Kentucky Journal of Excellence in College Teaching and Learning

Volume 12 | Article 2

June 2015

Triostatistics: T he Application of Innovative In - Depth Advanced Post Hoc Statistical Metrics for the Assessment and Analysis o f Statistically Significant Tri - Squared Test Outcomes

James Edward Osler II
North Carolina Central University

Follow this and additional works at: https://encompass.eku.edu/kjectl

Recommended Citation

Osler II, James Edward (2015) "Triostatistics: T he Application of Innovative In - Depth Advanced Post Hoc Statistical Metrics for the Assessment and Analysis o f Statistically Significant Tri - Squared Test Outcomes," *Kentucky Journal of Excellence in College Teaching and Learning*: Vol. 12 , Article 2.
Available at: https://encompass.eku.edu/kjectl/vol12/iss2014/2

This Article is brought to you for free and open access by the College of Education at Encompass. It has been accepted for inclusion in Kentucky Journal of Excellence in College Teaching and Learning by an authorized editor of Encompass. For more information, please contact Linda.Sizemore@eku.edu.

Triostatistics: The Application of Innovative In-Depth Advanced Post Hoc Statistical Metrics for the Assessment and Analysis of Statistically Significant Tri-Squared Test Outcomes *MONOGRAPH*

James Edward Osler II, North Carolina Central University

Abstract

This monograph provides an epistemological rational for the design of an advanced and novel parametric statistical analysis metrics. Triostatistics (or more simply "Triostat") is the application of Post Hoc measures to the statistically significant outcomes of the Trichotomous Squared Test. Triostatistics involves a variety of robust and rigorous calculations and computations to provide further insight on the inner workings of statistically significant Tri-Squared Test results. Each of the Triostatistics Tests are introduced and defined in a summative form. The Tri-Squared Test was first introduced in the *Journal on Mathematics* as an innovative and in-depth statistical qualitative and quantitative data analysis procedure.

Keywords: MULTICOVA, outcomes, post hoc, tri-center analysis, tri-cubed tri-coordinate meta-analysis test, trimetric tri-squared test, TRICOM, TRICOVA, TRIMOD, TRINOVA, trichotomous, tri-squared mean cross comparative analysis, tri-symmetrical omnibus tests, trivariant analysis

Introducing the Tri-Squared Test

Many statistical measures used in education are experimental research designs that require strict scientific methodologies that cannot be implemented in educational institutions without violating legal policies or severely disturbing the learning environment and associated instructional climate that is vital to instruction. The time has come for education to provide its own scientific field and subsequent measures based in its own rigor and grounded in the foundation of longstanding educational research, fundamental educational theory, and innovations in qualitative, quantitative, and mixed methods research designs native to the specifics of pedagogy and andragogy (Osler, 2012).

The Term "Trichotomy" Defined

The term "Trichotomy" is a noun pronounced ['trahy-kot-uh-mee'], with the plural written form "tri•chot•o•mies." Trichotomy has the following threefold definition: (1) Separation or division into three distinct parts, kinds, groups, units, etc.; (2) Subdivision or classification of some whole into equal sections of three or "trifold segmentation"; and (3) Categorization or division into three mutually exclusive, opposed, or contradictory groups, for example – "A trichotomy between thought, emotions, and action" (Osler, 2012).

What is Tri-Squared?

The following definition of Tri-Squared (and subsequent narrative) was first presented by the author in a 2012 Journal on Mathematics research article. "Tri-Squared" comprehensively stands for "The Total Transformative Trichotomous-Squared Test" (or "Trichotomy-Squared"). The Total Transformative Trichotomous-Squared Test provides a methodology for the transformation of the outcomes from qualitative research into measurable quantitative values that are used to test the validity of hypotheses. The advantage of this research procedure is that it is a comprehensive holistic testing methodology designed to be a static way of holistically measuring categorical variables directly applicable to educational and social behavioral environments where the established methods of pure experimental designs are easily violated. The unchanging base of the Tri-Squared Test is the 3 × 3 Table based on Trichotomous Categorical Variables and Trichotomous Outcome Variables. The emphasis on the three distinctive variables provides a thorough and rigorous robustness to the test that yields enough outcomes to determine if differences truly exist in the environment in which the research takes place (Osler, 2012a).

The Total Transformative Trichotomous-Squared Test provides a methodology for the transformation of the outcomes from qualitative research into measurable quantitative values that are used to test the validity of hypotheses. The unchanging base of the Tri-Squared Test is the 3 × 3 Table based on Trichotomous Categorical Variables and Trichotomous Outcome Variables. The Tri-Squared research procedure uses an innovative series of mathematical formulae that cover the following as a comprehensive whole: (1) Convert qualitative data into quantitative data; (2) Analyze inputted trichotomous qualitative outcomes; (3) Transform inputted trichotomous qualitative outcomes into outputted quantitative outcomes; and (4) Create a standalone distribution for the analysis' possible outcomes and establish an effective research effect size and sample size with an associated alpha level to test the validity of an established research hypothesis.

