THE REGULAR QUADRILATERAL FUNCTION OF E–LEARNING ENGINEERING: THE MATHEMATICAL CONJUNCTION OF ACCUMULATION AND ADVANCEMENT THAT DEFINES THE LOGIC, RATIONALE, AND ACTIVE INFOMETRICS OF INFORMATION DELIVERY IN THE DIGITAL AGE

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ABSTRACT

This monograph provides in-depth mathematical logic as the foundational rationale for the novel and innovative online instructional methodology called the 4A Metric Algorithm. The 4A Metric has been designed to address and meet the meta-competency-based education challenges faced by 21st century students who must now adapt to and learn in a multitude of educational settings (face to face, hybrid, and online). The 4A Metric has a geometrically-spatial infrastructure that mathematically defines its unique online "E–Learning Engineered" methodology for online information delivery. This methodology is defined as a "Quadrilateral Function of E–Learning Engineering" that is grounded in neuroscience of mathematical trichotomy and the "neuromeasurement" of the "Bi-coordinate Scale of Learning". The 4A Metric as an instructional methodology detailed in this narrative also provides an active solution that when implemented via an institutional Learning Management System (LMS)/Content Management System (CMS) uses virtual methods to achieve maximized information delivery in terms of meta-competence-based education for online learning. The explicative nature of the "Quadrilateral Function" also adds further mathematical value to online learning investigative inquiry through measurement, the efficacy of digital instrumentation, and information gathered through tools developed specifically for eduscientifically–engineered (Osler, 2013a and 2013b) research designs (Osler, 2013b and 2015a).

Keywords: 4A Metric ©, Brain-Based Learning, Cohesive Statement, Logic, Cognition, Cognitive Science, E–Learning Engineering, Eduscience, Emotional Intelligence, Epigenetics, Instructional Design, Inventive Investigative Instrument, Learning, Mathematical Model, Mechatronic Online Learning Model, Meta-Competency-Education, Online Learning, Outcomes, Neuroscience, Quadrilateral Function, Research, Tri–Squared Test, Trichotomy, Trioinformatics, Triple–I.

INTRODUCTION

The mathematical foundations of the process of information delivery in the information age can be readily explained through carefully defined mathematical concepts and principles. The in-depth analysis of "E–Learning Engineering for the Production of Online Course Delivery" can be precisely defined mathematically through the Cartesian coordinates and the mathematical concept of functionality. Additionally, the author notes that, in observing E–Learning from a "meta-competency-based education" perspective, the existence of a "tried and true" method of information delivery became readily apparent based upon years of experimentation, the integration of vital professional development with training, and ongoing active research in the field regarding online instructional efficacy. The aforementioned has led to the grounding foundation of research on the topic whose core is mathematically measureable and whose model can be rapidly replicated to improve and enhance both teaching and learning in the digital environment. The mathematics presented in this paper provides an explicative quadrilateral geometric-spatial model whose input is "E–Learning Engineering" and whose output is the 4A Metric Algorithm. The mathematical model presented in this narrative is the novel "Quadrilateral Function of E–Learning Engineering" that explains the duality inherent to meta-competency-based education (illustrated via the "Bi-coordinate Scale of Learning"), i.e., with an outcome that is the 4A Metric Algorithm a published, definitive, and comprehensive "E–Learning Engineering" methodology for the presentation of data in the online digital learning environment.

1. Rationale

At the outset of learning theory, Educational psychologists subdivided the arena of learning behavior educational objectives into three domains—the cognitive, affective, and psychomotor. The initial three domains of learning identify and represent the knowledge, beliefs, and skills, respectively, of a human performer. Learning can be thought of as occurring in these three domains (Adkins, 2004; Beane et al., 1986; Gage and Berliner, 1988). A forth domain, the social domain is introduced to accentuate sociocultural processes that accompany thinking, feeling, and sensing/movement (Dettmer, 2006). These four domains are and should be the foundation for holistic learning in any educational learning environment or institution. However, a holistic approach to teaching and learning that promotes self-growth is not always integrated into the instructional design of an educational curriculum or program. Thus, a neuroscientifically–grounded solution that emphasizes student assessment of their learning, promotes discovery, and adds opportunities for "micro-credentialing" (via specialized "certifications" and "badges") (Osler, 2016) is an ideal way to address content provision via "E–Learning Engineering". The purpose of the Quadrilateral Function provided in this paper is designed to introduce the reader to the precise mathematical foundations that support and ground online teaching and learning as "E–Learning Engineered courses" constructed using an innovative structural methodology. In addition, support is provided (via mathematical construction) for the use of the innovative neuroscience and neuroengineering 4A Metric © infrastructure first introduced in 2010 in a book written by the author entitled, "Infometrics: Optimal Learning via Instructional Solutions Developed through the Methodology of Technology Engineering" (Osler, 2010a).

2. Foundation

The Quadrilateral Function (or more specifically "The Regular Quadrilateral Function of E–Learning Engineering") has an outcome that is the 4A Metric Algorithm that is the primary digital learning environment that can be used to deliver subject matter content throughout the academic semester or quarter, during summer semester/session(s), or throughout the entire academic year. The Metric as a systemic sequential information delivery methodology is designed to integrate into any course in a traditional, online, and/or blended/hybrid format as an innovative problem-solving solution [similar to the "Isometric Cuboid" for "Visualus" (Osler, 2010b)]. As an algorithm the Metric has the following features: a) Provision of course information up front; b) Progression through course content at the student's own pace (while faculty can continue regular monitoring course progression during regular course-aligned meetings); c) Embedded opportunities for micro and comprehensive credentialing (through course completion as "digital badges" as rewards for steadily completed course progression along with external certification opportunities as internal course requirements are successfully completed); and d) Delivery of course assessments through regular sequential "Repetitive Mastery Tests" (that the instructor has set at a required level of completion, for example as specified completion scores at required matriculation levels of: 100%, 90%, 85%, etc.).

3. The Regular Quadrilateral Function

The "Regular Quadrilateral Function of E–Learning Engineering" is a "regular quadrilateral systemic mathematical format or pattern" that is a "true square function" represented symbolically by: "$Q[\varepsilon_e]$". This function has a capital "Q" for the term "quadrilateral" or more specifically "regular quadrilateral" (as a repetitive square mathematical format for the specific presentation of digital information for E–Learning) and the brackets are used for emphasis (unlike a more traditional function that uses a set of parentheses). The brackets represent "the concentration on the term x" as the input value associated with the explicative quadrilateral function format presented as: "Q[x]" or "Q of concentration on x" literally meaning the "Regular Quadrilateral function concentrated on term x". Furthermore, the definition of the Quadrilateral Function that is of the form "$Q[\varepsilon_e]$" literally means "the quadrilateral concentration on epsilon engineering" where, lower case Greek letter Epsilon "ε" represents the field of "E–Learning" and the subset of the lower case Roman letter "e" alongside it represents the science of "Engineering". As such, the "Quadrilateral Function of E–Learning Engineering" has as an outcome that is the 4A Metric which is an E–Learning Engineering Algorithm whose comprehensive relationship is fully represented by the equation: "$Q[\varepsilon_e] = 4A$" (which is literally interpreted as "The Regular Quadrilateral Function of E–Learning Engineering is equal to the 4A Metric Algorithm"). To understand precisely how this is derived via the functionality represented by $Q[\varepsilon_e]$ the complete mathematical definition of the full "Quadrilateral Function of E–Learning Engineering" is written as the mathematical formula shown in (a) and explained in more detail in (b) in the following two formats:

a) $Q[\varepsilon_e] = 4A$

Because,

b) $$Q[\varepsilon_e] = \sqrt{\left[\sum_{i=1}^{4}\left|\overset{1}{A_1}\ldots\overset{4}{A_1}\right| = \sum_{i=1}^{4}\left|\overset{1}{A_2}\ldots\overset{4}{A_2}\right|\right]} = \sqrt{16A^2} = 4A$$

