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Graphing Calculators and Learning Styles in Rural and Non-Rural High Schools

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ACCLAIM's mission is the cultivation of *indigenous leadership capacity* for the improvement of school mathematics in rural places. The project aims to (1) understand the rural context as it pertains to learning and teaching mathematics; (2) articulate in scholarly works, including empirical research, the meaning and utility of that learning and teaching among, for, and by rural people; and (3) improve the professional development of mathematics teachers and leaders in and for rural communities.

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GRAPHING CALCULATORS AND LEARNING STYLES IN RURAL AND NON-RURAL HIGH SCHOOLS

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Abstract

The purpose of this study was to examine rural and non-rural students in order to understand similarities and differences between their learning styles and the ease with which they learned Algebra with a graphic calculator. Two samples of students, one from a rural high school and one from a non-rural one, answered a survey asking about their use of graphic calculators. The students also were administered a Myers-Briggs Type Indicator (MBTI), a popular instrument for analyzing personality types, including learning styles. No significant differences were found between the two samples, either in their comfort with using graphic calculators to learn Algebra or in their Myers-Briggs learning-style types. For the non-rural students, the predominant Myers-Briggs type was ENFP (extroverts, intuitive, feelers and perceivers), accounting for 52.7% of the sample. Among the rural students, ENFP was also the most frequently identified Myers-Briggs type, 33.3% of the sample, followed by ESFP (extroverts, sensing, feelers and perceivers), with 20%. The modal type was ENF. Study findings did not show any evidence that students in the rural sample achieved less academically than those in the non-rural sample.

Graphing Calculators and Learning Styles in Rural and Non-Rural High Schools

Introduction

New technologies such as the graphic calculator, the computer, and the Internet have transformed the teaching-learning process, particularly in the field of mathematics. Teaching with technology changes the classroom atmosphere and consequently the understanding of the student; more and more schools incorporate this technology in their mathematics classes to improve student achievement, interest, and motivation in this important discipline. The U.S. government has supported the introduction of such technology into the classroom (White House, 1996), and today, it is commonplace to find graphic calculators in high school algebra classes in the United States, although not in underdeveloped countries. Arguably, students need to know how to work with and feel comfortable using the graphic calculator in class. Non-rural and rural schools may be quite different in how they approach using graphic calculators, however. In general, rural schools have fewer resources, pay teachers at a lower rate, and serve a larger proportion of impoverished students than non-rural schools.

While it is helpful to teach mathematics with graphic calculators, their appropriate use in the classroom also represents an opportunity to create new learning forms for students, contributing to their development of values, creativity, and interest in the world around them. Of course, giving students graphic calculators and equipping classrooms with computers will not by themselves ensure this objective will be achieved; it is also necessary to know how these tools are actually applied in mathematics classes and to assess their implications for the future.

Non-rural schools on average have higher budgets and spend more per enrolled student than rural schools. Rural schools as a group have fewer resources and pay lower salaries than non-rural ones. Rural student achievement is perceived to lag behind that of non-rural students. These observations foster the hypothesis that students in the two environments are dissimilar.

This paper concerns itself with improving the learning of Algebra in non-rural and rural high schools in the state of Tennessee. It focuses specifically on students' ease with using graphic calculators to learn Algebra, and also on students' learning styles. Students' comfort with using graphic calculators was assessed through a survey (GCS). Students' learning styles were evaluated and classified using the Myers Briggs Type Indicator (MBTI), a popular instrument for classifying personality types, including learning styles.

The Problem

The computer and scientific calculator have paved the way for the emergence of more and different technologies. The versatility of the graphic calculator has encouraged its introduction into most areas of daily life. Since their introduction into the classroom in 1985 (Kissane, 1995), graphic calculators are increasingly found in mathematics classrooms, where they have been for two decades now.

Our society believes that those who succeed in math are inherently different from other people; the mathematician is stereotyped as being outside the mainstream, or even as unable to relate well to others. Many people think mathematics is a discipline reserved for those who have great intelligence; this opinion is perpetuated by parents, teachers and students. Such is the general societal attitude towards the mathematician and mathematics as a subject.

The graphic calculator is increasingly within reach of all, and offers a tool for graphics in the classroom. This tool presents many advantages over the blackboard or paper and pencil, producing complex graphs with great speed and precision. Graphs are used mainly to illustrate geometric concepts and in calculation to visualize the behavior of functions; graphs also play an important role in statistics (Alfonzo, 1998). A teacher's knowledge of students' learning style and preferences using a graphic calculator could foster a favorable attitude in math students.