To effectively use Tri-Squared in a research investigation, one must first develop a series of trichotomous categorical variables based on associated trichotomous associated outcomes. This is the first initial and crucial step to using Tri-Squared as a valid, reliable, and objective means of analyzing data. Second, an "Inventive Investigative Instrument" must be created and implemented based on the initial trichotomous categorical variables and outcomes. This ensures that the research investigation is consistent throughout the study and that the later Tri-Squared computations are validly reporting what actually took place in the investigative environment during the research study.

The "Inventive Investigative Instrument" can be psychometrically delivered as a test, qualitatively delivered in the form of a research questionnaire, survey, interview or another form of metric. As long as the trichotomous categorical variables are measured according to the established associated trichotomous outcomes, then the research has merit within the confines and strict requirements of the Tri-Squared Test.

The Tri-Squared statistic transforms qualitative data into quantitative data and then measures the difference between the two to determine the validity of the initial research hypothesis. If no relationship is determined to exist between the qualitative and quantitative trichotomous categorical and outcome variables, then the Tri-Squared statistic equals zero. Adversely, the greater the relationship between the variables, the greater the value will be of the final Tri-Squared calculation. Statistics by nature is a methodical and selective science that requires specific and precise steps and is cautious about dealing with uncertainty. Thus, Tri-Squared is very comprehensive in its structure, taking into account: number of measures, accountability through trichotomous metrics, precision in effect size, specification in sample size, and strict methodology in hypothesis testing (Osler, 2012).

Mathematically Defining the Tri-Squared [Tri^2] Test

Tri-Square or Tri-Squared comprehensively stands for "The Total Transformative Trichotomous-Squared Test" (or "Trichotomy-Squared"). It provides a methodology for the transformation of the outcomes from qualitative research into measurable quantitative values that are used to test the validity of hypotheses. It is based on the mathematical "Law of Trichotomy." Apostol (1967), writing in his book on calculus, defined "The Law of Tricohotomy" as: Every real number is negative, 0, or positive. The law is sometimes stated as "For arbitrary real numbers a and b, exactly one of the relations $a < b$, $a = b$, and $a > b$ holds" (p. 20). It is important to note that in mathematics, the law (or axiom) of trichotomy is most commonly the statement that for any (real) numbers x and y, exactly one of the following relations holds. Until the end of the 19th century, the law of trichotomy was tacitly assumed true without having been thoroughly examined (Singh, 1997). A proof was sought by Logicians and the law was indeed proven to be true. If applied to cardinal numbers, the law of trichotomy is equivalent to the axiom of choice. More generally, a binary relation R on X is trichotomous if for all x and y in X exactly one of xRy, yRx or $x = y$ holds. If such a relation is also transitive, it is a strict total order; this is a special case of a strict weak order.

For example, in the case of three elements the relation R given by aRb, aRc, bRc is a strict total order, while the relation R given by the cyclic aRb, bRc, cRa, which is a non-transitive trichotomous relation. In the definition of an ordered integral domain or ordered field, the law of trichotomy is usually taken as more foundational than the law of total order, with $y = 0$, where 0 is the zero of the integral domain or field.

In set theory, trichotomy is most commonly defined as a property that a binary relation < has when all its members $<x, y>$ satisfy exactly one of the relations listed above. Strict inequality is an example of a trichotomous relation in this sense. Trichotomous relations in this sense are irreflexive and antisymmetric (Sensagent, n.d.).

Explaining the Foundation of the Tri-Squared Test

The foundational idea of a "Trichotomy" has a long, detailed history that is based in discussions surrounding higher cognition, general thought, and descriptions of intellect. Philosopher Immanuel Kant adapted the Thomistic acts of intellect in his trichotomy of higher cognition — (a) understanding, (b) judgment, (c) reason — which he correlated with his adaptation in the soul's capacities — (a) cognitive faculties, (b) feeling of pleasure or displeasure, and (c) faculty of desire (Kant, 1781/2007). The Total Transformative Trichotomous-Squared Test provides a methodology for the transformation of the outcomes from qualitative research into measurable quantitative values that are used to test the validity of hypotheses.

The advantage of this research procedure is that it is a comprehensive holistic testing methodology designed to be a static way of holistically measuring categorical variables directly applicable to educational and social behavioral environments where the established methods of pure experimental designs are easily violated. The unchanging base of the Tri-Squared Test is the 3 × 3 Table based on Trichotomous Categorical Variables and Trichotomous Outcome Variables. The emphasis on the three distinctive variables provides a thorough and rigorous robustness to the test that yields enough outcomes to determine if differences truly exist in the environment in which the research takes place (Osler, 2012).

Explaining the Tri-Squared [Tri ^{2}] Mathematical Model

Tri-Squared is grounded in the combination of the application of the research of two mathematical pioneers and the author's research into the basic two dimensional foundational approaches that ground further explorations into a three dimensional Instructional Design (Osler & Waden, 2012). The aforementioned research includes the original dissertation of optical pioneer Ernst Abbe, who derived the distribution that would later become known as the chi square distribution, and the original research of mathematician Auguste Bravais, who pioneered the initial mathematical formula for correlation in his research on observational errors. The Tri-

Squared research procedure uses an innovative series of mathematical formulae that cover the following as a comprehensive whole: (1) Convert qualitative data into quantitative data; (2) Analyze inputted trichotomous qualitative outcomes; (3) Transform inputted trichotomous qualitative outcomes into outputted quantitative outcomes; and (4) Create a standalone distribution for the analysis possible outcomes and to establish an effective—research effect size and sample size with an associated alpha level to test the validity of an established research hypothesis (Osler, 2012).

