to work with calculators. Nelson (2001) noted that science assessments also necessitate the use of graphing calculators.

Theoretical Framework

The theoretical framework for this study is grounded by the seminal work of Hembree and Dessart (1986). Their findings established a positive link between use of calculators and increased student achievement and attitudes. Recent meta analyses support Hembree and Dessart's work (Burrill et al., 2002; Ellington, 2003; Roschelle & Gallagher, 2005). A study by Hawkins, Stancavage, and Dossey (1998) found increased use of calculators improved student achievement on standardized tests. The use of calculators enhances students understanding of complex scientific and mathematical concepts by providing them with additional time to focus on the concept and problem (Center for Technology in Learning, 2007; Dossey, McCrone, Giordano, & Weir, 2002). Heller, Curtis, Jaffe, and Verboncoeur (2005) found that access to and use of graphing calculators resulted in higher mathematics test scores.

Students who are competent users of graphing calculators are more successful (Mokros, & Tinker, 1987). Students who solve problems that involve the use of CBL (calculator-based laboratory) probes are able to collect actual data on motion, sound, temperature, and light. Students with greater mathematical ability and experience tend to be more successful in agricultural mechanics CDE's (Johnson, 1991). Data showed that Texas agricultural mechanics students score as well as their peers in end-of-course assessments (Texas Education Agency, 2009). Johnson (1993) found also that the use of a calculator is strongly related to success in the Agricultural Mechanics CDE.career development event.

Teachers who provide opportunities for students to work with graphing calculators increase student success. Opportunities exist for agricultural science teachers to provide this type of instruction. According to the National FFA (2002), approximately 60% of the agricultural science programs in the United States include agricultural mechanics in their curriculum. Simulation-type problems have been shown to be effective vehicles for teaching many concepts of agricultural mechanics (Agnew & Shinn, 1991). Nelson (2002), however, noted many teachers are not familiar with instructional uses of graphing calculators. Nelson also noted that although school districts have graphing calculators on hand, they are used primarily for testing situations.

Graphing calculators are first introduced as a component of standardized assessment in Texas at the 8th grade level. Before this time, math teachers have generally provided their students with opportunities for guided practice. In many cases, science teachers have not provided these same opportunities. This is generally due to lack of familiarity with graphing calculators. Graphing calculator usage is often taught as a math skill rather than a science skill. Gathering data is often perceived as being a science skill, not a math skill. Interpreting the data contained in graphs is more often perceived as a math skill.

Opportunities should be provided for teachers and students to work with graphing calculators across a curriculum (Ozgül-Koca, 2001). Corporate entities are currently making attempts to expand the teacher knowledge base about graphing calculators with a variety of efforts. Texas Instruments (2009), for example, has developed an AgriScience curriculum and provides training to teachers through workshops offered around the country. The Texas Instruments (TI) AgriScience curriculum objectives are: reinforce agricultural education content across disciplines; promote the relevance between science and mathematics; enhance student learning experiences with real world activities; encourage the use of technology and hands-on learning by teachers; enhance student problem solving skills with real world activities; prepare students to use cutting-edge technology; and promote teacher collaboration across the curriculum.

One way to improve student skills is through the use of graphing calculators (Ozgül-Koca, 2001). Opportunities to integrate graphing calculator techniques with real-world application of this technology are provided at several locations. Extending instruction that involves graphing calculators to agricultural science classrooms should not result in budget increases, but will allow districts to make better use of equipment already in place. Research indicates the need for integrated educational activities anchored in real-world frameworks. Oakes (1997) suggested that a method combining discovery science with real-life situations will increase student understanding of calculator use and a greater understanding of science concepts. Balschweid (2002), however, noted that little evidence exists to show that general education teachers support their teaching with real-life examples in agricultural contexts. As early as 1983, the National Science Board recognized the need to incorporate more hands-on science experiences for students (NRC, 1988).

Scientific relevancy could be increased for students that seem to be uninterested with “traditional” approaches to science and mathematics through the use of curriculums that support science and math education (Balschweid, 2002). “Experiential” or problem-based learning may provide a transfer opportunity for many types of students. It has been demonstrated that problem-solving increases student retention. Solving real-world type problems in agricultural science classes incorporates the use of the scientific method and leads to student success (Boone, 1990). Complex calculations are an integral component of the world around us, and are contained in the Agricultural Mechanics CDE. Ozgün-Koca (2001) states that graphs are an effective means of summarizing complex information. Also, understanding and using graphs are a critical skill in the career development process for all students. Gliem and Warmbrod (1986) suggested that the utilization of practical mathematical problems should be an integral component of agricultural mechanics courses.