Graphic calculators change how mathematics is taught. Will these changes be positive for students? Rural schools tend to share a lack of certain resources and common student attitudes. Yet many of them also teach mathematics with graphic calculators. Are those students learning as effectively as their counterpart non-rural students?

This research will examine the problem of changes in learning mathematics with the use of new technologies. It seeks to answer the following question: Do surveys of learning styles and of graphic calculator use reflect any differences between rural and non-rural students?

Objectives

General objective

To determine the similarities and dissimilarities between students from non-rural and rural high schools regarding their ease of learning Algebra with a graphic calculator and their learning styles.

Specific objectives

1. To determine the level of comfort, quality and frequency of use of graphic calculators among the samples of math students from non-rural and rural contexts, as measured by survey research.
2. To determine the preferred learning styles of the selected math students from non-rural and rural contexts as measured by MBTI, or Myers-Briggs Type Indicator
3. To compare the ease of learning Algebra with a graphic calculator as reported by the students from each environment.
4. To compare the learning styles of the students selected from each environment.

Theoretical Framework

Learning styles

Each student learns in a different way. How he or she processes information is that student's learning style. Griggs (1991) says: "Everyone has a learning style. Our style of learning, if accommodated, can result in improved attitudes toward learning and an increase in productivity, academic achievement, and creativity."

The term "Learning Style" has been defined as the composite of characteristic cognitive, affective, and physiological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment (Keefe, 1979). Witkin affirms that learning styles refer to individual differences in how we perceive, think, solve problems, learn, and relate to others. Learning styles are concerned with the form rather than the content of the learning activity, (Witkin, Moore, Goodenough, and Cox, 1977).

Myers Briggs Type Indicator – MBTI

The Myers-Briggs Type Indicator (MBTI) is a personality test for evaluating psychological types. Katherine Briggs and her daughter, Isabel Myers, designed this test following the theories that Carl Jung put forth at the beginning of the twentieth century. MBTI has many applications in education; one of them is to determine the learning style.

The MBTI – Form M was used in this research. This is a written instrument designed to measure the constructs identified by Jung's theory of personality type. It was administered to determine the preferred learning styles among selected students from rural and non-rural high schools. This test is designed to obtain the subject's learning style preference on four dichotomous scales. The test can produce sixteen possible combinations, which are identified by four letters that represent the "type" or "style" preferred for each student.

The four sets of preferences are:

- ✓ Extroversion (*E*) / Introversion (*I*);
- ✓ Sensing (*S*) / Intuition (*N*);
- ✓ Thinking (*T*) / Feeling (*F*); and
- ✓ Judging (*J*) / Perceiving (*P*).

These preferences result in 16 learning styles, or types (Table 1). The scales of perception (Sensing/Intuition) and judgment (Thinking/Feeling) combined assess learning styles. (Myers, 1990; Cano, 1999).

The Myers-Briggs Type Indicator personality assessment tool indicates a person's likely psychological type. Psychological type describes the different ways people:

- ✓ Prefer to take in information - **E** / **I**
- ✓ Prefer to make decisions - **S** / **N**
- ✓ Are energized by the outside world or by the inner world **–** **T** / **F**
- ✓ Prefer to keep things open or to move towards closure - **J** / **P**

(Myers Briggs.org)

The sixteen possible types described by MBTI, which are typically denoted by four letters such as ENTP, INFP, and so on, (Table 1), are a combination of the preferences among four binaries described previously. No type is superior to any other. MBTI measures preference; it does not measure ability or pathology, that is, what is normal versus what is abnormal. MBTI is not an intelligence test. Any combination is not wrong, either. Table 2 shows a summary of 16 types of learning preference, (Gail, 1999).

Table 1. The sixteen possible type describe by MBTI

ISTJ	**ISTP**	**INFJ**	**INTJ**
ESTJ	**ESTP**	**INFP**	**INTP**
ISFJ	**ISFJ**	**ENFP**	**ENTP**
ESFJ	**ESFP**	**ENFJ**	**ENTJ**

Table 2. Summary of the students learning preference in each type, (Gail, 1999)

Extravert Types like**:**	**Introvert** Types like**:**

1. To discuss ideas and information in class.
2. To ask questions.
3. To learn through experiences such as lab work and field experiences.
4. To "think aloud."
5. To communicate by talking (instead of writing).
6. To move through material quickly, going for breadth (not depth).
7. To monitor class participation for appropriateness, learning when to speak and when to listen.