Explaining the Psychometrics of the Tri-Squared Test

The process of designing instruments for the purposes of assessment and evaluation is called "Psychometrics." Psychometrics is broadly defined as the science of psychological assessment (Rust & Golombok, 1989). The Tri-Squared Test pioneered by the author factors into the research design a unique event-based "Inventive Investigative Instrument" (Osler, 2013b). This is the core of the Trichotomous-Squared Test. The entire procedure is grounded in the qualitative outcomes that are inputted as Trichotomous Categorical Variables based on the Inventive Investigative Instrument (Osler, 2013c). Osler (2012) initially defined the Tri-Squared mathematical formula in the *Journal on Mathematics* article entitled, "Trichotomy-Squared – A novel mixed methods test and research procedure designed to analyze, transform, and compare qualitative and quantitative data for education scientists who are administrators, practitioners, teachers, and technologists" as follows: $Tri^2 = T_{Sum}[(Tri_x - Tri_y)^2 : Tri_y]$. The Tri-Squared Model (in tabular format) and its associated calculations, definitions, procedures are explained in detail on the pages that follow.

How Tri-Squared Works: Modeling the Standard Tri ^{2} Test 3 × 3 Table and its Corresponding Calculations

Table 1 follows and illustrates the Tri ^{2} Mathematical Model Illustrated in Tabular Format.

Table 1

Tri-Squared Test 3 × 3 Table Calculations: Explaining How the Tri ^{2} Statistical Mathematical Model is Constructed Displaying the 3 × 3 Table Calculation Values of Qualitative Outcomes of the Tri-Squared Test

$n_{Tri} = 0$
$\alpha = 0$

TRICHOTOMOUS OUTCOME VARIABLES	TRICHOTOMOUS CATEGORICAL VARIABLES a_1	a_2	a_3
b_1	$T_{a_1 b_1}$ = Cell$_1$	$T_{a_2 b_1}$ = Cell$_2$	$T_{a_3 b_1}$ = Cell$_3$
b_2	$T_{a_1 b_2}$ = Cell$_4$	$T_{a_2 b_2}$ = Cell$_5$	$T_{a_3 b_2}$ = Cell$_6$

b_3	$T_{a_1b_3}$ = Cell$_7$	$T_{a_2b_3}$ = Cell$_8$	$T_{a_3b_3}$ = Cell$_9$

$$\boldsymbol{Tri}^2\ d.f. = [C - 1][R - 1] = [3 - 1][3 - 1] = 4 = \boldsymbol{Tri}^2_{[\bar{x}]}$$

The Resulting Tri–Squared Effect Size Distribution Table:

Tri–Squared Distribution Table
Displaying Primary Alpha Levels with
Associated Critical Values for Hypothesis Tests

α Level	*0.995*	*0.975*	*0.20*	*0.10*	*0.05*	*0.025*	*0.02*	*0.01*	*0.005*	*0.002*	*0.001*
$Tri^2_{[\bar{x}]}$ = *d.f.* = 4	0.207	0.484	5.989	7.779	9.488	11.143	11.668	13.277	14.860	16.924	18.467
Tri^2_{Eff} = *Effect Size*	*Small* 4[4]	*Small* 4[4]	*Small* 4[4]	*Small* 4[4]	*Small* 4[4]	*Medium* 4[16]	*Medium* 4[16]	*Medium* 4[16]	*Large* 4[64]	*Large* 4[64]	*Large* 4[64]+
Tri^2_{Sm} = *Sample Size [Intervals]*	1–16	17–33	34–40	41–57	58–74	75–139	140–204	205–269	270–526	527–783	784–1040+

The Resulting Tri–Squared Probability Table:

Tri–Squared Probability Distribution Table

Number of Research Participants Placed in Intervals Based off of Tri–Squared Effect Size Magnitude: [Small, Medium, or Large] is Based off of the Tri–Squared Mean = [d.f.] = 4

Magnitude	Small Unit Intervals: Multiple of 1 = 4[4] = 4 • 4 = 16 Therefore, Interval has Increments of 16					Medium Unit Intervals: Multiple of 2 = 4[16] = 4[4 • 4] = 64 Therefore, Interval has Increments of 64			Large Unit Intervals: Multiple of 3 4[4 • 4 • 4] = 4[64] = 256		
Number of Participants	1— 16	17—33	34—40	41—57	58—74	75-139	140-204	205-269	270-526	527-783	784-1040+
Probability P(x)	0.995	0.975	0.20	0.10	0.05	0.025	0.02	0.01	0.005	0.002	0.001

The Tables associated with Table 1 that are immediately below it are used to comprehensively determine the research alpha level and the Tri-Squared test hypothesis test critical value, all based upon the research sample size. Table 2 follows and illustrates the Tri^2 Test Total Calculations by Cell, Row, and Column Illustrated in Tabular Format to explain how the Trichotomous-Squared Test is calculated.

