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THE LAW OF PERFORMANCE AND EXCELLENCE IN RESEARCH

A COMPREHENSIVE, PRECISE, DYNAMIC, AND QUINTESSENTIAL GUIDE TO SUCCESSFUL CAREERS IN SCIENCE, MATHEMATICS, ENGINEERING, AND TECHNOLOGY (SMET) FIELDS AND OTHERS

"Luck is what happens when preparation meets or makes, recognizes, and acts on opportunity."

This paper first identifies essential attributes (knowledge, skills, experience, behavioral traits) that undergird successful careers in SMET and other fields. It then presents the Power Law of Performance and the Law of Performance that assert that any individual not suffering from a severe physiological or mental impairment can excel in any discipline of study, including SMET fields, and can secure successful and rewarding research-based careers. *Devoting adequate time to learning and to the practice of research, according to the Law of Performance or of Practice (LP), is the a condition that applies to every individual—irrespective of "perceived" notions of "innate" abilities.* Using meta thinking, we attempt to warn the reader about common errors and misconceptions related to careers, in general, and the ones in SMET, in particular. Specifically, the dynamic or ever-changing nature of work, market, and related environments is a fundamental reason for acquiring the versatility bestowed by research performance and skills. In the context of changes that are becoming faster, due to developments in SMET, research proficiency is both a warranty for continued employment, by virtue of its versatility, and of happiness, due to its many reward$ that include money and very much more. *Hence, beginning immediately and continuing to prepare oneself is the key to excellence.*

INTRODUCTION

While we have no need or intention to sound pretentious, we are compelled to warn the reader that no less than total concentration and the harnessing of most intellectual attributes are needed to appreciate fully what follows. Given the complexity of the issues, we had to utilize universal and powerful principles to address the topic in a comprehensive fashion. We did so by avoiding minutia that change with time and by focusing on overarching principles, trends, and patterns that are germane to the dynamics of human activities—from antiquity to the present and beyond. The size of this paper dictates that the reader be referred to current and future sources that delve into the details of careers in many professions. A second reason for this referral stems from the fact that these details change continually. The "smart" approach, in such instances, is to get the permanent sources of information as opposed to a specific piece of

information that may be obsolete in a year or less [1]. The rest of this article follows the order intimated in the abstract.

THE "IMPERATIVES" FOR A SUCCESSFUL CAREER (IN RESEARCH IN SMET)

Language and Communication Skills

A detailed analysis of the tasks a person performs at most jobs reveals the following: **(a)** the need to read and to understand information from a variety of sources, including written and oral sources, diagrams, videos, etc.; **(b)** the need to transmit information to others in a flawless fashion—this perfect transmission requires that the information possess the following qualities: *accuracy, precision, completeness, coherence, and clarity (i.e., APC³)*; the volume of information to transmit and the need for continuity often dictate that a flawless transmission include *written materials*; **(c)** the fact that learning is cumulative and that the more one knows about a subject or task, the better and faster one can learn additional, related materials, topics, processes, or instruments; and **(d)** the fact that thinking, after all, is done in a language.

In the case of a research careers in competitive sectors (public or private), having enough knowledge and experience to read and understand the literature and being able to write articles that pass peer or departmental reviews are simply non-negotiable. Further, the continual changes noted above require, to avoid obsolescence, that one follow new developments in *a regular fashion*—through professional magazines (i.e., science, nature), journals, web sites, books, and conferences. To do so, however, demands competitive language and communication skills (i.e., reading, writing, listening, and speaking). These skills, that are acquired and enhanced through practice, constitute the first "imperative" for a successful career. The implication of this everlasting reality is that there is no substitute for the mastery of the applicable language and of the utilization of the key qualities of information (i.e., APC³). This mastery has to include that of the grammar, vocabulary, syntax, etc. in that language—as verified by standardized tests as opposed to self-misleading perceptions of mastery [see American College Test (ACT), the Graduate Record Examination (GRE), and other tests]. *Consequently, from pre-K to the Ph.D. and beyond, very well-informed individuals regularly and consistently work to hone their language and communication skills. (Well, parents have to ensure the regular and consistent learning up to middle school, in many cases.)*

Homework: As all good professors, the only way we can verify that learning occurred is to close the feedback loop. So, the homework to be done for the above chapter on "competitive language and communication skills" is the following. Conduct three or more interviews of *successful* researchers and professionals (government, academia, or in industry). Design and ask ten (10) or more questions aimed a determining the extent to which language and communication skills play a role in their work. Hint: Do they get information from others? Do they transmit information to others? Do they write proposals? Do they have to follow guidelines or procedure manuals? Do they write strategic or other plans? Do they write reports or any kind? Do they conduct reviews (that require extensive reading)? Do they publish? Do they receive or send letters, memoranda, or electronic mails? Without APC³, how do they avoid misunderstandings of all kinds—particularly when vital or critical issues are at $take? To what extent have their communication skills (i.e., language and APC³) contributed to their advancement or promotion?