1. To reflect on ideas.
2. To listen instead of talking.
3. To work on individual projects.
4. To observe and absorb in class.
5. To learn through inner thought (reading and writing).
6. To understand a few things in depth rather than quickly go over a wide-range of material.
7. To participate in writing, tests, or individual projects instead of speaking before the class.

Sensing Types like**:**

1. Learning facts.
2. Memorization work.
3. Following step-by-step procedures.
4. Going from specifics to the general.
5. Working with concrete problems.
6. Seeing actual results, what is useful and practical?
7. Specific, exact directions and assignments from teachers.

Intuitive Types like**:**

1. Learning new ideas.
2. Getting the big picture, rather than details.
3. Skipping around and following hunches.
4. Starting with the theory, and then going to examples.
5. Working with new, complex problems and symbols.
6. Being original.
7. Asking lots of "*What if*" questions**.**

Thinking Types like**:**

1. Logic and cause-and-effect reasoning.
2. Studying and writing about impersonal material (technical, factual, scientific).
3. Teachers who clearly demonstrate their own expertise.
4. A grading system that is absolutely and consistently fair and impartial.
5. Being shown WHY.
6. Being able to criticize an idea or project and debate it.

Feeling Types like**:**

1. Personal values and reactions to evaluate material.
2. Writing assignment which allow for a personal touch
3. Knowing a teacher cares and takes a friendly approach.
4. Content that is personally meaningful
5. Courses where personal values, people-issues and expressiveness are important.
6. A classroom with a sense of belonging.

Judging Types like**:**

1. Finishing one project before starting something else.
2. Completing an assignment.
3. Avoiding deadline pressure by beginning early.
4. Teachers who are punctual and who stick to the syllabus.

Perceiving Types like**:**

1. Flexible classes.
2. Some surprises in activities and assignments.
3. Freedom in class and in assignments.
4. Teachers who are spontaneous and not too strict.

<u>Rural and non-rural schools</u>

To differentiate between the rural and non-rural school, it is necessary to consider population density and remoteness. The U. S. Census Bureau defines a rural area as one that is not urban. “Urban” is defined as either an urbanized area or places with populations of 2,500 or more outside urbanized areas. An urbanized area is a place and its adjacent densely settled surrounding territory that together have a minimum population of 50,000 (U. S. Department of Commerce, 1992). Rural is defined as a place with fewer than 2,500 people, or a place with a ZIP code designated as rural by the Census Bureau. To classify the rural/non-rural status of school districts more precisely, Elder (1992) created a district-level file that uses local codes from the CCD Public School Universe file. Because districts may contain rural and non-rural schools, one way to classify districts as rural or non-rural is to examine the percentage of the districts' students attending rural schools (as recorded in the CCD Public School Universe file). The 1990 data suggest that, based on the types of schools students attend, most districts are either all rural (43 percent) or all non-rural (47 percent). Ten percent of the districts include both rural and non-rural schools.

Rural and urban high schools are different from one other. Barcinas (1989) investigated and reported significant differences in an Ohio data set, including a diversity of curricula and per pupil expenditures. Rural schools were characterized by smaller numbers of teachers, support staff, and administrators than were found in urban schools. (Raven & Barrick, 1989). The concern about potential rural-urban differences in education is, moreover, not limited to the United States, but rather appears to be a global issue.

Graphic Calculator (GC)

In addition to having basic operations (+, -, *, and /), graphic calculators have the following functions: graphing, statistics and probability, programming, scientific operations, trigonometric functions, and logarithmic functions. The spread of advanced scientific technology, as represented by tools such as personal computers and graphing calculators, offers new instruments for teaching and learning. These technological advances require educators to change how they teach as well.

More than 10 years ago, Demana and Waits stated that graphing calculators offered a powerful new technology for teaching mathematics. A GC is really an inexpensive, hand-held computer with built-in numerical solvers and graphing software. Graphing calculators could be viewed as computers available to all students because of their low cost, ease of use, and portability (Demana, & Waits, 1990, 1992).

In “Principles and Standards for School Mathematics” (2000), The National Council of Teachers of Mathematics (NCTM) makes recommendations to schools, administrators and teachers for improving the teaching of mathematics. Equity, Curriculum, Teaching, Learning, Assessment, and Technology are the principles that guide this document for mathematics education. The Technology Principle states: “Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students’ learning” (Page 25). It suggests that technology makes learning and teaching mathematics easier. It hinges on the principle that when the student is learning mathematics, he or she must have a calculator available, but the teacher is important for the successful use of the graphing calculator in the classroom.