Table 2

A Tri ^{2} 3 × 3 Standard Table of Statistically Significant Tri ^{2} Test Total Calculations by Cell, Row, and Column

The Table below is a Trichotomous-Squared Standard 3 x 3 Table designed to analyze the research questions from an Inventive Investigative Instrument with the following Trichotomous Categorical Variables: $\boldsymbol{a_1}$; $\boldsymbol{a_2}$; and $\boldsymbol{a_3}$. The 3 × 3 Table has the following Trichotomous Outcome Variables: $\boldsymbol{b_1}$; $\boldsymbol{b_2}$; and $\boldsymbol{b_3}$. The Sample Total Calculations are conducted as follows:

$n_{Tri} = 0$

$\alpha = 0$

		TRICHOTOMOUS CATEGORICAL VARIABLES			
		$\boldsymbol{a_1}$	$\boldsymbol{a_2}$	$\boldsymbol{a_3}$	Tri-Squared Test Row Calculations
TRICHOTOMOUS OUTCOME VARIABLES	$\boldsymbol{b_1}$	0	0	0	$= \boldsymbol{Tri^2}_{Cell_1 [\boldsymbol{a_1b_1}] + Cell_2 [\boldsymbol{a_2b_1}] + Cell_3 [\boldsymbol{a_3b_1}]}$
	$\boldsymbol{b_2}$	0	0	0	$= \boldsymbol{Tri^2}_{Cell_4 [\boldsymbol{a_1b_2}] + Cell_5 [\boldsymbol{a_2b_2}] + Cell_6 [\boldsymbol{a_3b_2}]}$
	$\boldsymbol{b_3}$	0	0	0	$= + \boldsymbol{Tri^2}_{Cell_7 [\boldsymbol{a_1b_3}] + Cell_8 [\boldsymbol{a_2b_3}] + Cell_9 [\boldsymbol{a_3b_3}]}$
	Tri-Squared Test Column Calculations	$\boldsymbol{Tri^2}_{\boldsymbol{Cell_1} [\boldsymbol{a_1b_1}]}$ $\boldsymbol{Tri^2}_{\boldsymbol{Cell_4} [\boldsymbol{a_1b_2}]}$ $+ \boldsymbol{Tri^2}_{\boldsymbol{Cell_7} [\boldsymbol{a_1b_3}]}$	$\boldsymbol{Tri^2}_{\boldsymbol{Cell_2} [\boldsymbol{a_2b_1}]}$ $\boldsymbol{Tri^2}_{\boldsymbol{Cell_5} [\boldsymbol{a_2b_2}]}$ $+ \boldsymbol{Tri^2}_{\boldsymbol{Cell_8} [\boldsymbol{a_2b_3}]}$	$\boldsymbol{Tri^2}_{\boldsymbol{Cell_3} [\boldsymbol{a_3b_1}]}$ $\boldsymbol{Tri^2}_{\boldsymbol{Cell_6} [\boldsymbol{a_3b_2}]}$ $+ \boldsymbol{Tri^2}_{\boldsymbol{Cell_9} [\boldsymbol{a_3b_3}]}$	$\text{T}Tri^2_{Cell_1 [a_1b_1]} \ldots + \ldots \text{T}Tri^2_{Cell_9 [a_3b_3]}$ = ***Grand Total of All Table Cells***

Tri ^{2} *degrees of freedom =*

[***Tri*** ^{2} *d.f.* = [*C* – 1][*R* – 1] = [3 – 1][3 – 1] = 4 = $\boldsymbol{Tri}^2_{[\bar{x}]}$]

The next section details Triostatistics as the "post hoc" (or research studies that occur after the initial research has been conducted) measurements that can be conducted immediately following a Tri-Squared Test.

Introducing the Science of "Triostatistics"

Triostatistics (or more simply "Triostat") is the application of Post Hoc measures to the outcomes of the Trichotomous Squared Test. As a statistical discipline Triostat concerns the development and application of specific and uniquely designed advanced post hoc statistical tests, methodologies, and techniques. Triostat is used to further investigate the research outcomes from initially statistically significant Tri-Squared Tests. Research studies that analyze data through the use of the Trichotomous Squared Test are the foundation for Triostatistics. Thus, Triostatistics is the further investigation and precise in-depth study of the dynamic data that constitute the statistically significant Tri-Squared Test results.

The word "Triostatistics" is a portmanteau of the terms: "Triochotomous" and "Statistics"; that can also be referred to as "Triostat," "Advanced Trichometrics," or "The Science of Trichometry." More definitively Triostatistics is a branch of the science statistics that specifically applies statistical methods, techniques, and strategies to a wide range of topics that concern the Tri-Squared Test. At the heart of this statistical discipline is the application of the mathematical "Law of Trichometry."

The science of Triostatistics encompasses the design of Tri-Squared experiments, especially in education and social behavioral settings. However, the utility and flexibility of Triostat as a body of statistical metrics allows it to be applied to a variety of sciences (through the use and application of the mathematical "Law of Trichotomy"). Triostatistics as a discipline is the collection, summarization, and analysis of data from Tri-Squared experiments, and the interpretation of, and inference from, statistically significant Tri-Squared Test results.