The 4A that is the final outcome of the Regular Quadrilateral Function is in fact the full "4A Metric Algorithm" (as presented in the publication: Osler, 2016) that is the methodology for the delivery of E–Learning content in the digital environment (typically via a Learning or Course Management System). Thus, the "Regular Quadrilateral Function of E–Learning Engineering" is equal to the 4A Metric Algorithm (as indicated in $Q[\varepsilon_e]$ = 4A equation) as the fundamental foundational mathematical methodology and meta-competency-based information deployment methodology of E–Learning Engineering ("ε_e"). The internal elements of this formula can be expressed geometrically in the following mathematical graphical representation provided in Figure 1.

Figure 1 shows the summative format of the Regular Quadrilateral Function provides an in-depth observation of a concentration on the summation of the absolute value of the Cartesian coordinates that on dual parallel axes (x and y respectively). The geometric graph provided is the "Bi-coordinate Scale of Learning" that represents the dual aspects of learning that are parallel and equally increase exponentially as content is provided in a systematic and sequential method as outlined by the graph. Achievement (as "Gain" indicative of "Up") towards Acceleration (as "Progress" indicative of "Out") is exponential and provided in blocks of 16 units. As such, the derivative (or the "instantaneous rate of change") of the Quadrilateral Function is the constant "A^2" which is the perfect parallel exponentiation of Cartesian Coordinates (represented by ($|x| = |A_1|$, $|y| = |A_2|$) where, $|x| = |y|$ as $|A_1| = |A_2|$ and the outcomes are always maximized in a grand total of 4 parallel, sequential, and equal units. The four units have the following sequential and systemic

$$\left[\sum_{i=1}^{4}\left|\overset{1}{A_1}\ldots\overset{4}{A_1}\right| = \sum_{i=1}^{4}\left|\overset{1}{A_2}\ldots\overset{4}{A_2}\right|\right]$$

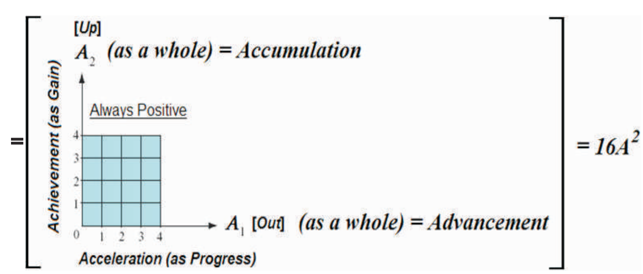


Figure 1. The Geometric Representation of the Internal Working Components of the "Regular Quadrilateral Function of E–Learning Engineering"

definitions per geometric axis:

A^1 = Active (First level of engagement that when mastered proceeds to the second Level)

A^2 = Able (Second level of utility that when mastered proceeds to the third Level)

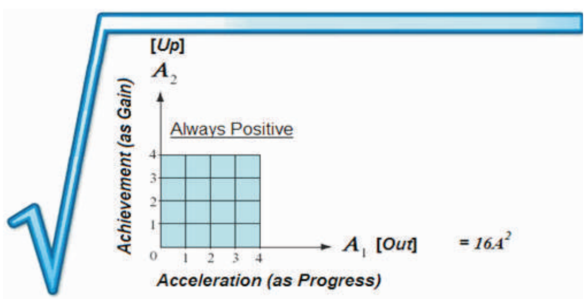
A^3 = Adept (Third level of enablement that when mastered proceeds to the second Level)

A^4 = Apex (Fourth and final level of mastery that indicates completion)

Accordingly, the Quadrilateral Function is the mathematical representation of E–Learning Engineering that has its final representation as the 4A Metric Algorithm. This is idealistically represented as the "Square Root of the Quadrilateral Function" = 4A. This is graphically and geometrically represented in Figure 2.

The imagery is indicative of the use square root in the quadratic formula to create the 4A Metric Algorithm that is the delivery of information in the E–Learning environment. Learning in this instance is the parallel process of "Acceleration towards Achievement" from beginning state to level of mastery through the completion of all of

$$Q[\varepsilon_\varepsilon] = \sqrt{\left[\sum_{i=1}^{4}\left|\overset{1}{A_1}\dots\overset{4}{A_1}\right| = \sum_{i=1}^{4}\left|\overset{1}{A_2}\dots\overset{4}{A_2}\right|\right]} = \sqrt{16A^2} = 4A =$$



Therefore, the following is also true:

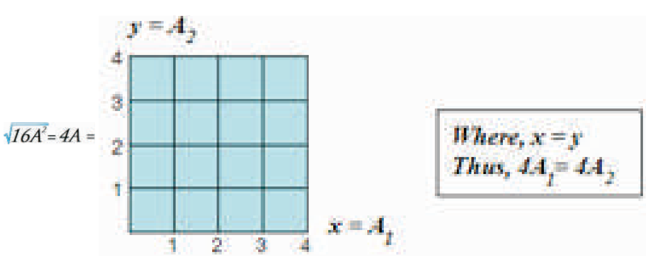


Figure 2. The Comprehensively defined Geometric Representation of the Square Root of the "Regular Quadrilateral Function of E–Learning Engineering"

the specific components as the sixteen elements of the mathematical formulae that compose the final 4A Metric Algorithm. The specific elements are defined in the following dual list:

On the x-axis (as the Cartesian coordinate of Acceleration = "A_1" as "Outward Self-Growth") the following four parameters are the four levels of learning as "Professional Development Criterion" or (PDCs) that are the four applicable learning levels that used in the 4A Metric (as indicated in the aforementioned geometric representation on the x-axis):

A^1_1 = Active (Starting Outward Self-Growth = Emerging)

A^2_1 = Able (Utilized Outward Self-Growth = Developing)

A^3_1 = Adept (Enabled Outward Self-Growth = Proficient)

A^4_1 = Apex (Maximized Outward Self-Growth = Accomplished).

On the y-axis (as the Cartesian coordinate of Achievement = "A_2" as "Upward Content Knowledge Attainment") the following four additional parameters are the four levels of learning as "Professional Development Criterion" or (PDCs) that are the four applicable learning levels that used in the 4A Metric (as indicated in the aforementioned geometric representation on the y-axis):

A^1_2 = Active (Starting Outward Content Knowledge Attainment = Emerging)

A^1_2 = Able (Utilized Outward Content Knowledge Attainment = Developing)

A^1_2 = Adept (Enabled Outward Content Knowledge Attainment = Proficient)

A^1_2 = Apex (Maximized Outward Content Knowledge Attainment = Accomplished).