How could they function successfully *without* the communication tasks noted above? Please note, in these web and e-mail days, that many of these interviews could be conducted at a distance!

Mathematics (the language of Science and Technology)

Numbers and mathematics, believe it or not, have been inextricably woven into the fabric of human activities from the dawn of humanity to present. Further, scientific and technological developments that partly rest on mathematics are rendering the master of some mathematics an inescapable condition for successfully fitting into current and particularly future societies. This assertion could be substantiated, at an elementary level, by looking around oneself. What do you see, hear, or feel that can be totally characterized without using mass (numbers), shape (numbers and geometry), volume (numbers and geometry), or intensity (as of light or of sound, numbers)? At the intermediate level, motions of all kinds require numbers and mathematics for a complete description. It will require more than one book to describe the mathematics that went into the design and production of tools of all genres [i.e., kitchen appliances, pieces of equipment in hospitals, cars, airplanes, computers, sophisticated software products performing formidable operations, etc.]. **The ubiquity of mathematics is the reason it is the second "imperative" for a successful career (and for simply fitting functionally into present and future societies).**

The direct and obvious consequence of the above status of mathematics is that from pre-K to the Ph.D. and beyond, well-informed individuals work regularly and persistently to acquire, maintain, and enhance their mastery of mathematics. This mastery, as in the case of language and communication skills, is to be determined by objective measures and not delusional perceptions or ideas of mastery. Be kind and inform your younger relatives and your descendants that a solid mathematics course (or more) should be taken every year of high school—up to calculus, at a minimum. Inform parents you know that Algebra I should be taken in the 8th grade, at the latest. In college, the calculus series is a necessity, from calculus I to III. (Pre-calculus courses may need to be taken, before the first college calculus, if the high school mathematics was not adequate; before this paper, it is presumed that many people, unfortunately, did not know the utter seriousness with which mathematics has to be taken at all grade levels.) SMET undergraduate students should generally take, in addition to the calculus series, differential equation. Physics majors should add complex variables, vector calculus, and college level linear algebra. We provide below the general way of determining the needed mathematics courses for any major.

Mathematics is the language of science and technology, period, understanding it or not. Unfortunately, one has to know a great deal of science and technology to know appropriately the extent to which this assertion is true. So, a student is generally at a loss as to what mathematics courses to take and in what sequence—given that she/he does not know enough to know. The simple solution to this conundrum is to consult seriously (not in passing) with successful faculty members, researchers, engineers, technologists, medical doctors, etc. while one if far away from their level. (We advise doing it in the freshman or sophomore years if possible.) A synthesis of the responses from these professionals as to what mathematics courses to take and in what order will provide a clear road map. The

reason this is critical rests in part on the fact that knowledge is often sequential or taxonomic in mathematics, i.e., Algebra I is needed before Algebra II, irrespective of one's "innate" abilities. *(Remember that no "innate abilities" guarantee championship titles in the Olympics, the National Basket Ball Association (NBA), the National Football Association (NFL), tennis, golf, etc., without extensive and sustained practice over time. Similarly, it takes studying, reviews, practice to excel in intellectual endeavors—so says the law of performance discussed below!)* Oh, some people do not understand that most difficulties in a mathematics class, *for someone who is studying appropriately*, are due to an inadequate background and not to any lack of innate "smartness" as explained below with the law of performance.