The Primary Twelve Triostatistical Measures and Metrics

Triostatistics have their foundation in the analysis of initially statistically significant Tri-Squared Tests. Triostatistical measures are all grounded in Trichotomous-Squared research methods. They extend that methodology into novel statistical metrics that provide "Triostatisticians" detailed information on a variety of quantitative analytical areas. These areas are identified as: the relationships between Tri-Squared variables, the varied parameters of trichotomous variables, the transformation of trichotomous data into inferential metrics and/or measures, and a host of other post hoc statistical arenas. The Triostatistical procedures that provide more insight into the Tri-Squared Test are as follows:

1.) Tri-Symmetrical Omnibus Tests;
2.) The Trimetric Tri-Squared Test;
3.) Tri-Squared Mean Cross Comparative Analysis;
4.) Trivariant Analysis;
5.) TRINOVA;
6.) TRICOVA;
7.) MULTICOVA;
8.) Trichotomous Progression Analysis;
9.) TRICOM;
10.) Tri-Center Analysis;
11.) Tri-Cubed [Tri ^{3}] Tri-Coordinate Meta–Analysis Test; and
12.) TRIMOD.

Triostat Measures and Metrics: Defining Each of the Twelve Triostatistics Procedures

Tri-Symmetrical Omnibus Tests. An Omnibus Test is a global or overall test of a given statistic. Tri-Squared Post Hoc Tri-Symmetrical Omnibus Tests have two distinctive metrics in the form of Dichotomous Analytical statistical measurement procedures: (1) Tri-Correlational Analytics; and (2) Tri-Associative Analytics. Tri-Correlational Analytics are based upon small sample sizes and can only be used with small Tri-Squared interval effect sizes. Tri-Associative

Analytics are applicable to any size of Tri-Squared Test as long as a level of statistical significance has first been established in an initial research study (an established Tri-Squared level of statistical significance is also true of Tri-Correlational Analytical statistical measures). The two branches of Tri-Squared Post Hoc Tri-Symmetrical Omnibus Tests are defined as follows: Tri-Correlational Analytics: **[$\mathbf{Tri}_{r}$]** and Tri-Associative Analytics: **[$\mathbf{Tri}_{\equiv}$]**. Tri-Correlational Analytics **[$\mathbf{Tri}_{r}$]** are statistically defined as an omnibus methodology that includes statistical post hoc testing to determine the value of a significant small sample-sized Tri-Squared Test. Tri-Associative Analytics **[$\mathbf{Tri}_{\equiv}$]** are defined as a dual Omnibus Statistical Test methodology that includes two statistical post hoc tests to determine more detailed information on the value and significance of the relationships between the Categorical and Outcome Variables of a significant Tri-Squared Test.

The Trimetric Tri-Squared Test. The Trimetric Tri-Squared Test is designed to determine the Construct Validity of statistically significant Tri-Squared Inventive Investigative Instruments. In this case, Construct Validity is defined as: "The overall validity (or "truthfulness") of the itemized inferences that the researcher designed Inventive Investigative Instrument purported to accurately and actually measure regarding the Trichotomous Categorical Variables that were under initial research investigation. To do this, the Trimetric Tri-Squared Test first uses the "Summative Post Hoc Tri-Squared Differential Operator" [$\boldsymbol{\nabla}_{Tri^2}$] to determine the input and output mean differences from the initial Tri-Squared investigation. Tri-Squared Differential Operator does this by converting the input and output mean differences into a new "Mean Difference 3 × 3 Tri-Squared Table" and conducts a Tri-Squared Test on the subsequent outcomes. This is a sequential calculation that involves the summation of the initially inputted qualitative outcomes with their corresponding quantitative outcomes (via Matrix Algebra) and individually dividing them by the Total Number of Distributed Tri-Square Tests [n_{Tri}].

Tri-Squared Mean Cross Comparative Analysis. Tri-Squared Mean Cross Comparative Analysis (or "TSMCCA") is an advanced novel analysis metric designed to analyze the outcomes of the Tri-Squared Test. This methodology is referred to as: "Tri-Squared Mean Cross Comparative Analysis" (given the acronym TSMCCA). Tri-Squared Mean Cross Comparative Analysis involves the computation and in-depth study of means extracted from an initial Tri-Squared Test. The Tri-Squared Test had an established level of statistical significance that provided the grounds for further post hoc investigation. The TSMCCA statistic is an Advanced Post Hoc test of the transformative process of qualitative data into quantitative outcomes through the Tri-Squared Test first introduced in the Journal on Mathematics. Advanced statistical analytics are involved in the TSMCCA mathematical model, allowing for the critical analysis of mean scores on item results. This type of in-depth post hoc statistical analysis permits a higher level of Tri-Squared meta-analytical investigative inquiry.