In terms of multiplicative properties (represented in Cartesian coordinates as the abscissa (x) and ordinate (y) equivalent to the "Product of the Quadrilateral Function of E–Learning Engineering" the Quadrilateral Function can be reinterpreted in product notation and written as:

b) $$\prod_{i=1}^{4}\left|x_1\dots x_4\right|\cdot\left|y_1\dots y_4\right|$$

Sequentially, the 4A Metric Algorithm can be mathematically represented in terms of matrix algebra matrices that by row and column indicate the sequencing and subject matter topics of the specific

$$\left[\overset{1}{\underset{i=1}{4A}}\right] = 1A = \begin{bmatrix} 1A_{1.1} & 1A_{1.2} & 1A_{1.3} & 1A_{1.4} \\ 1A_{2.1} & 1A_{2.2} & 1A_{2.3} & 1A_{2.4} \\ 1A_{3.1} & 1A_{3.2} & 1A_{3.3} & 1A_{3.4} \\ 1A_{4.1} & 1A_{4.2} & 1A_{4.3} & 1A_{4.4} \end{bmatrix} = \text{Active Level}$$

$$\left[\overset{2}{\underset{i=1}{4A}}\right] = 2A = \begin{bmatrix} 2A_{1.1} & 2A_{1.2} & 2A_{1.3} & 2A_{1.4} \\ 2A_{2.1} & 2A_{2.2} & 2A_{2.3} & 2A_{2.4} \\ 2A_{3.1} & 2A_{3.2} & 2A_{3.3} & 2A_{3.4} \\ 2A_{4.1} & 2A_{4.2} & 2A_{4.3} & 2A_{4.4} \end{bmatrix} = \text{Able Level}$$

$$\left[\overset{3}{\underset{i=1}{4A}}\right] = 3A = \begin{bmatrix} 3A_{1.1} & 3A_{1.2} & 3A_{1.3} & 3A_{1.4} \\ 3A_{2.1} & 3A_{2.2} & 3A_{2.3} & 3A_{2.4} \\ 3A_{3.1} & 3A_{3.2} & 3A_{3.3} & 3A_{3.4} \\ 3A_{4.1} & 3A_{4.2} & 3A_{4.3} & 3A_{4.4} \end{bmatrix} = \text{Adept Level}$$

$$\left[\overset{4}{\underset{i=1}{4A}}\right] = 4A = \begin{bmatrix} 4A_{1.1} & 4A_{1.2} & 4A_{1.3} & 4A_{1.4} \\ 4A_{2.1} & 4A_{2.2} & 4A_{2.3} & 4A_{2.4} \\ 4A_{3.1} & 4A_{3.2} & 4A_{3.3} & 4A_{3.4} \\ 4A_{4.1} & 4A_{4.2} & 4A_{4.3} & 4A_{4.4} \end{bmatrix} = \text{Apex Level.}$$

Figure 3. The Matrix Algebra representation of Each Level of the 4A Metric Algorithm as the Holistic Solution to the "Quadrilateral Function of E–Learning Engineering"

E–Learning Engineered course. Figure 3 provides the four sequential matrix algebra infrastructures of the 4A Metric Algorithm by level in the following format:

The four matrix algebra tables are representative of the four level of the 4A Metric Algorithm. Each table is presented in the Quadrilateral Function geometric format with sixteen sequential outcomes to complete each level. Each one is indicative of the use square root in the quadratic formula to produce the 4A sequential pattern of information delivery in the digital environment. Each row (left to right) corresponds to the Active (as row micro-level presented in subset 1.1 through 1.4), Able (as row micro-level presented in subset 2.1 through 2.4), Adept (as row micro-level presented in subset 3.1 through 3.4), and Apex (as row micro-level presented in subset 4.1 through 4.4) Sub-levels needed to systemically and sequentially complete each level. Each column (top to bottom) corresponds to the required content needed as subject matter readings (as column micro-level presented in subset 1.1 through 4.1), corresponding subject matter exercises (as column micro-level presented in subset 1.2 through 4.2), specified subject matter projects (as column micro-level presented in subset 1.3 through 4.3), and lastly precisely set and scored Repetitive Mastery Tests (as column micro-level presented in subset 1.4 through 4.4) for each level to sequentially (by row) move from Sub-level to Sub-level to complete the necessary requirements to demonstrate content mastery.

Comprehensively, Figure 4 displays the matrices from Figure 3 in a rectilinear model with an associated scoring scale for each element of each matrix sub-level.

Figure 4 first illustrates the mathematical matrix as the systemic sequential infrastructure of the 4A Metric Algorithm (see Figure 3 for the initial 4A Metric Algorithm structure). Consequentially, the sub-levels of the 4A Metric

$$\left[\overset{4}{\underset{i=1}{4A}}\right] = 1A = \begin{bmatrix} 1A_{1.1} & 1A_{1.2} & 1A_{1.3} & 1A_{1.4} \\ 1A_{2.1} & 1A_{2.2} & 1A_{2.3} & 1A_{2.4} \\ 1A_{3.1} & 1A_{3.2} & 1A_{3.3} & 1A_{3.4} \\ 1A_{4.1} & 1A_{4.2} & 1A_{4.3} & 1A_{4.4} \end{bmatrix} + 2A = \begin{bmatrix} 2A_{1.1} & 2A_{1.2} & 2A_{1.3} & 2A_{1.4} \\ 2A_{2.1} & 2A_{2.2} & 2A_{2.3} & 2A_{2.4} \\ 2A_{3.1} & 2A_{3.2} & 2A_{3.3} & 2A_{3.4} \\ 2A_{4.1} & 2A_{4.2} & 2A_{4.3} & 2A_{4.4} \end{bmatrix} + 3A = \begin{bmatrix} 3A_{1.1} & 3A_{1.2} & 3A_{1.3} & 3A_{1.4} \\ 3A_{2.1} & 3A_{2.2} & 3A_{2.3} & 3A_{2.4} \\ 3A_{3.1} & 3A_{3.2} & 3A_{3.3} & 3A_{3.4} \\ 3A_{4.1} & 3A_{4.2} & 3A_{4.3} & 3A_{4.4} \end{bmatrix} + 4A = \begin{bmatrix} 4A_{1.1} & 4A_{1.2} & 4A_{1.3} & 4A_{1.4} \\ 4A_{2.1} & 4A_{2.2} & 4A_{2.3} & 4A_{2.4} \\ 4A_{3.1} & 4A_{3.2} & 4A_{3.3} & 4A_{3.4} \\ 4A_{4.1} & 4A_{4.2} & 4A_{4.3} & 4A_{4.4} \end{bmatrix} \equiv 4.00$$

$$\textbf{\textit{Where}},\ 1A_{1.1} \ldots 1A_{4.4} = \left[\prod_{i=1}^{4} \left[1A_{1.1} + 1A_{4.4}\right]_{1A \ldots 4A}\right] 0.0625 = 4.00$$ (Osler, 2016).