Fundamentals of Probability and Statistics

Our third "imperative" is "fundamentals of probability and statistics," a part of mathematics. While space limitation does not allow us to provide details on this affirmation, its importance is the reason it is addressed here by itself. This importance includes system failure issues in engineering, the plethora of probability and statistical systems in physics, and the inescapable presence of probability and statistics in dealing with large numbers of anything (people, electrons, atoms and molecules, nuclei and their decay processes, the parts in a complex system, etc.). Understanding that statistical correlations have nothing to do with causation, in general, may save one from falling under the spell of false claims by ill-informed sources. The complexity of issues in science, technology, and in society makes it patently necessary that a leader, lawyer, scientist, engineer, well-meaning politician, etc., understand the fundamentals of probability and statistics in order to avoid doing the opposite of what she/he meant! The June 15 issue of *Science* reads in part, on page 1971 [2], *"statistics have become indispensable to scientists in almost every discipline."*

If you find the little book entitled "How to use and misuse statistics," or a similar one, you will have illustrations of the above point. The overall need for "probability and statistics" and the *need for it in most graduate programs in SMET demand that one take at least an introductory course in "probability and statistics" before completing the Bachelor's degree program.* In some SMET departments, the above introduction is provided in some courses (i.e., statistics and thermodynamics, in the case of some physics departments). The online textbook by David Lane of Rice University [2] is an ideal self-help tool for an introduction to the basics of statistics. The online, interactive demonstrations of key concepts are noted by *Science* as a distinction of this new resource that was developed in part with funding from the National Science Foundation (NSF).

RESEARCH PROFICIENCY: ULTIMATE VERSATILITY, LIFELONG EMPLOYMENT WARRANTY, ETC.

The process of creating new knowledge, i.e., research, is a very complex one. To begin with, it generally demands "competitive language and communication skills" that partly enable life long learning. In SMET, it also demands the mastery of some fundamental mathematics: the scope and depth of the needed mathematics vary with SMET fields, the experimental or theoretical nature of the work, and other factors. Please recall that without some serious mathematics, one cannot even read many publications in SMET let alone add to them.

Research proficiency or expertise includes knowledge, comprehension, application, analysis, synthesis, and evaluation. These six intellectual attributes are known as categories of the Bloom taxonomy of the cognitive domain. As noted above, research proficiency demands "competitive language and communication skills" and "adequate knowledge and skills in some areas of mathematics"—particularly in the case of SMET fields. The performance of research in SMET often follows *the scientific method* that can be written in a variety of ways. Our succinct rendition follows: (1) observations and note taking in accord with APC^3; (2) search for explanations in the scientific literature and note taking according to APC^3; (3) design of experiment or construction of a theory—accompanied with written notes that follow APC^3; (4) conduct of experiments or applications of a new theory—with detailed notes obeying APC^3; (5) analysis of findings (from experiment or theory) and comparison with observations and established, theoretical or experimental knowledge—documented in writing that obeys APC^3; (6) writing report and publishing findings—while paying special attention to accuracy, precision, completeness, coherence, and clarity (APC^3) for every proposition or statement; (7) in case of problems in a step (or if the comparison in step 5 does not lead to agreements), then go back to (1), (2), (3), or (4) to (a) look for possible oversights or errors or (b) formulate a new hypothesis, design a new experiment, or to construct a new theory. It must be clearly understood that while high school and other discussions of the scientific method do not generally include the extensive, detailed, and complete writing according to APC^3, this writing is the hallmark of an understanding of the actual scientific process or method. Laboratory journals or research journals or notes, the latter for theoreticians, are indispensable in the actual practice of research. (Let the hypocentral need for *accurate, precise, complete, coherent, and clear notes* be another reminder of the indispensable role of "language and communication skills" in SMET and in most intellectual endeavors.)

Once the research questions are posed, most research can be thought of a "problem-solving"! Indeed, the only difference may be that some research problems may require months or years to solve completely while some mundane or classroom problems can be solved rapidly. Essentially, however, research is just a form of problem-solving. Some of the researchers we admire the most, besides the ones in SMET, include law enforcement and forensic professionals. For the latter groups, *the critically of paying attention to every detail and of recording every detail cannot be overemphasized.* Indeed, in this area, some data or information can be lost forever—making a solution to the problem extremely difficult if not impossible. For training oneself in problem-solving, i.e., some aspects of research, the reader is urged to consult "A Problem-Solving Paradigm (PSP)" by Bagayoko, Kelley, and Hasan [3], in *College Teaching*. For the first time to our knowledge, there is finally a comprehensive way for teaching or learning problem-solving. The mental attributes or dispositions involved in problem-solving are often the same ones for research—even though the specific, *technical knowledge and skills* for research in different fields could be vastly different.