Jeffrey Smith (1998) asserts that graphing calculators are redefining the notion of demonstrated knowledge in secondary mathematics as the four-function calculator previously did. For this reason, the mathematical content, educational methods, and assessment strategies that mathematics teachers employ must be reconsidered.

The calculator is a vehicle that makes learning and teaching easier. Technology, particularly the calculator in the mathematics class, develops positive attitudes in the students; it allows teachers and students to work at their own speed.

Graphing Calculator Survey

In order to asses how comfortable students feel about working with the graphing calculator in the classroom, samples of rural and non-rural students were administered the "graphing calculator survey," which was developed by the investigator. This survey was conducted during algebra classes in the fall of 2003. The survey consisted of a free-response instrument containing 11 multiple choice or closed-ended questions dealing with the use of the graphing calculator and its implications in mathematics learning. Closed-ended questions permit the respondent to select his or her answers from the given options, and to get answers more easily and quickly using a scale (Fraenkel & Wallen 2000)

Methodology

The study had four major phases. The first phase included formulation of research questions, designing the project, assembling and revising the bibliography, and contacting prospective schools for participation. The second phase consisted of obtaining informed consent to participate from district school officials, principals, mathematics departments, teachers, parents and students. The third phase was collecting and assembling the data from the MBTI and the GCS. The final phase consisted in analyzing the data, interpreting findings, answering the research questions, writing the research report and disseminating the findings.

The present quasi-experimental study was carried out in two schools from the state of Tennessee. It involved surveys conducted with samples of Algebra I students from two high schools, one classified as non-rural and the other one as rural. Data was collected during the fall semester 2003. Participants completed the GCS, which assessed their comfort levels with using a graphing calculator, and the MBTI, which identified their learning styles in Algebra I class.

Population

The target population was five classes of the Rural High School and three of the Non-rural High School. The accessible samples were selected from one school classified as a rural school (N =75) and the other classified as a non-rural school (N=55).

Instrumentation

The graphing calculator survey was a questionnaire made by the investigator to establish student opinions about working with the graphing calculator. Respondents answered the questionnaire during an Algebra class in fall of 2003. It was a free-response instrument containing eleven closed-ended and three open-ended questions dealing with the use of the graphing calculator and its implications in mathematics learning. The *Qs* represented a condition in this study. *Qs* are closed-ended question in the *graphing calculator survey*

The MBTI developed by Myers and Briggs is a valid and reliable instrument. It is in booklet form and was administered during ongoing algebra classes to identify the learning style of each student, taking time from class. It contains 93 multiple choice items, an answer sheet, and basic interpretive information written at a 7th grade reading level. The instrument was calibrated for persons 14 years and older, and had an administration time of 15-25 minutes. The edition of MBTI used was the self-scorable Form M (Consulting Psychologists Press, 2003), and was hand-scored by the researcher. The instrument is designed to obtain the subject's preferences on four dichotomous scales (Extraversion/Introversion; Sensing/Intuition; Thinking/Feeling; Judging/Perceiving). Table 3 explains the scoring scale for the MBTI in each preference. The student's preferences on each pair are then assembled to create a collection of 4 letters corresponding to a particular personality type (Table 1).

Table 3: Preferences clarity category

Preferences	Slight	Moderate	Clear	Very Clear
		Raw Points Ranges		
E or I	11-13	14-16	17-19	20-21
S or N	13-15	16-20	21-24	25-26
T or F	12-14	15-18	19-22	23-34
J or P	11-13	14-16	17-20	21-22

Tie- Breaking rule	If E = I	Then write	I
	If S = N	Then write	N
	If T = F	Then write	F
	If J = P	Then write	P

Analysis

The raw data from rural and non-rural students was analyzed using SAS/PC (Statistical Analysis System/Personal Computer) and Minitab Statistical Software. For the graphing calculator survey, a multivariate two-sample profile analysis was adapted to compare responses to the closed-ended questions in the survey, *Q1*, *Q2, Q3, Q8, Q9, Q10* and *Q11*. A two-sample profile analysis is a method of comparing two groups that are subject to the same number of measurements. The author found it convenient to use the *T-test* (also called Student's t) for question *Q4, Q5, Q6* and *Q*7. The analysis of student's MBTI personality type focused on frequencies and percentages.

Graphing Calculator Survey

One of the most frequently used data-collection and analysis designs in education and psychology is the *two-sample profile analysis, repeated-measure* design (Timm, 1975). Each question from the survey means a condition for the analysis. T^2 is used to test the null hypothesis (H_0). This is rejected at the ά if the observed value for T^2 exceeds the critical value T^α. If the null hypothesis (H_0) is rejected, then the relationship does exist. The *Qs* represented a condition in this study. *Qs* are closed questions in the *graphing calculator survey*.