Trivariant Analysis. Trivariant Analysis seeks to determine the differences in group means for Trichotomous Outcome Variables, both externally and internally. The Trivariant or "Trichotomous Variation" can also be referred to as the "Trivariance" or "Trivariation." Due to the invariant structure of Trichotomous Inventive Investigative Instruments (they are always in a 3 × 3 tabular format), the mean comparisons are in column form. Trivariant Analysis is similar to a 3 × 1 Factor ANOVA in its process of analyzing group means to determine a difference overall in treatment effects. In this case, the researcher is attempting to show the differences in the three

Trichotomous Outcome Variables to validate the repeated measures design of the post hoc significant Tri-Squared Inventive Investigative Instrument (which was designed and ultimately deployed based upon an overarching research question). In addition, the Trivariant Analysis research methodology also validates the differences in the post hoc 3×3 Standard Table mean on the external (between) and internal (within) Trichotomous Outcomes of the initially significant Tri-Squared Test.

TRINOVA: Trichotomous Nomographical Variance. TRINOVA is an in-depth [Trichotomous Nomographical Variance] statistical procedure for the internal testing of the transformative process of qualitative data into quantitative outcomes through the Tri-Squared Test first introduced in the Journal on Mathematics, and further detailed in the Journal on Educational Technology, Journal on School Educational Technology, and Journal on Educational Psychology. TRINOVA is an advanced statistical measure that is designed to check the validity and reliability of a Tri-Squared Test. This is a novel approach to advanced statistical post hoc Tri-Squared data analysis. It adds considerable value to the mixed methods approach of research design that involves the holistic combination and comparison of qualitative and quantitative data outcomes.

TRICOVA: Trichotomous Covariance. TRICOVA is a detailed statistical procedure for the internal testing of the outcomes of a significant transformation of qualitative data into quantitative outcomes through the Tri-Squared Test. TRICOVA as an advanced statistical procedure is designed to measure the overall size of the movement between inputted and outputted Tri-Squared variables. It is also designed to identify the magnitude and type of covariant relationship in existence between Tri-Squared Test Qualitative and Quantitative Variables. This new innovative approach to the advanced statistical post hoc metrics of the Tri-Squared Test adds an additional layer of richness and insight into the inner workings of the Tri-Squared Test. It also adds considerable value to the mixed methods approach of research design that involves the holistic combination and comparison of qualitative and quantitative data outcomes.

MULTICOVA: Multiple Trichotomous Coefficient of Variation Analysis. "Multiple Trichotomous Coefficient of Variation Analysis" statistic, represented by the acronym "MULTICOVA," is an innovative, in-depth way of further investigating a statistically significant post hoc Tri-Squared Test. MULTICOVA is an advanced and detailed statistical procedure for the internal testing of the outcomes of the mixed methods Tri-Squared Test. MULTICOVA as an advanced statistical procedure is designed to measure the "Trichotomous Coefficient of Variation" of inputted and outputted Tri-Squared variables. The Trichotomous Coefficient of Variation is also a normalized measure of a trichotomous probability distribution or trichotomous frequency distribution. This new statistic is an innovative approach to the sequential series of advanced post hoc Tri-Squared Test statistical metrics.

Trichotomous Progression Analysis. In Tri-Squared statistics, Trichotomous Progression Analysis is a post hoc statistical method used for estimating the direction and nature of relationships among statistically significant Trichotomous Categorical and Outcome Variables. It includes many mathematical techniques for modeling and analyzing the results of initially significant Trichotomous Qualitative and Quantitative Variables, when the focus is on the relationship between a significant Trichotomous Quantitative Variable as [“*y*”] the Trichotomous Dependent Variable and the significant Trichotomous Qualitative Variable as the Trichotomous Independent Variable [“*x*”]. More specifically, Trichotomous Progression Analysis enables research investigators to determine how each of the recorded values of the Trichotomous Dependent Variable (or “Trichotomous Criterion Variable”) [“*y*”] changes when any one of the Trichotomous Independent Variables [“*x*”] varies. Trichotomous Progression Analysis also provides information on how the average values of the Trichotomous Dependent Variable vary or are fixed when the corresponding Trichotomous Independent Variables vary or are fixed. The graphed Cartesian Bi-Coordinate Line (for Trichotomous Variables *x* and *y*) that indicates the relationship between Trichotomous Qualitative and Quantitative Variables is the “Trichotomous Estimation Target.” Also, a “Trichotomous Function of the Trichotomous Independent Variables” is referred to as the “Trichotomous Progression Function.”

This function best illustrates the predictive relationship between the Trichotomous Dependent and Independent Variables (or Trichotomous Quantitative and Qualitative Variables). In Trichotomous Progression Analysis, the variation of the Trichotomous Dependent Variable around the Trichotomous Progression Function can be illustrated and described by the Tri-Squared Probability Distribution. Trichotomous Progression Analysis is applicable for both prediction and forecasting, where its outcomes can be used to accurately make conjectures about future Tri-Squared Test outcomes (if the significant Tri-Squared Test were to be replicated under the same conditions and circumstances). In summation, Trichotomous Progression Analysis is used to comprehend (through accurate, meticulous, and rigorous calculation) which significant Trichotomous Independent Variables are related to their respective Trichotomous Dependent Variables. In gathering this data, researchers are able to explore the forms and predictive nature of the relationships between post hoc statistically significant Tri-Squared Test Trichotomous Variables.