We assert that research proficiency through the process described above is applicable to most human activities! In particular, the actual practice of research in SMET fields and in others follows our seven steps rigorously. Hence, research proficiency acquired in a discipline, except for some specific technical knowledge and skills, is transferable to research processes in many others. This transferability (i.e., versatility) is a key

reason that research proficiency is our fourth "imperative" for a successful career in SMET and other fields. When a division in a major corporation is closed, for any reasons, professionals with research proficiency will generally be transferred to other divisions or will easily find other research-based jobs in the private or public sectors. There lies the reason that research proficiency is lifelong employment warranty.

In the event the reader does not know, we should underscore the loss of employment by individuals with no research experiences or skills, upon the closure of their divisions, and the great difficulties they have in finding comparable positions that pay adequately. The increasingly rapid developments in science, mathematics, engineering, and technology are fueling the changes in the job markets. *[Unfortunately, some are not still getting it that good salaries without research skills are very often traps; if and when robots, new technologies, or new knowledge render their positions irrelevant, they will find themselves in debt (house, car, and other notes) and without a meaningful prospect for employment or self-employment.]*

The above point is very difficult to understand. The difficulties stem in part from the fact that some parents or acquaintances without research experiences seem to have done or to be doing rather well! *A reason* for that situation is that when they entered the workforce, the rate of changes was very slow compared to the picture today: there were not cellular phones, Internet, genome maps, sophisticated transportation means, nano-materials, global warming, or space tourism, etc. It is therefore critical *"not to move forward to the past." A second reason* that can lead to grave errors is explained by statistics. The "impressions about some doing very well without research expertise" are very often ill-informed. *Yes, exceptions are not rules. Let the rules guide you.* Indeed, with some basic knowledge of statistics, one can see that anecdotal cases, however glittering or numerous they may be, are never to be taken as central tendencies (a statistical concept) without a full knowledge of the total picture of the groups or systems under study. In other words, the relative success of a few high school or college dropouts, for the cautious thinkers, must not overshadow the dead-ends faced by the great majority of them! *Always remember and be guided by these two reasons.*

Another illustration of the *exception and rule* scenario for you and your peers or relatives follows. Knowing a few NBA or NFL draftees who did very well, financially and otherwise, is one thing; choosing basket ball or football as your profession is another. While the expanding nature of the job market in SMET and related fields can accommodate SMET graduates, particularly the ones with research skills, the NFL or NBA teams, in fixed numbers, cannot employ all college graduates who are good basket ball or football players! To understand this further, just calculate the total numbers of players on the NBA and NFL teams and compare them to the total numbers of college seniors on college teams! Do not stop there, remember also that most teams already have a full roster and only take a few draftees in a given year!

THE LAW OF PERFORMANCE:
Adequate practice begets excellence in school, college and in research—the same way it does in sport!

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The Power Law of Human Performance or of Practice (PLP) states that the time (T) it takes an individual to perform a given task decreases as the number of times (N) the individual practiced the task increases. In mathematical terminology, the law is [4]:

$$T = A + B\,(N + E)^{-p} \quad \text{or} \quad T = A + B/(N + E)^{p}$$

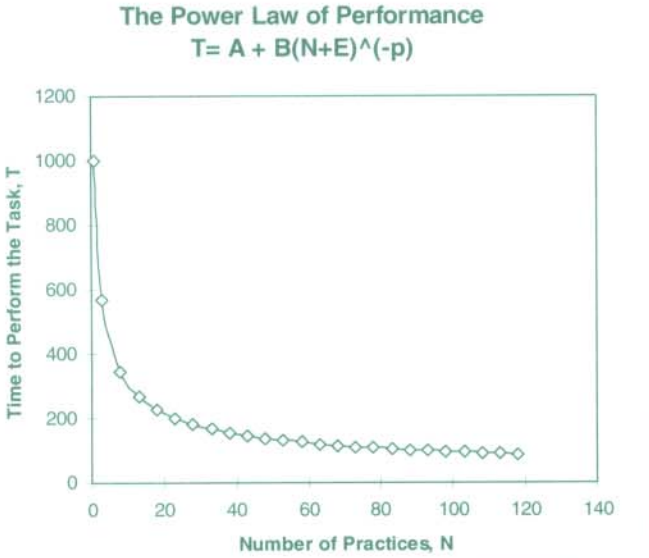
where A, B, E and p are constants that vary (a) with the task at hand and (b) with the individual performing the task. A represents a physiological limit. B and E partly denote prior experiences before the beginning of the practice sessions, and p is the learning rate. In other words, the law states that *"practice renders perfect."* This law applies to the performance of *sensory-motor (or athletic), creative (or artistic), and cognitive (or intellectual) tasks.* The shorter the time T to perform the task - *completely and correctly* - the higher the level of proficiency. *Hence, as the number of practices increases, so does the proficiency of the individual.* The figure below graphically shows the plot of the above expression for a problem-solving task.