The null hypotheses are:

H_{01}: *Are the profiles for the two groups parallel?*

H_{02}: *Are there differences among conditions?*

H_{03}: *Are there significant differences between groups?*

The target population for this two-sample profile analysis multivariate study consisted of two groups of high school algebra students: rural and non-rural. Students in each group were asked to respond to the following questions *Q1, Q2* and *Q3* , using the 5-point scale in the figure below.

1 2 3 4 5

I. Questions *Q1, Q2* and *Q3*

Q1: *How much do you like the Algebra I class?*

Q2: How much do you like the Algebra I class using the graphing calculator?

Q3: How much does the graphing calculator help you in the Algebra I class?

The *Qs* represented a condition in this study. *Qs* are closed-ended question in the *graphing calculator survey*.

Let:

x_1 stand for a 5-point scale response to Question 1

x_2 stand for a 5-point scale response to Question 2

x_3 stand for a 5-point scale response to Question 3

and let the two populations be defined as follows:

Population 1 stands for rural students

Population 2 stands for non-rural students

The population means are the average responses to the p=3 questions for the populations of rural and non-rural students. Assuming a common covariance matrix Σ, it is of interest to see whether the profiles of rural and non-rural students are the same.

We should concentrate on two groups. Let $\mu_1' = [\mu_{11}, \mu_{12}, \mu_{13}]$ and $\mu_2' = [\mu_{21}, \mu_{22}, \mu_{23}]$ be the mean responses to p treatments for populations 1 and 2, respectively. The hypothesis $H_0{:}\mu_1 = \mu_2$ implies that the treatments have the same (average) effect on the two populations. In terms of the population profiles, we can formulate the question of equality in a stepwise fashion.

H_{01}: Are the profiles for the two groups (rural or non-rural) parallel or group-by-condition interaction?

H_{02}: Are there differences among conditions?

H_{03}: Are there significant differences between groups?

The null hypothesis will be rejected at the significance level if

$T^2 > T^{\alpha}(p-1, N_1+N_2-2)$

If T^2 value is less than the critical value of $T^{0.05}_{2,126} = 6.196$ *for* $\alpha=0.05$

Table 4: Data arrangement among two groups profile analysis
Conditions Q1, Q2 and Q3

Null Hypothesis	**T^2**	
H_{01}	1.329	$T^2 < T^{\alpha}$ then is not rejected
H_{02}	2750.3165	$T^2 > T^{\alpha}$ then H_{02} is rejected
H_{03}	10.716	$T^2 > T^{\alpha}$ then H_{03} is rejected

*The null hypothesis is rejected at the significance level α=0.05

The hypothesis H_{02}, difference in conditions

$$H_{02}: \frac{\mu_{11}+\mu_{21}}{2} = \frac{\mu_{12}+\mu_{22}}{2} = \frac{\mu_{13}+\mu_{23}}{2}$$

is rejected at the significance level α=0,05 if $T^2 > T^{0.05}_{2,126} = 6.196$. For this, the hypothesis of no difference in conditions is rejected. That is, the responses of rural and non-rural students to the three questions posed appear to be not the same.

The hypothesis of no difference between groups, H_{03}, in terms of the parameters

$$H_{03}: \begin{bmatrix} \mu_{11} \\ \mu_{12} \\ \mu_{13} \end{bmatrix} = \begin{bmatrix} \mu_{21} \\ \mu_{22} \\ \mu_{23} \end{bmatrix}$$

is rejected at the significance level α=0,05 if $T^2 > T^{0.05}_{2,126} = 6.196$.

Having rejected H_{02}, confidence-interval procedures are applied to determine which conditions contributed significantly to rejection. To obtain simultaneous confidence intervals the expression

$$c'\bar{y}_{..} - c_0\sqrt{\frac{c'Sc}{N_1+N_2}} \le c'\bar{\mu}_{..} \le c'\bar{y}_{..} + c_0\sqrt{\frac{c'Sc}{N_1+N_2}} \qquad (1)$$

is evaluated, where $c_0^2 = T^{\alpha}\left(p-1, N_1+N_2-2\right)$ and $\bar{\mu}_{..}$ are used to denote the weighted average of the population mean vectors $\bar{\mu}_{..} = \frac{\left(N_1\mu_1 + N_2\mu_2\right)}{N_1+N_2}$. For differences in conditions, with $c_0 = \sqrt{6.196}$ =2, 4892, the following contrasts are examined:

$\psi_1 = \mu_1 - \mu_3$ $\qquad \hat{\psi}_1 =$ 3.3055 – 3.715=-0.4095

$\psi_1 = \mu_2 - \mu_3$ $\qquad \hat{\psi}_1 =$ 3.2485 – 3.715=-0.4665

$\psi_1 = \mu_1 - \mu_2$ $\qquad \hat{\psi}_1 =$ 3.3055 – 3.2485=0.057

The standard errors for these contrasts are obtained from $\sqrt{\frac{c'Sc}{N_1+N_2}}$, where c is chosen so that $\psi_i = c'y_{..}$ Thus, for each ψ considered,

$\hat{\sigma}_{\hat{\psi}_1}$ =0.1378527

$\hat{\sigma}_{\hat{\psi}_2}$ = 0.0997045

$\hat{\sigma}_{\hat{\psi}_3}$ = 0.1071939

By evaluating expression (1), which, in general, is of the form

$$\hat{\psi}_i - c_0\hat{\sigma}_{\hat{\psi}_i} \le \psi_i \le \hat{\psi}_i + c_0\hat{\sigma}_{\hat{\psi}_i} \qquad (2)$$

an interval for each contrast is obtained:

$-0.752643 \leq \mu_1 - \mu_3 \leq -0.066357$ **s** comfort level –help level using GC

$-0.714685 \leq \mu_2 - \mu_3 \leq -0.218315$ **s** comfort level using GC – help level using GC

$-0.209827 \leq \mu_1 - \mu_2 \leq 0.3238271$ **ns** comfort level- comfort level using GC

s -Significance since zero is not covered by the interval
ns – Not significance since zero is into the interval

The three conditions can be compared by the simultaneous confidence intervals for their mean differences. Zero is into the third interval ($-0.209827 \leq \mu1 - \mu2 \leq 0.3238271$), meaning that there are no significant differences between ease or comfort with algebra class and comfort using GC.

II. Questions *Q8, Q9, Q10* and *Q11*

Rate your comfort level in using a graphing calculator during each of the listed activities

(1) Very comfortable (2) Comfortable (3) neutral (4) uncomfortable (5) very uncomfortable

	Questions	**1**	**2**	**3**	**4**	**5**
Q8	Writing test					
Q9	During class					
Q10	Doing homework					
Q11	Work in group					

H_{01}: Are the profiles for the two groups (rural or no rural) parallel or group-by-condition interaction?

H_{02}: Are there differences among conditions?

H_{03}: Are there significant differences between groups?

The hypothesis H_{01} is rejected at the significance level if

$T^2 > T^{\alpha}(p-1, N_1+N_2-2)$.

Since T^2 =2.874 is less than the critical value of $T^{0.05}_{3,125} = 8.181$ for α=0.05,

Table 5 : Data arrangement among two groups profile analysis Conditions Q8, Q9, Q10 and Q11.

Null Hypothesis	$\mathbf{T^2}$	
H_{01}	2.874	$T^2 < T^{\alpha}$ then is not rejected
H_{02}	3621.4676	$T^2 > T^{\alpha}$, then H_{02} is rejected
H_{03}	2.971	$T^2 > T^{\alpha}$ then H_{03} is rejected

*The null hypothesis is rejected at the critical value $T^{\alpha} = T^{0.05}_{3,125} = 8.181$ for α=0.05

H_{01}: The profiles are for the two groups (rural or no rural) parallel is not rejected

H_{02}: There are differences among conditions is rejected

H_{03}: There are significant differences between groups is rejected

The two-sample profile analysis computed for group differences between rural and non-rural student is not significant.

There are differences in the means of three conditions. The confidence intervals are used to find this difference. It is done by evaluating expression:

$$\hat{\psi}_i - c_0\hat{\sigma}_{\hat{\psi}_i} \le \psi_i \le \hat{\psi}_i + c_0\hat{\sigma}_{\hat{\psi}_i} ,$$

To find differences in conditions, the expression

$$c'\overline{y}_{..} - c_0\sqrt{\frac{c'Sc}{N_1+N_2}} \le c'\overline{\mu}_{..} \le c'\overline{y}_{..} + c_0\sqrt{\frac{c'Sc}{N_1+N_2}}$$

is evaluated with $c_0 = \sqrt{8.181} = 2.8602$. For differences in conditions, the following contrasts are examined.