TRICOM: Trichotomous Comparative Oneness of Measurement. Trichotomous Comparative Oneness of Measurement [or TRICOM] takes the standard Trichotomous-Squared Test and applies it to a single case study. Thus, a TRICOM Test is a method used to conduct research on a single individual ($n = 1$). The power of the Test and its general applicability lies in the longitudinal repeated measurement of the researcher-designed Trichotomous Inventive Investigative Instrument.

There are two forms of Repeated Measures in Trichotomously-Squared Inventive Investigative Instruments. They are: (1) “Iterative repetitive Trifold Trichotomous Categorical Variables” ($\boldsymbol{a_1}$, $\boldsymbol{a_2}$, and $\boldsymbol{a_3}$); and (2) “Nested Trifold Recursive Trichotomous Outcome Variables” ($\boldsymbol{b_1}$, $\boldsymbol{b_2}$, and $\boldsymbol{b_3}$). “Iteration” is generally defined as the act of process repetition with the aim of reaching a desired target, goal, and/or result. Sequentially, each subsequent “iterate” (individual iteration) is a repetition of the process. The outcome of an individual iteration is used as the starting point for the iteration that immediately follows. In the case of Tri-Squared research instruments, the term “Iteration” refers to the breakdown of the overall overarching investigation research question into three specific Categorical Variables so that it can be accurately measured. The results of these variables will clearly and statistically state whether or not the initial research question has merit. “Recursion” is broadly defined as the process of repeating items in a self-similar way. For an example of this process, consider an illustration that contains multiple or possibly infinite smaller and smaller nested identical images that repetitively occur over and over (as an identical image within an image within an image etc.). The term is applicable to the Tri-

Squared researcher-designed instrument in that it describes the threefold repetition of the structure of the Trichotomous Categorical Variable sub-questions that are each extracted from the three Categorical Variables (this thereby provides an Inventive Investigative Instrument that has a grand total of nine Trichotomous Outcomes nested within three interrelated, but distinctively specific Trichotomous Categorical Variables, the tabulated results of which create the Standard 3 × 3 Tri-Squared Table).

Tri-Center Analysis. Tri-Center Analysis is a measurement of the central tendency data of a statistically significant Tri-Squared Test. The metric as a statistic is designed to analyze the post hoc outcomes of the Tri-Squared Test using the traditional parametric statistical measures of central tendency [the Trichotomous Mean, Mode, and Median, respectively]. This methodology is referred to as: "Tri-Center or Tri-Central Analysis." Tri-Center Analysis involves the computation of normal distribution parametric measures to examine the values of an independent statistically significant Tri-Squared Test. The Tri-Squared Test values are considered to be a representation of a holistic series of sequential within group Trichotomous results.

The following calculations are the basis of Tri-Center Analysis. They consist of the traditional statistical "measures of center" or "measures of central tendency." They are represented in terms of Trichotomous relations in the following manner: (1) Calculating the Tri-Squared Test Mean = $\boldsymbol{Tri}^{\,2}_{[\bar{x}]}$: which represents the arithmetic average of Tri-Squared Test data; (2) Calculating the Tri-Squared Test Mode = $\boldsymbol{Tri}^{\,2}_{[Mo]}$: which represents the most frequently occurring numerical value in the set of data; and (3) Calculating the Tri-Squared Test Median $\boldsymbol{Tri}^{\,2}_{[Me]}$: which represents the middle score in the data set. To calculate the spread and variation of Tri-Squared Test results, the researcher will need a set of mathematical conventions and specific Trichotomous statistical formulae which use those conventions to determine the Trichotomous Variance and Standard Deviation, respectively.

Tri-Cubed [Tri ^{3}] Tri-Coordinate Meta-Analysis Test. Trichotomous Cubed (or "Tri-Cubed") Tri-Coordinate Meta-Analysis is an advanced and highly precise research methodology that offers an accurate, in-depth analysis of existing reported data on a specifically identified criterion. The Tri-Cubed Test integrates the Tri-Squared Test in a Tri-Coordinate [*x, y,* and *z*] data analysis methodology, involving a variety of robust rigorous calculations and detailed computations to provide further insight into the inner workings of reported and/or statistically significant data. A dynamic and complex third trichotomous variable (the Trichotomous Algorithmic Variable or "TAV") is factored into the data analysis and calculation procedures of the Tri-Squared Test, producing the Tri-Coordinate nature of the Tri-Cubed Test. The Tri-Cubed methodology uses the Isometric Cuboid mathematical geometric model from Visualus (Osler, 2010).

TRIMOD: Trichotomous-Cubic Parametric Model. The Trichotomous-Cubic Parametric Model (collectively abbreviated as "TRIMOD") is a rigorous post hoc mathematical data analysis methodology, designed to more accurately detail the outcomes of a statistically significant Tri-Squared Test. TRIMOD infuses the Tri-Cubed Test model with the Tri-Squared Test in a detailed sequential Tri-Coordinate series of *x, y,* and *z* planar vectors native to the Visualus Isometric Cuboid (Osler, 2010). A series of methodical mathematical calculation procedures are then conducted to yield the Tri-Cubic Parametric Model outcomes.