The 2003 Texas Agricultural Mechanics CDE involved teams of students using graphing calculators to solve problems. Slavin (1995) found that cooperative problem-solving increases student effectiveness. Problem solving with graphing calculators and interaction between team members is an effective method of instruction when the problem is carefully chosen (Grouws & Cebulla, 2000). Students experience greater success when solving problems because concepts and skills can be employed jointly. The agricultural mechanics CDE is an event that is balanced between problem-solving and individual skill performance.

To enhance the mathematical skills of high school agricultural science students, their teachers must become better teachers of mathematics skills. This can be done through the development of teacher opportunities that focus on the application of mathematics to agricultural problems (Miller & Gliem, 1994). A need exists for in-service opportunities that incorporate specific problem-solving skills utilizing graphing calculators. The research presented in this paper is an attempt to expand the work of Johnson (1991, 1993) and Gliem and Warmbrod (1986) within the theoretical framework of Hembree and Dessart (1986) by looking at the impact of student access to, experience with, and use of graphing calculators for testing, class work, homework, and extra curricular activities on achievement in the Texas agricultural mechanics CDE.

Purpose

The purpose of this study was to describe student performance in the Texas FFA agricultural mechanics Career Development Agricultural Event by access to, experience with, and use of a graphing calculator. The objectives of the study were:

1. Describe participants by whether their school allowed them to use their personal graphing calculator or provided them with access to a graphing calculator for standardized testing (Texas Assessment of Knowledge and Skills-TAKS), routine class work, homework, or extra curricular activities.
2. Describe participants by their experiences with graphing calculators.
3. Describe participants by their use of graphing calculators.
4. Describe participants by CDE performance and personal characteristics.

Methods

The research design used for this study was descriptive in nature. The target population was all high school students participating in the Texas FFA agricultural mechanics Career Development

Event. The population consisted of 107 students who qualified for the state event through regional competitions. A census of the defined population was conducted. Data for this study were collected in-person by the researchers during registration at the contest site. Because a census was conducted, analyses of the data are reported as parameters.

The Agricultural Mechanics competition consisted of six parts and students were allowed to use a graphing calculator during the entire competition. The six parts included three individual activities (power and machinery, electricity, agricultural structures), one team activity (problem solving), and two multiple choice examinations (cognitive skills and critical thinking). Competition rules allowed participants to use a graphing calculator on any part of competition. The competition's technical experts indicated that the use of a graphing calculator would likely improve students' scores, minimize mathematical errors, and increase student efficiency. For the team activity, all participants were provided with and allowed to use only TI 83 graphing calculators, which were supplied by TI. The team activity was specifically designed to engage the students in new and challenging situations that involve mathematical concepts (Dossey, McCrone, Giordano, & Weir, 2002). The activity required students to "recognize and formulate the situation in mathematical terms; determine which relationships are necessary and which are sufficient; select relevant strategies, data, and models; use reasoning (spatial, inductive, deductive, or statistical) in new setting; and judge the reasonableness and correctness of outcomes" (Dossey, McCrone, Giordano, & Weir, 2002).

The research instrument was designed to measure participants' access to, experience with, and use of graphing calculators in a variety of in-school and extra-curricular activities. A limitation of this study is that students self-reported their responses. The first part of the instrument was designed to gather information on students' ownership of a graphing calculator (brand and model if known) and school classification. The second part was designed to gather information on students' use of a graphing calculator for standardized testing, routine class work, and extra curricular activities using a nominal scale. The third part of the instrument was designed to gather information on students' experiences with graphing calculators using a five-point Likert-type scale. The points on the scale were: 1=strongly disagree; 2= disagree; 3=neither agree or disagree; 4=agree; and 5=strongly agree. The fourth part of the instrument was used to gather data on students' use of a graphing calculator using a five-point Likert-type scale. The points on the scale were: 1=never; 2=seldom; 3=some; 4=lots; and 5=always. Additional data were gathered on student and team performance upon completion of the competition. Student responses to the instrument were then matched with their individual and team scores.

The instrument was developed with assistance of the Agricultural Mechanics technical experts, judges, and TI AgriScience Academic Coordinator. Content and face validity of the instrument were established by a panel of experts consisting of university faculty, technical experts, and contest judges. Minor wording and formatting changes were made based of the recommendations of the panel.