Therefore, the following is also true:

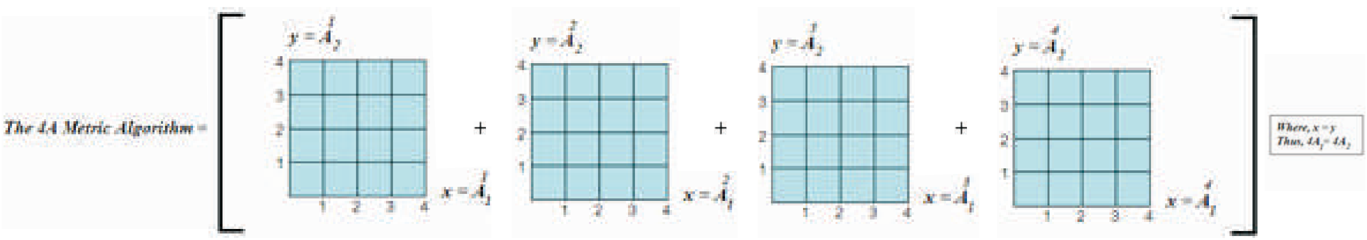


Figure 4. A Detailed Illustration of the Comprehensive 4A Metric Algorithm in Mathematical Algebraic Matrix Format: As the Foundational 4A Metric Matrix with the 4A Metric Systemic Sequential Scoring Scale

are indicated by levels 1A through 4A in a summative sequential manner. The micro-levels contained within the four sub-levels are displayed as: micro-levels [$1A_{1.1}$ to $1A_{1.4}$] through micro-levels [$4A_{1.1}$ to $4A_{1.4}$] sequentially. The second part of Figure 4 contains the summative scoring of each sub-level of the entire 4A Metric Algorithm as the 4A Metric Sub-level Product Formula: [$\prod_{i=1}^{4}[1A_{1.1} + 1A_{1.4}]_{1A.....4A}$]. Thus, each sub-level is equal to 1.00 (as points comprehensively and quantitatively computed) and each micro-level item is equal to exactly 0.0625 points respectively. The comprehensive computation of a single 4A Metric level has the following calculation: [$16_{[\text{Level Elements}]} \times 0.0625_{[\text{Points}]}$] = 1.00 (at completion) where, the four 4A Metric levels are equal to: [$1.00_{[\text{Active Level}]} + 1.00_{[\text{Able Level}]} + 1.00_{[\text{Adept Level}]} + 1.00_{[\text{Apex Level}]}$] = 4.00 (at complete mastery). Thus, the entire 4A Metric has a sum total of 4.00 points as a whole (Osler, 2016). This makes it much easier for an instructor to calculate grades and much easier for a student to know what their grades are at any time during the course (based upon the specifics of course completion) (Osler, 2016). Table 1 highlights and defines the "Professional Development Criterion" of the 4A Metric by level as it sequentially approaches the Apex Level (the final sequential Table 1 row.

Table 1 summarizes that the 4A Metric Algorithm is a comprehensive quantitative analysis methodology for the evaluation of candidate skills and growth based upon one of 4 distinct Professional Development Criterion (or "PDCs"). The PDCs are first presented in the 2010 book entitled, "Infometrics ©". The PDCs are the reflective outcomes of evidence that clearly illustrate the precise professional level of candidate knowledge and skill. The Metric is designed to measure how well candidates have learned skills and are able to apply them at the most creative, reflective, and rigorous level. The 4A Metric and the method of measuring candidate outcomes are covered in the following analytics final row in Table 1 indicates the level of performance that should be the final candidate outcome when they complete the course) (Osler, 2010a). Table 1 extracted from the 2010 book "Infometrics" (Osler, 2010a) by the author. Neuroscience definitions follow that provide the logical rational for the use of the Regular Quadrilateral Function as a "Mechatronic Online Learning Model" ("mechatronics" is the multidisciplinary field of science that includes a combination of Mechanical Engineering, Electronics, Computer Engineering, Telecommunications Engineering, Systems Engineering, and Control Engineering (Saleem and Khan, 2014; Güllü et al., 2015; Hardcastle, 2016) to accommodate online mastery learning from a "Meta-Competency-Education" perspective based upon the triune trichotomous structure of the human brain.

4. Neuroscience Definitions that apply to E–Learning Engineering

A "Mechatronics E–Learning Engineer" unites the principles of mechanics, electronics, neuroscience, and computing to generate a simpler, more economical, and reliable system in the online learning environment to create an ideal online learning environment from a "Meta-Competency-Based Education" perspective. "Meta-Competency-Based Education" goes well beyond regular competency-based education models as it is designed to take a learner from a beginning to a mastery level from a professional development ideology using the 4A Metric Algorithm to promote an sustain self-growth. From an educational disciplinary perspective the field of "Mechatronics E–Learning Engineering" bridges the gap

Professional Development Criterion Quantitative Levels	Professional Development Criterion Level Definitions
1A = Active	A learner who has recently acquired the required skills, skill sets, and content knowledge; and uses them to create a product.
2A = Able	A developing expert of required skills and content knowledge who is capable of applying concepts, methods, and techniques in a meaningful and effective product.
3A = Adept	A content developer who creates and builds an original product that is extensible in multiple arenas and areas and fully expresses concepts, methods, and techniques.
4A = Apex	An authoritative content producer who creates innovative and dynamic content in an original product as an expression of their unique voice and experiences that completely defines concepts, methods, and techniques.

Table 1. The 4A Metric Algorithm: Measuring Content Authoring (from Osler, 2016 and 2010a)

between the disparate fields of "Technology Education" (which studies Vocational Education and Occupational Education in industry through the varied practices and sciences of Mechanics, Mechanical Engineering, Robotics, Entrepreneurship, Commercialization, Production, and Manufacturing), and "Educational Technology" (which in turn contains the practices and sciences of Instructional Design, Instructional Technology, Online Competency-based Education, Computer-based Education, and Computer-based Instruction) through a focus on online education for relevant and current workforce development, professional development, and training. The principles of trichotomous human brain-based neuroscience are used in this narrative to illustrate the foundation rationale that is the basis for the "Regular Quadrilateral Function of E–Learning Engineering.

The next series of definitions that follow in six blocks (from Alpha to Eta) organized and categorized according to their specific applied function in relation to E–Learning Engineering. The definitions connect the neuroscience of E–Learning Engineering with the mathematical concept of the Regular Quadrilateral Function of E–Learning Engineering by providing a categorized compendium of relevant terms that are related to the foundational cognitive and brain-based learning concepts that provide the rationale for the development of E–Learning Engineering as a science.

4.1 [A] Alpha Block of Neuroscience Vocabulary

It is categorized as—Mental Function Terminology that supports E–Learning Engineering (extrapolated from Osler, 2016).