$\psi_1=\mu_1 - \mu_4$ $\qquad \hat{\psi}_1 =$ 2.51155 – 1.919=0.59255

$\psi_1=\mu_3 - \mu_4$ $\hat{\psi}_1 =$ 1.9597 – 1.919= 0.0407

$\psi_1=\mu_2 - \mu_4$ $\hat{\psi}_1 =$ 1.88395 – 1.919=-0.03505

$\psi_1=\mu_1 - \mu_2$ $\hat{\psi}_1 =$ 2.51155 – 1.88395=0.6276

The standard errors for these contrasts are obtained from $\sqrt{\frac{c'Sc}{N_1+N_2}}$, where c is chosen, such that for each ψ considered

$\hat{\sigma}_{\hat{\psi}_1}$ =0.1243

$\hat{\sigma}_{\hat{\psi}_2}$ = 0.0873925

$\hat{\sigma}_{\hat{\psi}_3}$ = 0.0726622

$\hat{\sigma}_{\hat{\psi}_4}$ =0.1179537

By evaluating Expression (1), which, in general, is of the form

$$\hat{\psi}_i - c_0\hat{\sigma}_{\hat{\psi}_i} \le \psi_i \le \hat{\psi}_i + c_0\hat{\sigma}_{\hat{\psi}_i} \qquad (2)$$

an interval for each contrast is obtained:

$0.2368931 \le \mu_1 - \mu_4 \le 0.9482069$ s

$-0.20926 \le \mu_3 - \mu_4 \le 0.29066$ ns

$-0.242878 \le \mu_2 - \mu_4 \le 0.1727783$ ns

$0.2902287 \le \mu_1 - \mu_2 \le 0.9649713$ s

III. Questions *Q4, Q5, Q6* and *Q7*

Questions *Q4* through *Q7* were applied the *T- test*, also called *T-student*, as a statistical test.

H_0: Null hypothesis for questions Q4 through Q7

H_1: alternative hypothesis for questions Q4 through Q7

H_0: There are no differences between the rural and non-rural environment at the average level of difficulty in learning mathematics using GC.

H_1: There are differences between the rural and no rural environment at the average level of difficult in the learning of mathematics using GC.

If the null hypothesis is true, the means of the populations are different. The t value will be closer to zero. But the null hypothesis will be rejected if both populations are similar and the T values are exactly zero.

*Q4**:** What is your level of difficulty in learning math with the graphing calculator?*

(5) very easy, (4) easy, (3) neutral, (4) difficult, (5) very difficult

Table 6 : T-test for *Q4*

	N	Mean	SD	Se Mean
Rural	73	3.301	0.739	0.087
Non-rural	53	3.321	0.936	0.13

T- Test of difference = 0 T-Value= -0, 13 p-value= 0,901 DF=95
SeMean: Standard error of the mean
SD: Standard deviations

Q5: How good do you consider yourself as a user of the graphing calculator?

(5) very good, (4)good, (3)medium, (4)bad, (5)horrible

Table 7 : T-test for *Q5*

	N	Mean	S D	Se Mean
Rural	74	3.284	0.852	0.099
Non-rural	53	3.321	0.996	0.14

T- Test of difference = 0, T-Value= -0,22 p-value= 0,827 DF=101

Q6: How much do you believe the graphing calculator should be used in math class?

(5) always, (4) in every class, once a week, (2) once a month, (1)only for graphing purposes

Table 8 : T-test for *Q6*

	N	Mean	S D	Se Mean
Rural	73	4.26	1.19	0.14
Non-rural	33	4.09	1.47	0.26

T- Test of difference = 0, T-Value= -0, 58 p-value= 0,563 DF=5

Q7: How much do you use your graphing calculator on vacations from school?

(5) always, (4) very often, (3)sometimes, (2) not often, (1) never

Table 9 : T-test for *Q7*

	N	Mean	S D	Se Mean
Rural	74	1.676	0.908	0.11
Non-rural	33	2.15	1.06	0.19

Difference= μ rural – μ non-rural. Estimated difference: -0,476
T- Test of difference = 0 (vs<): T-Value = -2,23 p-value= 0,015 DF= 53

H_0 is true because the t values found are closer to zero, *but not exactly zero*.

Then the alternative hypothesis is rejected, meaning that both populations are similar.