The dramatic impact of this law becomes apparent when one considers its application to several tasks over several days, months, and years. Then, it becomes clear that *genius is mostly the result of sustained, competitive practice.* The same way adequate practice, at an adequate scope and depth, is needed for the making of Olympic, National Basketball Association, National Football Association, and Major League Soccer champions and for the making of musicians and artists, the same way it is needed for the making of science, engineering, and mathematics scholars and researchers in any discipline.

Further, this law is implacable. It applies whether one likes it or not! It applies to the refinement or the enhancement of the *teaching*, mentoring, research, and writing skills of a teacher or faculty member! The law implicitly addresses the need to strive for quality! Indeed, practicing bad grammar, incorrect mathematics, etc. renders one very good at them! So, even though the power law and the law of performance do not explicitly factor in the issue of quality, they do so indirectly.

The compound law of human performance, or simply the *law of performance* (Education, Vol. 115, No. 1, pp. 31-39, 1994), is the convolution of the power law of performance as simultaneously applied to several tasks over a long period of time. The main difference between the *power law* and the *law* is that the former follows a simple equation that involves an exponent or power (i.e., p) while the mathematical form of the latter is yet to be determined. *The quintessential point here, however, stems from the fact that according to the law of human performance, the abilities, skills, and attributes (of individuals) that are meaningfully engaged and challenged in and outside the classroom (as by lessons, assignments, research)—from pre-K through graduate school and beyond — are the ones that will develop!* The law of human performance provides the scientific basis for high expectations for all students! Professional mentoring, as defined elsewhere by Bagayoko (http://www.phys.subr.edu/timbuktu.htm), provides an almost fail-safe strategy for promoting the academic excellence of all students (female or male, minority or non-

minority, young or mature). Student retention, on-time graduation, and their success in graduate school are partly by-product of the quest for proficiency and excellence— through competitive teaching, learning, and research. *It is critical to note that the same way the LP applies to the cognitive domain, the same way it applies to non-cognitive (i.e., behavioral) variables: Character and study habits are also molded through practice!*



Newel, A. and P. S. Rosenbloom (1981)." Mechanisms of Skill Acquisition," Edited by Anderson, J. R. Hillsdale, N. J.: Erlbaum

DIRECT APPLICATIONS: the need to plan and to execute (i.e., practice)

By linking prior experiences or practice to the speed with which one learns or discover new knowledge, the law of performance states that our levels of achievements in the classroom, in athletic events, artistic endeavors, and in research are determined for the most part by us—given that **we decide every day on the time we devote to various tasks**! Further, the law of performance is a great liberator that says that there is nothing wrong in not being an expert in a subject or a task at once—no one is! Hence, consulting experts, getting the appropriate materials, doing adequate practice is all that is needed.

Each and every one of the *imperative proficiencies* described above (*i.e., in language and communication, mathematics, probability and statistics, and research)* is acquired through practice! And no one should forget, in light of the meaning of B and E, that difficulties in mathematics, science, engineering, and technology courses are very often caused by an inadequacy of background, practice, prior experiences, or of studying. In fact, for individuals not suffering from a severe physiological or mental impairment, that is the case.

In particular, research expertise often requires many years of practice. Hence, the sooner one starts performing research, the better it will be. *If you missed the opportunity in high school, make certain that you start as soon as possible in college.* (And if your institution or department does not understand this point, then find one that does and that has good faculty research-mentors.) Of course, the law of performance says to remember, at the beginning of new learning experiences, that the feeling or impression of being lost is a sign that one started learning new things! (Oh, yes, I know, many students erroneously take it to mean that they are not "smart" enough. Please explain the facts to them.) At conferences, the best experts do not know or understand everything—including the ones making the presentations! So, you are not alone. And, these experts know that research questions can be found, in a quasi–infinite number, in the professional and technical literature (magazine, journals, books, etc., on paper or in electronic media) and not by looking at the sky or ground. *The experts keep on learning; according to the law of practice, that is how they built and continue to enhance their expertise!*

We explained above the need to consult several faculty members, peers, experts, etc. in order to determine the background that is needed for career options one is contemplating. The same is true for courses one has to take in college or in graduate school. Hence, there is a critical need to plan professionally, in writing. Only through such a planning can one determine indispensable background or experiences and take the needed steps to acquire them — through regular and persistent efforts. *"A college portfolio"* should be prepared by 10th or 11th grade students; *"a graduate school portfolio"* should be prepared by college sophomores or juniors; and *"a research career portfolio"* should be prepared by every graduate student. The preparation of these portfolios, first and foremost, brings to light needed credentials, background, experiences, etc. when there is still time to acquire them. See Reference [1] for an example of a "college portfolio" that can be easily adapted to design other portfolios noted above.