4.1.1 Brain-Based Learning

Brain-based learning refers to teaching methods, lesson designs, and school programs that are based on the latest scientific research about how the brain learns, including such factors as cognitive development-how students learn differently as they age, grow, and mature socially, emotionally, and cognitively (Hidden Curriculum, 2014).

4.1.2 Cognition

Cognition is a term referring to the mental processes involved in gaining knowledge and comprehension. These processes include thinking, knowing, remembering, judging, and problem-solving. These are higher-level functions of the brain and encompass language, imagination, perception, and planning (Cherry, 2014).

4.1.3 Cognitive Science

Cognitive science is an interdisciplinary field devoted to exploring the nature of cognitive processes, such as perception, reasoning, memory, attention, language, imagery, motor control, and problem–solving. The goal of cognitive science is to understand (1) the representations and processes in our minds that underwrite these capacities, (2) how they are acquired, and how they develop, and (3) how they are implemented in underlying hardware (biological or otherwise). Stated more simply, the goal of cognitive science is to understand how the mind works (Yale, 2010).

4.1.4 Epigenetics

"Epigenetics" refers to covalent modification of DNA, protein, or RNA, resulting in changes to the function and/or regulation of these molecules, without altering their primary sequences. In some cases, epigenetic modifications are stable and passed on to future generations, but in other instances they are dynamic and change in response to environmental stimuli. Nearly every aspect of biology is influenced by epigenetics, making it one of the most important fields in science (Zymo Research, 2014).

4.2 [B] Beta Block of Neuroscience Vocabulary

It is categorized as—specific Neuroscience Terminology that supports E–Learning Engineering (extrapolated from Osler, 2016).

4.2.1 Neuroanatomy

Neuroanatomy is the specialized study of human anatomy, the human brain, and the human nervous system. The first known written record of a study of the anatomy of the human brain is the ancient Egyptian document, the Edwin Smith Papyrus (Atta, 1999).

4.2.2 Neuroscience

Neuroscience is a branch of science that deals with the anatomy, physiology, biochemistry, or molecular biology of nerves and nervous tissue and especially their relation to behavior and learning (Neuroscience, 1963; Royal Society, 2011).

4.2.3 Neurogenesis

Neurogenesis is the process by which neurons or nerve cells are generated in the brain. The term neurogenesis is made up of the words "neuro" meaning "relating to nerves" and "genesis" meaning the formation of something. The term therefore refers to the growth and development of neurons (Mandal, 2014).

4.2.4 Neurobiology

Neurobiology is the study of the brain and nervous system, which are the cells and tissue that generate sensation, perception, movement, learning, emotion, and many of the functions that make us human (UC-Berkeley, 2014).

4.2.5 Neuroplasticity

Neuroplasticity, also called brain plasticity, is the process in which your brain's neural synapses and pathways are altered as an effect of environmental, behavioral, and neural changes (Cobarrubias, 2014).

4.2.6 Neurocardiology

Neurocardiology is the study of the neurophysiological, neurological, and neuroanatomical aspects of cardiology, including especially the neurological origins of cardiac disorders (Natelson, 1985). Neurocardiology refers to the pathophysiological interplays of the nervous and cardiovascular systems. It is an emerging field in medicine over the last decade (van der Wall and van Gilst, 2013). The constant communication between the heart and the brain have proved invaluable to interdisciplinary fields of neurological and cardiac diseases (Carrero, 2011).

4.2.7 Neurolaw

Neurolaw is an emerging field of interdisciplinary study that explores the effects of discoveries in neuroscience on legal rules and standards. Drawing from neuroscience, philosophy, social psychology, cognitive neuroscience, and criminology, neurolaw practitioners seek to address not only the descriptive and predictive issues of how neuroscience is and will be used in the legal system, but also the normative issues of how neuroscience should and should not be used (Eagleman, 2011). The most prominent questions that have emerged from this exploration are as follows: To what extent can a tumor or brain injury alleviate criminal punishment? Can sentencing or rehabilitation regulations be influenced by neuroscience? Who is permitted access to images of a person's brain? Neuroscience is beginning to address these questions in its effort to understand human behavior, and will potentially shape future aspects of legal processes (Petoft, 2015).

4.2.8 Neuromathematics

A new terminology first introduced in this research that pertains to the use of brain-based neuroscience in terms of mathematics grounded in the mathematical law of trichotomy (Osler, 2012a) exemplified in the advanced post hoc use of the Tri–Squared Test (see Table 1) to analyze and determine the trichotomous: (a) viability, (b) validity, and (c) verifiability of the research hypothesis (also the "alternative hypothesis" = [H_1]) and its associated outcomes (see Figures 1, 2, and 3, respectively) (Osler, 2015a).

4.3 [Γ] Gamma Block of Neuroscience Vocabulary

It is categorized as—Specific Neuroscience Terminology that measures E–Learning Engineering (extrapolated from Osler, 2016).

4.3.1 Neuromeasurement

The use of "Neuromathematics" to support the research on the use of neuroscientific solutions designed to enhance learning, in terms of "measurement" neuroscientific solutions produce and develop scales as "Neurometrics" that provide in-depth data on the level of efficacy of neuroscience solutions.

4.3.2 Neurodidactics

Neurodidactics, a relatively young discipline, represents an interface between neuroscience and didactics. Based on the findings of brain research neurodidactics provides principles and proposals for effective (brain-based) teaching and learning (Sabitzer, 2011).

4.3.3 Neuroeducation/Educational Neuroscience

Neuroeducation or Educational Neuroscience can be defined as a broad interdisciplinary and multidimensional field concerning matters pertaining to mind, brain, and education; it is grounded in a variety of interrelated fields, including (but not limited to) education, neuroscience, psychology, and cognitive science (Nouri and Mehrmohammadi, 2012).

4.4 [Δ] Delta Block of Neuroscience Vocabulary

It is categorized as—specific Neuroscience Terminology that describes E–Learning Engineering Construction (extrapolated from Osler, 2016).

4.4.1 Neuroengineering

The use of "Neurotechnology" to support the engineering of E–Learning as an educational solution.

4.4.2 Neurotechnology

Neurotechnology is any technology that has a fundamental influence on how people understand the brain and various aspects of consciousness, thought, and higher order activities in the brain. As the field's depth increases it will potentially allow society to control and harness more of what the brain does and how it influences lifestyles and personalities. Common place technologies already attempt to do this in games like "BrainAge" (BrainAge, 2006).

4.4.3 Neuropsychology

Neuropsychology is a branch of psychology that is concerned with how the brain and the rest of the nervous system influence a person's cognition and behaviors. More importantly, professionals in this branch of psychology often focus on how injuries or illnesses of the brain affect cognitive functions and behaviors (careersinpsychology.org, 2015). Neuropsychology studies the structure and function of the brain as they relate to specific psychological processes and behaviors. It is an experimental field of psychology that aims to understand how behavior and cognition are influenced by brain functioning and is concerned with the diagnosis and treatment of behavioral and cognitive effects of neurological disorders. Whereas classical neurology focuses on the physiology of the nervous system and classical psychology is largely divorced from it, neuropsychology seeks to discover how the brain correlates with the mind. It thus shares concepts and concerns with neuropsychiatry and with behavioral neurology in general. The term neuropsychology has been applied to lesion studies in humans and animals. It has also been applied to efforts to record electrical activity from individual cells (or groups of cells) in higher primates (including some studies of human patients) (Posner and Digirolamo, 2000).