A pilot study was conducted at qualifying CDE's with 75 students. Reliability for the construct access to a graphing calculator ($r=.65$), was estimated by calculating a split-half coefficient. Reliability for the section could be increased to .78 by removing the question on access to a graphing calculator on the day of TAKS testing. Based on the researchers need to gather descriptive information on students' access to a graphing calculator on the day of testing, this question was retained. Reliability for the construct student experience with graphing calculators ($r=.90$) was estimated by calculating a Chronbach's *alpha*. Reliability for the

construct student use of graphing calculators ($r=.83$) was estimated by calculating a Chronbach's *alpha*.

As a measure of instrument stability, a paired samples t-test was conducted on 33 students participating in the qualifying CDE's and the results of those same students participating in the State CDE's. There were no statistically significant differences between student responses at the qualifying CDE and the State CDE. It appears, therefore, that the instrument is stable. Alpha for all statistical procedures was set *a priori* at .05. The magnitudes of relationships were described using Davis' convention (1971).

Findings

This section presents a summary of findings by objectives. One-hundred seven high school students participated in the event. Approximately 42% of the students were seniors, 42% juniors, 15% sophomores, and 1% freshman. Approximately 42% of the students indicated that they owned a graphing calculator. Of those students indicating they owned a graphing calculator, 37 students reported owning a Texas Instrument graphing calculator and one student reported owning a Casio graphing calculator.

Objective 1

The first objective of this study was to describe participants' by whether their school allowed them to use their personal graphing calculator or provided them with access to a graphing calculator for standardized testing (TAKS), routine class work, homework, or extra curricular activities. Table 1 shows that 93.1% of students indicated that their school allowed them to use a graphing calculator for routine class work, 87.1% for extra curricular activities, 80.6% for homework, and 77.5% for standardized testing.

Table 1

Student Access to Graphing Calculators (N=107)

<i>Student Access</i>	Yes		No	
	<i>f^a</i>	<i>%^b</i>	<i>f^a</i>	<i>%^b</i>
My school allowed me to use my personal graphing calculator or provided me with access to a graphing calculator:				
• for routine class work	95	93.1	7	6.9
• for extra curricular activities such as CDE	88	87.1	13	12.9
• for homework	83	80.6	20	19.4
• on the day of TAKS testing	79	77.5	23	22.5

Note. ^aFrequencies may not sum to N=107 due to item nonresponse. ^bValid percent.

Objective 2

The second objective of this study was to describe participants' by their experiences with graphing calculators. As shown in Table 2, students agreed or strongly agreed with the statement, my teachers have instructed me how to appropriately use a graphing calculator for TAKS testing (66.2%) and extra curricular activities such as CDE (55.9%). Students agreed or strongly agreed with the statement, I am comfortable using a graphing calculator for TAKS testing (77.4%) and extra curricular activities such as CDE (76%). Students provided mixed responses as to their level of agreement with respect to the statement, I think I am an expert in using a graphing

calculator for mathematics (89.3%, disagree, neither agree/disagree, or agree), science (89.3%, disagree, neither agree/disagree, or agree), and agricultural science (86.5%, disagree, neither agree/disagree, or agree). Students agreed or strongly agreed with the statement, the use of a graphing calculator improves my achievement in mathematics (83.3%), science (71.6%), and agricultural science (68.6%).

Table 2

Student experiences with graphing calculators (N=107)

<i>Student Experiences</i>	Strongly Disagree		Disagree		Neither Agree or Disagree		Agree		Strongly Agree	
	<i>f^a</i>	<i>%^b</i>	<i>f^a</i>	<i>%^b</i>	<i>f^a</i>	<i>%^b</i>	<i>f^a</i>	<i>%^b</i>	<i>f^a</i>	<i>%^b</i>
My teachers have instructed me how to appropriately use a graphing calculator for:										
• TAKS testing	2	1.9	20	19.4	13	12.6	58	56.3	10	9.9
• extra curricular activities such as CDE	3	2.9	25	24.5	17	16.7	45	44.1	12	11.8
I am comfortable using a graphing calculator for:										
• TAKS testing	0	0	11	10.8	12	11.8	60	58.8	19	18.6
• extra curricular activities such as CDE	1	1.0	11	11.0	12	12.0	54	54.0	22	22.0
I think I am an expert in using a graphing calculator for:										
• Mathematics	6	5.8	17	16.5	33	32.0	42	40.8	5	4.9
• Agricultural Science	7	6.9	22	21.6	32	31.4	37	36.3	4	3.9
• Science	9	8.7	24	23.3	36	35.0	29	28.2	5	4.9
The use of a graphing calculator improves my achievement in:										
• Mathematics	2	2.0	3	2.9	12	11.8	65	60.8	23	22.5
• Science	3	2.9	9	8.8	17	16.7	53	52.0	20	19.6
• Agricultural Science	4	3.9	7	6.9	21	20.6	51	50.0	19	18.6

Note. ^aFrequencies may not sum to N=107 due to item nonresponse. ^bValid percent.