CONCLUSION

At the beginning of this presentation, I noted that it had already been delivered by Dr. Norman Y. Mineta, the honorable U.S. Secretary of Transportation. It has also been reiterated by Dr. Henry Ponder, the President of NAFEO. Indeed, these officials just addressed you and underscored the fact that the opportunities in science, mathematics, engineering, and technology are almost limitless. Paraphrasing Dr. Mineta's statement, we see that the sky is the limit in transportation alone. (And, if you ask NASA, even the sky or ocean floor may not be limits!) We added that many interdisciplinary areas offer more opportunities than can hold on a single list. Some of these areas include Earth Science, Energy and Environmental Science, Global Climate Change Research (with possible application to other planets), Materials Science, Engineering, and Technology (MSET), Genomics and the nascent Proteomics, Agriculture Science and Technology, Biomedical Research, and many others. Honorable Dr. Mineta and Dr. Ponder acknowledged your present accomplishments, including the research you already performed and the technical presentations many of you will make in the following session.

In light of the foregoing, it is my deepest hope that you will fully utilize the content of this provocative address not only to take your accomplishments and preparedness to new heights, but also to inform many other people, including your peers, young relatives, and your descendants. *"Luck is what happens when PREPARATION (through effort or practice as per the LP) meets or makes, recognizes, and acts on opportunity."* We are counting on you.

ANNOTATED BIBLIOGRAPHY

[1] http://www.phys.subr.edu/timbuktu/careers.htm This site pro-

vides a listed of hot links to extensive information on careers in science, mathematics, engineering, and technology. Sources include the American Institute of Physics, the American Physical Society, the American Chemical Society, the American Mathematical Society, the American Psychological Association, etc. Available information include: how to prepare for a career, interview tips, resume preparation, free posting of a resume, etc. (Also visit the site of the American Association for the Advancement of Science: http://www.aaas.org/)

[2] Science, Vol. 292, No. 5524, Page 1971, June 15, 2001. See *"Scoop on Stats"* in the Section on Netwatch. The web site on a recently developed online statistics textbook, by David Lane at Rice University, is provided (http://www.ruf.rice.edu/~lane/rvls.html).

[3] *"A Problem Solving Paradigm,"* D. Bagayoko, Ella L. Kelley, and Saleem Hasan. College Teaching, Vol. 48, No. 1, pp. 24-27, 2000. Understanding, knowing, and paying attention to the five (5) categories involved in problem-solving is a prerequisite for properly teaching or learning it, by design. These categories are *knowledge, skills, resource, strategy/experience, and behavioral bases* of problem solving proficiency or expertise.

[4] *"The Dynamics of Student Retention: A Review and a Prescription,"* D. Bagayoko and Ella L. Kelley. Education, Vol. 115, No. 1, Pages 31-39, 1994. This paper elaborates extensively on the Power Law of Performance and it introduces the compound law (or simply the Law) of Performance. The article utilizes the law of performance to explain the creation of educational, research, and professional value-added (high academic achievements and expertise).

[5] Jaime Escalante, in our view, rigorously applied the law of performance when he worked with his Hispanic American students to make calculus geniuses out of them. Please think about his equation that says the following: **"determination + discipline + hard work = success."** Anyone who understands and heeds this equation will be following the law of practice by devoting significantly large amounts of time to learning and research tasks at hand, and that over months and years.

[6] *Writing for Success: A User-Friendly Manual for Effective Communication,* By Professor Ora Plummer and Dr. Diola Bagayoko. Publisher: McGraw Hill. ISBN: 0-07-154196-9 (1998). A copy of this book was provided to student participants of this 2001 NAFEO High Tech Expo with the hope that it will be *persistently* used for "continuous improvements" of language and communication skills. Please refer to the first "imperative" discussed above. [Note: Dr. Bagayoko does not make any money from sales of this book; he donated his share of the royalties to the Southern University Foundation for the purpose of establishing and endowment for the Timbuktu Academy.]

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