4.4.4 Neurocognitive

Neurocognitive functions are cognitive functions closely linked to the function of particular areas, neural pathways, or cortical networks in the brain substrate layers of neurological matrix at the cellular molecular level. Therefore, their understanding is closely linked to the practice of neuropsychology and cognitive neuroscience, two disciplines that broadly seek to understand how the structure and function of the brain relates to perception defragmentation of concepts, memory embed, association, and recall both in the thought process and behavior (Green, 1998).

4.5 [E] Epsilon Block of Neuroscience Vocabulary

It is categorized as—specific Neuroscience Terminology that supports the impact of E–Learning Engineering (extrapolated from Osler, 2016).

4.5.1 Neurolaw

The research network on law and Neuroscience, supported by the John D. and Catherine T. MacArthur Foundation, addresses a focused set of closely-related problems at the intersection of neuroscience and criminal justice: 1) investigating law-relevant mental states of, and decision-making processes in, defendants, witnesses, jurors, and judges; 2) investigating in adolescents the relationship between brain development and cognitive capacities; and 3) assessing how best to draw inferences about individuals from group-based neuroscientific data (Research Network on Law and Neuroscience, 2014). The Neuroscientific Neuromathematical Brain–based Learning Model is next presented as the foundation of the study lending credence to brain–based application of advanced trichotomous research designs that holistically grounded in the trichotomous threefold nature of the brain (see Figure 2), the learning domains (cognitive, affective, and psychomotor), and the holistic yet trifold structure of the brain.

4.5.2 Neuropsychiatry

Neuropsychiatry is a branch of medicine that deals with mental disorders attributable to diseases of the nervous system. It preceded the current disciplines of psychiatry and neurology, which had common training (Yudofsky and Hales, 2002).

4.5.3 Neurology

Neurology (taken from the Greek word "Neuro" from which the term "neuron" is derived, and the suffix - logia meaning the "study of") is a branch of medicine dealing with disorders of the nervous system. Neurology deals with the diagnosis and treatment of all categories of conditions and disease involving the central and peripheral nervous system (and its subdivisions, the autonomic nervous system and the somatic nervous system); including their coverings, blood vessels, and all effector tissue, such as muscle (American Academy of Neurology [AAN], 2012).

4.6 [Z] Zeta Block

It is specific Neuroscience Terminology that supports the science of E–Learning Engineering.

4.6.1 Educational Science

Educational science is the study and application of solutions to improve and enhance the learning environment and learning in general (Osler, 2013a).

4.6.2 Eduscience

The term "Eduscience" which is a portmanteau of the two terms "Education" and "Science". Eduscience is solution–driven and is actively concerned with the transfer and dissemination of knowledge (Osler and Waden, 2012b).

4.6.3 Instructional Design

Instructional design, also known as instructional systems design is the analysis of learning needs and systematic development of instruction. Instructional designers often use instructional technology as a method for developing instruction (Merrill et al., 1996).

4.6.4 Learning

Learning is a step-by-step process in which an individual experiences permanent, lasting changes in knowledge, behaviors, or ways of processing the world (Goodfriend, 2014).

4.6.5 Emotional Intelligence

"Emotional Intelligence" [EI] is the area of cognitive ability involving traits and social skills that facilitate interpersonal behavior.

4.7 [H] Eta Block of Neuroscience Vocabulary

It is categorized as—specific Neuroscience Terminology that supports the research on E–Learning Engineering (extrapolated from Osler, 2016).

4.7.1 Tri–Squared Test

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 that is designed to be static way of 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 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 investigation takes place (Osler, 2012a).

4.7.2 Inventive Investigative Instrument

It also referred to as the "Triple–I", the base tool used to empower the researcher using the Tri–Squared test. To effectively use Tri–Squared in a research investigation one must first develop a series of "trichotomous categorical variables" based on associated "trichotomous outcome variables". This is the first initial and crucial step to using Tri–Squared as a valid, reliable, and objective means of analyzing data. Second, a specific "trichotomy-engineered" or "Inventive" (i.e., original) Investigative Instrument must be created and implemented based on the initial trichotomous categorical variables and outcomes. This insures 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 research environment. The "Inventive Investigative Instrument" can be psychometrically delivered as a test, qualitatively delivered in the form of a research questionnaire, provided anonymously as a survey, given as in–depth questions during an interview, or evaluated as a comprehensive metric via an assessment rubric. As long as the trichotomous categorical variables are measured according to the established associated trichotomous outcome variables then the research has merit within the strict confines and rigorous requirements of the Tri–Squared test (Osler, 2012a). Figure 5 presents a detailed illustration of the "Triune (or threefold) structures of the Human Brain" that are trichotomously "triotic" and aid in the development of E–Learning designed to engage and encode information using the neuroscience of online E–Learning solutions (Osler and Mason, 2015).

Figure 5 is the illustration from Osler, drafted after observing Feidakis and Daradoumis (2013). The multiple Trifold/Tripartite/Triplex structure of the Human Brain model illustrates the neuromathematic trichotomous neuroscientific organizations of the human brain (in terms of "Trilimbic" systemic structure: Hypothalamus/ Amygdala/Hippocampus, "Trilobic" structural groupings: a) Frontal/Parietal/Occipital; b) Frontal/Temporal/ Parietal; c) Frontal/Temporal/Occipital; d) Parietal/Temporal/ Occipital; etc., and "Tricerebral" systemic structure: Cortex/Limbic/Cerebellum) that lend to E–Learning Engineering for the express purposes of digital information delivery to transfer content subject matter knowledge (Using the "trine" methodology presented in Osler, 2013c) includes the following: The "neocortex" portion of the human brain that has the cluster of myelinated sheaths of neuronal axons as dynamically active brain structures involved in higher cognitive functions that trichotomously and holistically include: 1) advanced cognitive thought processes; 2) systemic and sequential functions that are involved in detailed planning; and 3) active procedures involved in the process of dynamic mental modeling and detailed sensory simulation(s). The internal "limbic brain" refers to the portion of the brain comprised of the basal