Objective 3

The third objective of this study was to describe participants' use of graphing calculators. Table 3 shows how often students used a graphing calculator in their school classes. Students indicated they used a graphing calculator lots or always in their math classes (59.4%), science classes (30.7%), agricultural science classes (15.9%), and in any/all other classes (8%).

Table 3

Student use of graphing calculators (N=107)

<i>Student Use</i>	Never		Seldom		Some		Lots		Always	
	<i>f^a</i>	<i>%^b</i>	<i>f^a</i>	<i>%^b</i>	<i>f^a</i>	<i>%^b</i>	<i>f^a</i>	<i>%^b</i>	<i>f^a</i>	<i>%^b</i>
How often do you use a graphing calculator in your:										
• Math classes?	9	8.9	13	12.9	19	18.8	24	23.8	36	35.6
• Science classes?	22	21.8	19	18.8	29	28.7	20	19.8	11	10.9
• Agricultural Science classes?	26	25.7	26	25.7	33	32.7	12	11.9	4	4.0
• In any/all other classes?	33	32.7	29	28.7	31	30.7	5	5.0	3	3.0

Note. ^aFrequencies may not sum to N=107 due to item nonresponse. ^bValid percent.

Objective 4

The fourth objective of this study was to describe participants' by individual performance and personal characteristics. The maximum individual overall score possible on the Agricultural Mechanics event was 223 points. The maximum individual overall score achieved was 177 points and the minimum individual overall score achieved was 73 points. The average individual overall score was 116.3 points (SD=24.2) with a median score of 110 points. Students ($f=43$) that indicated they owned a graphing calculator scored approximately seven points higher than students ($f=59$) that indicated they did not own a graphing calculator. This point discrepancy translated into an average difference of nine places in the individual judging contest.

Approximately 56% of sophomores, 42% of juniors, and 37% of seniors indicated that they owned a graphing calculator. The average score for seniors was approximately 122 points, for juniors 114 points, for sophomores 111 points, and freshman 102 points.

The maximum team activity individual score achieved was 18 points and the minimum score achieved was 0 points. The average team activity individual score was 6.9 points (SD=4.6). Students who indicated that they owned a graphing calculator scored approximately one point higher than students who indicated they did not own a graphing calculator.

Table 4

Individual Overall Score and Team Activity Individual Score by Graphing Calculator Ownership and Student Classification (N=107)

<i>Graphing Calculator Ownership</i>	<i>f^a</i>	<i>%^b</i>	<i>Individual</i>		<i>Team Activity Individual</i>	
			<i>Overall Score^c</i>	<i>SD</i>	<i>Score^d</i>	<i>SD</i>
Own a graphing calculator	43	42.2	120.0	24.3	7.3	5.3
Do not own a graphing calculator	59	57.8	113.4	24.2	6.7	4.2
<i>Student Classification</i>						
Senior	44	41.9	122.0	26.2	9.0	4.6
Junior	44	41.9	114.1	23.5	6.0	3.9
Sophomore	16	15.2	110.6	19.3	3.6	3.3

Note. ^aFrequencies may not sum to N=107 due to item nonresponse. ^bValid percent.

^cMaximum score = 177, minimum score = 73, mean score = 116.3, standard deviation = 24.2. ^dMaximum score = 18, minimum score = 0, mean score = 6.9, standard deviation = 4.6.

Seniors, on average placed nine places higher in the judging than juniors, 11 places higher than sophomores, and 26 places higher than freshman. Those seniors who owned graphing calculators scored approximately one point more and one rank better than seniors who did not own graphing calculators. Juniors who owned a graphing calculator scored approximately 14 points more and 18 ranks better than those who did not own a graphing calculator. Sophomores who owned a graphing calculator scored approximately six points more and ten ranks better than those who did not own a graphing calculator.