Analysis of Myers--Briggs Type Indicator – MBTI

Table 10: Frequency and Percents of MBTI preferences

Profile	Non-rural N 55			Rural N 75		
	F	Percent	Cumulative percent	F	Percent	Cumulative percent
ESTP	2	3.6	3.6	6	8	8
ESTJ	1	1.8	5.4	1	1.3	9.3
ESFP(2)	6	10.9	16.3	15	20	29.3
ESFJ	2	3.6	19.9	2	2.7	32.0
ENFP(1)	29	52.7	72.3	25	33.3	65.3
ENFJ	1	1.8	74.3	5	6.7	72.0
ENTP	0	0	74.3	3	4	76
ENTJ	0	0	74.3	1	1.3	77.3
ISTJ	2	3.6	78	0	0	77.3
ISTP	3	5.5	83.5	0	0	77.3
sISFJ	1	1.8	85.3	0	0	77.3
ISFP	2	3.6	88.9	7	9.3	86.6
INFJ	0	0	88.9	3	4	90.6
INFP	4	7.2	96.1	5	6.7	97.3
INTJ	1	1.8	97.6	0	0	97.3
INTP	1	1.8	99.7	2	2.6	99.9
Total	**55**	**99.7**	**99.7**	**75**	**99.9**	**99.9**

*Data reported a in Algebra class from Non-rural and Rural High Schools Located in Knox and Scoot County – Tennessee, fall 2003.

Table 11: Frequency and Percents of MBTI dimensions
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The Dichotomy Type Preferences*		Non-rural **		Rural**	
		n=55	percent	n= 75	percent
Direction of energy and attention	**Extroversion**	41	76	58	77
	Introversion	14	24	17	23
How people like to take in information	**Sensing**	19	35	31	41
	iNtuition	36	65	44	59
How a person likes to make decisions	**Thinking**	11	20	13	17
	Feeling	44	80	62	83
Orientation to the outer world	**Judging**	8	15	12	16
	Perceiving	47	85	63	84

*MyerBrigg.org
** Reported in Algebra class from Non-rural and Rural High Schools Located in Knox and Scoot County – Tennessee, fall 2003

Table 10 indicates an analysis of the personality type profile measured for students in non-rural and rural schools by the MBTI, using frequencies and percentages. In the rural sample taken for this study, the most frequent type is ENFP (33.3%), followed by ESFP (20%). Ranking third and fourth, respectively, are ISFP (9.3 %) and ESTP (8%); INFP and ENFJ share 6.7%; ENTP, INFJ are both at 4%. The types ESTJ, ESFJ, ENTJ, and INTP have a low preference. ISTJ, ISTP, ISFJ and INTJ are not represented by any students from the sample.

In the non-rural students sample, the predominant inclination type is ENFP (52.7%), followed by ESFP (10.9%), INFP (7.2%), and ISTP (5.5 %). ESTP, ESFJ, ISTJ and ISFP have the same occurrence, 3.6%. ESTJ, ENFJ, ISFJ, INTJ and INTP have the lowest frequency, 1.8%. The types ENTP, ENTJ and INFJ are not represented in any student from the sample. The modal type is ENFP (extraverts, intuitive**,** feelers and perceivers preferences).

Among non-rural students in the sample (see Table 11), 76% were extroverted (E) types, 65% were intuitive (N), 80% were feeling (F), and 85% were perceiving (P). Their counterparts, the rural students, did not display appreciable differences. Among them, 77% were extroverted (E), 59% intuitive (N), 83% were feeling (F), and 84% were perceiving (P).

Conclusions

The two-sample profile analysis of the GCS found no statistically significant difference between non-rural and rural high school samples in relation to the incidence of ease in Algebra class and comfort using a graphing calculator. Differences were also not observed in writing throughout class, doing homework, working in groups, or in the incidence of using a graphing calculator. The *T-test* was used to relate the rural and non-rural environment at the average level of difficulty in learning mathematics using a graphing calculator. There were no differences between those environments. The *t value* obtained is closer to zero, leading to a rejection of the null hypothesis (the null hypothesis is rejected if both populations are similar and the *T values* are exactly zero). The students from non-rural and rural high school who participated in this study preferred an ENFP personality type (Extroversion (*E*) / Intuition (*N*) / Feeling (*F*)/ Perceiving (*P*). There were no significant differences between those environments.

The results of this investigation lead to the conclusion that differences do not exist between non-rural and rural students regarding either the ease with which they use a graphing calculator in mathematics graphing or in their learning styles. This finding corroborates the findings of Fan and Chen (1999). This study did not find evidence of any weakness among the rural population examined.

Studies on the use of graphing calculators in mathematics classes and on learning styles for non-rural and rural schools should continue. It might be advisable to experiment with alternative forms of assessment, such as relationships between learning style and the grading of students, and relationships between learning style and teaching style. Also, it is recommended that further investigations consider larger population samples.

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