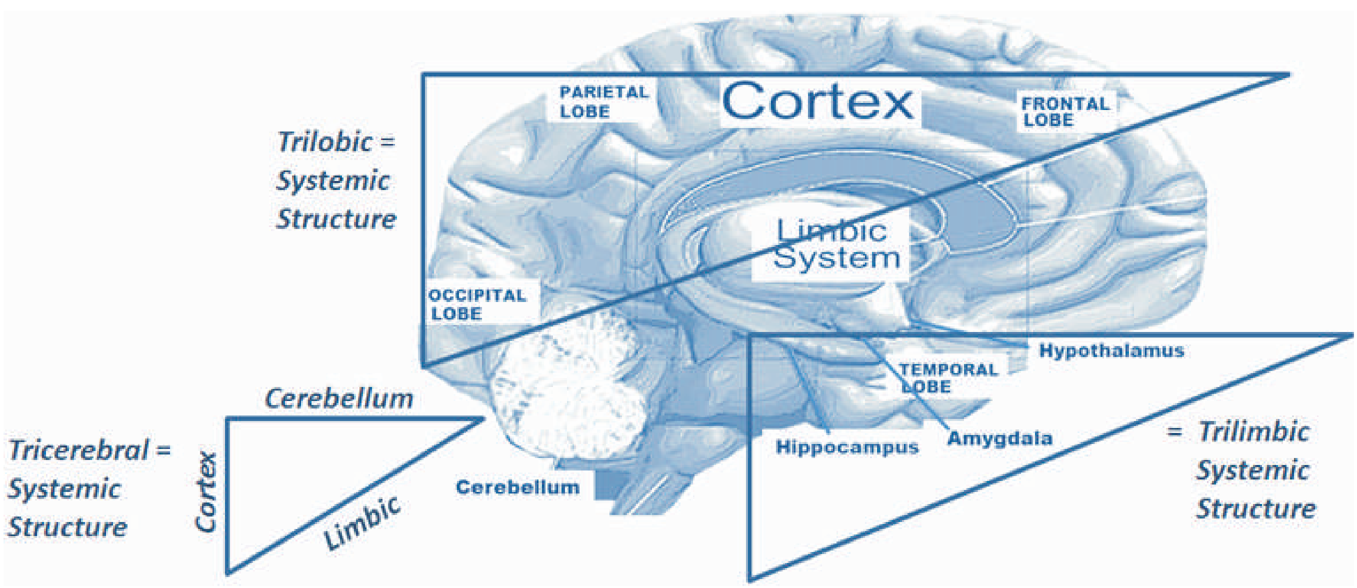


Figure 5. A Detailed Illustration of the Mathematical "Triotic" (also known as the "Triple Trichotomous Neuromathematic Triune Structures") of the Human Brain

ganglia (also more commonly referred to as the "basal nuclei") that comprise the multiple subcortical internal human brain nuclei and its internal structures that are neuromathematically and trichotomously in charge of advanced emotional intelligence represented by: a) advanced engaging teamwork through social interactions that can be expressed as parental nurturing and group-think mechanisms that are expressed as compassionate behavior; b) advanced interactive and empowering neurocordial metacognition typically expressed as external and mutual reciprocity; and c) advanced perceptive and perspective insight that creates internal interpretation of rapport expressed as external empathy and connectivity with others. The "cerebral cortex" portion of the human brain that has the cluster of "cortial columnal nicrocircuits" as the active and interspersed brain structures involved in cognitive holistic neuromathematic trichotomous functions that are not limited to but primarily include: ("delta") the active sensory perception of place [location]; ("nabla") the active sensory perception of the passage of time [happening(s)]; and the active sensory perception of matter [existence]. The trichotomous trifold structure of the human brain leads to the inclusion and rapid acceptance of the carefully constructed "solution" as neuroscience–based E–Learning provided by the university LMS or CMS ("Learning Management System" or "Course Management System") (Osler, 2016).

5. Relating the Regular Quadrilateral Function of E–Learning Engineering to the 4A Metric Algorithm through the Taxonomy of Process Education

The model that follows describes the "Taxonomy of Process Education" as an organizational metric that displays how a student grows (for the AMOVA statistic from Osler, 2015b). This model engages the Process Education four levels of student growth within its triangular confines (as "Emerging"; "Developing"; "Proficient"; and lastly "Accomplished"). These four areas are systemically equal to the four professional development criterion areas of the "Infometrics" (Osler, 2010a): "4A Metric" (see Table 1).

The Accumulative Manifold Validation Analysis (Figure 6) is the Taxonomy of Process Education in terms of Self–growth. It is designed to illustrate the sequential hierarchal (from bottom to top) steps that one matriculates through from "No Experience" (i.e. "Non–Existent") to a maximized "Accomplished" level indicating the penultimate level of achievement of "Professional Development". This particular taxonomy has universal applicability. The terms and associated values can be used to assess growth, disposition, content mastery, level of expertise, value of particular items, analysis of skill sets, the power relative to performance, the building of a specific set of measurement data (as in the

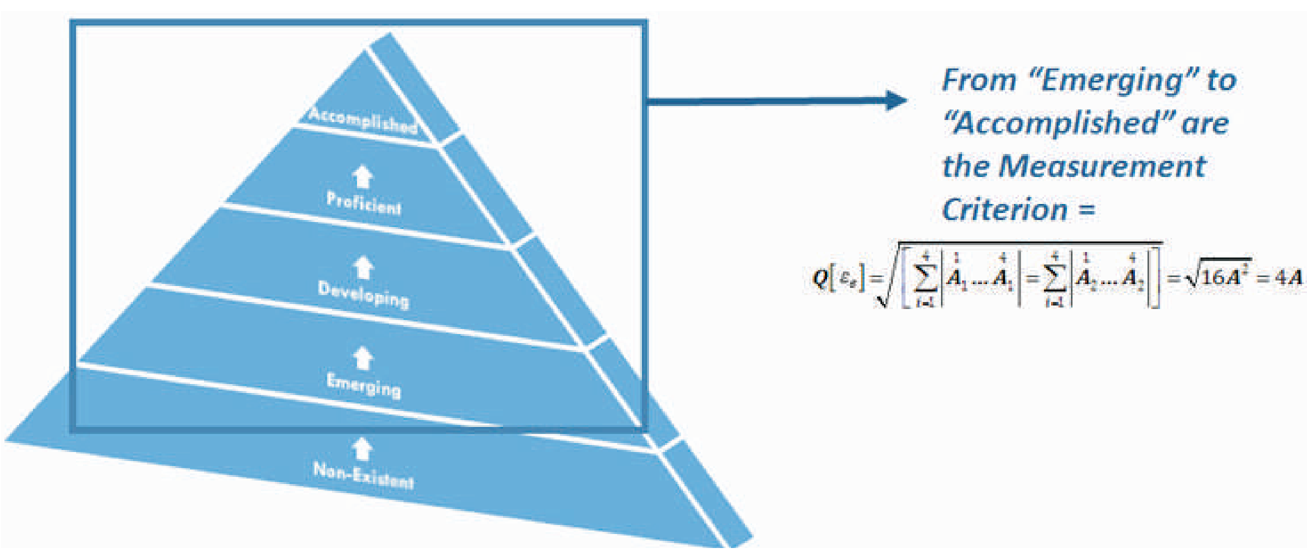


Figure 6. The Model of the Taxonomy of Process Education in terms of Self–Growth as used to Measure Professional Development

course design "4A Metric" from the book "Infometrics") (Osler, 2010a), the creation of implicit goals and objectives, and the amount of assigned value to a particular criterion. The quantitative numerical equivalent of these "indices" or "indicators" can be found in Figure 7, which displays the holistic "Learn to Learn Continuum Rubric" specifically for the Itemization of Accumulative Crosswise–Validation Analysis for the purposes of research instrumentation psychometric analysis. Figure 7 presents, "The Explicative Model of the Repetitive Weight Assignment Based on the Taxonomy of Process Education in terms of Self–Growth" (Osler, 2015b; Osler, 2016).