To address whether individual overall scores or team activity individual scores, that required use of a TI graphing calculator, were related to access to, experience with, or use of a graphing calculator appropriate correlations coefficients were calculated (see Table 5). There were no statistically significant relationships between an individuals overall score and access to a

graphing calculator, $r_{pb}(101) = -.10, p > .05$, experience with a graphing calculator, $r_s(102) = .02, p > .05$, or use of a graphing calculator, $r_s(99) = .06, p > .05$. There were no statistically significant relationships between team activity individual scores and access to a graphing calculator, $r_{pb}(101) = -.17, p > .05$, experience with a graphing calculator, $r_s(102) = .01, p > .05$, or use of a graphing calculator, $r_s(99) = .05, p > .05$.

Table 5

Relationship between Individual Overall Score and Team Activity Individual Score and Access to, Experience with, and Use of Graphing Calculators (N=107)

<i>Individual Overall Score</i>	<i>Correlation</i>	<i>Magnitude</i>
Access to Graphing Calculator	$r_{pb} = -.10$	Low
Student Experience with Graphing Calculator	$r_s = .02$	Negligible
Student Use of Graphing Calculator	$r_s = .06$	Negligible
<i>Team Activity Individual Score</i>		
Access to Graphing Calculator	$r_{pb} = -.17$	Low
Student Experience with Graphing Calculator	$r_s = .01$	Negligible
Student Use of Graphing Calculator	$r_s = .05$	Negligible

Conclusions, Implications and Recommendations

The agricultural mechanics CDE in Texas provides students an opportunity to demonstrate their competence and judges to perform authentic assessments of such competence. Overall student achievement ranged from 79% to 33% with an average achievement of 52%. Johnson (1993) noted that CDE “activities should be challenging and discriminate among contestants while still providing participants with the opportunity to achieve higher levels of success” (p. 44). Overall student achievement provides evidence that the event is both challenging and discriminating.

The Texas Education Agency requires school districts to provide students with access to graphing calculators for testing, class work, homework, and extra curricular activities (Nelson, 2001, 2002). Students, in general, indicated that they had access to a graphing calculator for testing, class work, homework, and extra curricular activities. It is a concern, however, that some students indicated they did not have access to a graphing calculator for such activities. Because of the positive link between student use of calculators and achievement (Hembree, & Dessart, 1986) and the student perception or reality that access and use are not universal, students should be encouraged to purchase a graphing calculator if they do not already own one or if they do not have ready access to one.

Students in this study tended to perceive that the use of a graphing calculator improved their achievement in mathematics, agricultural science, and science. This finding is supportive of Hawkins, Stancavage, and Dossey (1998) and Hembree and Dessart’s (1986) conclusions. Students overall, however, did not perceive that they were experts in using a graphing calculator for mathematics, agricultural science, and science. A majority of students indicated that they were comfortable using and had been adequately trained by their teachers to use a graphing calculator for standardized testing and extracurricular activities. Students indicated they were more likely to use a graphing calculator in their math classes than any other classes. An implication exists that overall student achievement could be improved further through additional

training and use across a school's curriculum. A majority of students indicated that they never or seldom used a graphing calculator in their agricultural science courses. An implication exists that a student's overall achievement in CDE events could be enhanced by increasing student use of graphing calculators in agricultural science courses. This implication is supported by the findings of Johnson (1993) and Gliem and Warmbrod (1986).

Student classification and graphing calculator ownership were positively associated with higher agricultural mechanics CDE scores. Student access to, experience with, and use of a graphing calculator were not associated with achievement on the CDE. A limitation of this study was that there was not a control variable for actual use of a graphing calculator on the agricultural mechanics CDE contest. Future studies on this topic should attempt to control for actual use of a graphing calculator during a portion of the contest. To ensure students are not disadvantaged by being placed in the control group (which would be predicted), a non judged activity could be scheduled at the end of the contest. Research should also include questions on participant access to and use of a graphing calculator during the contest. Additional measures of access to a graphing calculator may improve the reliability of this section of the questionnaire.

The results of this study may be useful in improving the agricultural mechanics CDE. In addition to incorporating the most up-to-date agricultural mechanics technologies into the contest, technical experts need also to ensure that CDEs take advantage of new and emerging educational technologies that are associated with deeper and more meaningful student learning experiences. While the literature and findings of this study highlight the relationship between student achievement and use of graphing calculators, future research should also address other emerging technologies that may also be related to student achievement. Emerging technologies include global positioning systems, personal digital assistants, mobile computing laboratories, point-to-point video conferencing, expert systems, 3D and virtual modeling, bar coding, total station systems, and lasers. By merging these technologies into the CDE, deeper and more meaningful learning experiences may be produced.

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