Contextualizing Triostatistics in Terms of MANOVA and Group Statistical Analytics

MANOVA is an acronym for "Multiple Analysis of Variance," also called "Multivariate Analysis of Variance." It is a statistical procedure for the multivariate analysis of multiple groups of data with two or more dependent or outcome variables. Multivariate Analysis of Variance is also an advanced statistical test procedure for comparing the multivariate population means of several groups. As a unique multi-group procedure, it is most commonly used in research designs when there are two or more outcome variables associated with multiple within and between group means in a specified research setting (the vast majority of statistical studies that use the MANOVA procedure provide a set of individual probability values for each outcome variable in order to test for specific levels of statistical significance). MANOVA is often used to answer the following research questions:

1. Do changes in the independent (treatment) variable(s) have significant effects on the dependent (outcome) variable(s)?
2. What are the interactions that take place among the dependent variable(s) and independent variable(s)? (Stevens, 2002)

When analyzing multiple groups of data, the inferential statistical measure of variance (or the spread of scores around the distribution mean) is a more accurate method of analyzing data than the more traditionally used inferential rectilinear Standard Deviation (the square root of the Variance) statistic. There are multiple forms of group data analysis in traditional statistical procedures. These measures include: ANOVA ("Analysis of Variance"), the standard statistical metric used to analyze multiple group means; ANCOVA ("Analysis of Covariance"), the statistical test used to measure pre- and post-outcomes for multiple groups and their associated group mean; and MANOVA (the aforementioned "Multiple Analysis of Variance"), which is designed to analyze and provide feedback on multiple group means and their associated outcome variables. Similar to the previously listed multiple methods of group data analysis (that greatly depend upon the research design and methodology used by the researcher in deciding exactly how to analyze group data at the outset of research), Triostatistics are a series of post hoc research methods that are uniquely grounded in the statistical significance of an initial Tri-Squared Test.

Triostatistics Summary

There are a number of Triostatistical metrics and tests that can provide additional information on statistically significant Tri-Squared research investigations, which can greatly enhance the understanding of initial research results. The post hoc use of Triostatistics on statistically significant Tri-Squared Test data provides a series of plausible statistical measures that allow research investigators to further interpret the deep and rich complexities of Tri-Squared research data. The widespread use of these measures will push the body of knowledge in a variety of research fields and thereby make the field of statistics more intrinsically approachable, more dynamically plausible, and more ergonomically usable.

References

Aldrich, J., & Miller, J. (n.d.). *Earliest uses of symbols in probability and statistics*. Retrieved March 10, 2014, from http://jeff560.tripod.com/stat.html

---. (n.d.). *Earliest known uses of some of the words of mathematics*. Retrieved March 10, 2014, from http://jeff560.tripod.com/mathword.html

Apostol, T. M. (1967). *Calculus, second edition, Volume one: One-variable calculus, with an introduction to linear algebra*. Waltham, MA: Blaisdell.

Kant, I. (2007). *Critique of pure reason* (M. Müller, Trans.). New York: Penguin Classics. (Original work published 1781)

Osler, J. E. (2010). *Visualus* ™ © *visioneering volumetrically*: *The mathematics of the innovative problem–solving model of inventive instructional design* (*First edition*). OSI: Publishing Division. Lulu, Morrisville NC.

---. (2012). Trichotomy-Squared – A novel mixed methods test and research procedure designed to analyze, transform, and compare qualitative and quantitative data for education scientists who are administrators, practitioners, teachers, and technologists. *iManager's Journal on Mathematics, 1*(3), 23-32.

Osler, J. E., & Waden, C. (2012). Using innovative technical solutions as an intervention for at risk students: A meta–cognitive statistical analysis to determine the impact of ninth grade freshman academies, centers, and center models upon minority student retention and achievement. *iManager's Journal on School Educational Technology*, *7*(3), 11-23.

Osler, J. E. (2013a). The Psychometrics of Educational Science: Designing Trichotomous Inventive Investigative InstrumOsleents for Qualitative and Quantitative for Inquiry. *iManager's Journal on Educational Psychology*, *8*(3), 15-22.

---. (2013b). The Psychological Efficacy of Education as a Science through Personal, Professional, and Contextual Inquiry of the Affective Learning Domain. *iManager's Journal on Educational Psychology*, *6*(4), 36-41.

---. (2013c). Algorithmic Triangulation Metrics for Innovative Data Transformation: Defining the Application Process of the Tri-Squared Test. *Journal on Mathematics*, *2*(2), 10-16.

Rust, J. & Golombok, S. (1989). *Modern psychometrics: The science of psychological assessment* (2nd ed.). Florence, KY: Taylor & Frances/Routledge.

Sensagent. (n.d.) *Trichotomy*. Retrieved from http://dictionary.sensagent.com/trichotomy+(mathematics)/en–en/

Singh, S. (1997). *Fermat's enigma: The epic quest to solve the world's greatest mathematical problem*. New York: Anchor Books.

Stevens, J. P. (2002). *Applied multivariate statistics for the social sciences*. Mahwah, NJ: Lawrence Erblaum.

James Edward Osler II is Associate Professor, School of Education, and Program Coordinator of the Online Graduate Program in Educational Technology, North Carolina Central University.