The Accumulative Manifold Validation Analysis (Figure 7) is designed to explain Figure 1 in terms of mathematical weighted outcome yield. It is sequential (from bottom to top) in terms of professional development and associated Self–growth. The base has an overall outcome of "Never" (equivalent to a mathematical term of "0.00"). Built into the weighted assessment of instrument item efficacy based on this diagram is the mathematical rounding of values to the nearest whole number (using the nearest integer function for the floor and ceiling function values to determine outputted weights per research instrument categorical cluster). This provides the pure value needed to determine each individual group (or categorical) quantifiable value that will be eventually used to determine the overall instrument efficacy as an "Accumulative Manifold Validation" coefficient based on the above numerical values. It is important to note that the diagram above is a continuation of the Taxonomy of Process Education from [PE] (Process Education) (Osler, 2015b) and is specifically designed in deference to Figure 6 (in terms of listed sequential titles and their associated mathematical weighted instrument item values). It is also important to note the floor and ceiling values in the model from the AMOVA [x]. Figure 7 illustrates the AMOVA Triostatistic (Osler, 2014) as a, "Sample of Weighted Means in terms of Statistical Accumulative Manifold Validation Analysis for Unequal Size Groups" (Osler, 2015b).

6. Recommendations and Future Implications

The narrative of this paper provides the rationale, purpose, and methodology for the "Regular Quadrilateral Function of E–Learning Engineering" that can be used for the design and development of online learning courses and serve as an ideal "Mechatronics E–Learning Engineering Model" that unites the principles of mechanics, electronics, neuroscience, and computing to generate a simpler, more economical, and reliable system in the

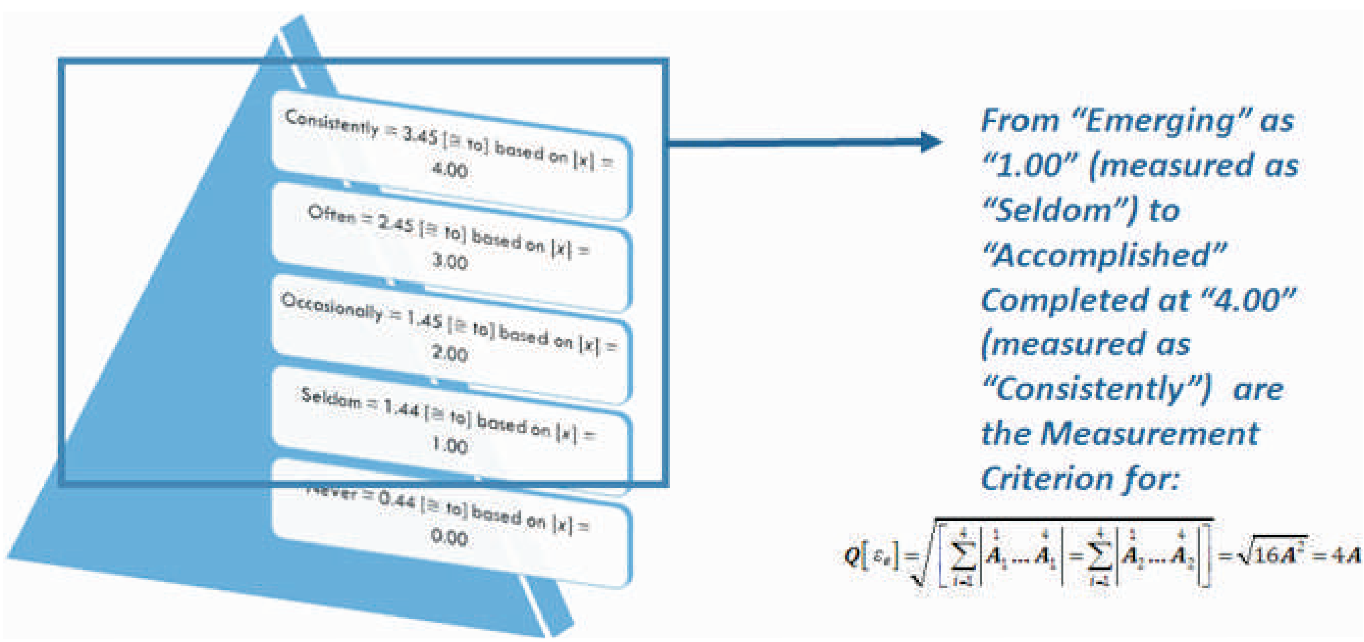


Figure 7. The Explicative Model of the Repetitive Weight Assignment based on the Taxonomy of Process Education in terms of Self–Growth as used to Measure Instrument Item Efficacy

online learning environment to create an ideal form of "Meta-Competency-Based Education". Future research using the function should focus on course design efficacy (and thereby provide a girth of information regarding the overall utility of the function in practice via the prescribed E–Learning environment). Such data could provide educators and administrators the grounds for meeting the needs of their learners in a rapidly changing world (via educational opportunities that are designed with workforce development, professional development, and training at the forefront of the course design process).

The author therefore recommends the following in deference to the information:

- That more research be conducted with the function as a model to substantiate its applicability.
- As new and novel approaches are developed using the function, they are actively shared via conferences and published research to build upon existing best practices and teaching strategies.
- That the researchable applications and discoveries regarding this particular function as a model are regularly documented so that the novel research innovations can be readily applied towards the creation of a new set of standards for the online learning community and the field/practice of distance education.

Conclusion

The "Regular Quadrilateral Function of E–Learning Engineering" presented in this paper ultimately in practice provides the logical foundation for an engaging and empowering online learning methodology as a model designed to support learners in their pursuits towards a successful life and future career. As an online learning information delivery procedure the Regular Quadrilateral Function has its foundations in cognitive neuroscience and active human brain-based neuroengineering. The function clearly defines the 4A Metric Algorithm that can be applied in a variety of traditional and non-traditional educational settings. The 4A Metric completely integrates curricula from a professional development perspective to enhance the retention and transfer of subject matter data. The use of the function allows the instructor to rapidly monitor and measure student learning at every level as they matriculate through the course. As such, the 4A Metric as a teaching and learning solution, factors into its sequencing the four learning domains (affective, cognitive, psychomotor, and social) in the context of authentic and active learning. This thereby, enhances the learning experience and productively creates a timely and relevant student learning experience that has immediate impact towards their respective careers. In addition, student learning is self-pace and retains an extremely high "locus of control" placing the onus for professional development on the student and the facilitation of supportive experiences in the hands of the instructor. Thus, through the Regular Quadrilateral Function of E–Learning Engineering: learning becomes much more personal; sharing and collaborating becomes the classroom cultural norm; the process of discovery thereby enhances knowledge; and the learner is placed at the forefront of the course. This in turn creates an "instructional mindset of student growth" as the new distance education teaching standard that is at the front of online learning and at the forefront of innovative online instruction.

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