Distributional Analytics for Large Scale Pedagogical Effectiveness: The CVIF Dynamic Learning Program Experience[1]

M. Victoria Carpio-Bernido and Christopher C. Bernido

Research Center for Theoretical Physics, Central Visayan Institute Foundation
Jagna, Bohol 6308, Philippines, and
Department of Physics, University of San Carlos, Cebu City 6000, Philippines

ABSTRACT

We highlight the vital role of distributional analytics and correlation studies for ensuring effectiveness of a learning program in achieving well defined educational targets. Since pedagogical efficacy and effectiveness are of extreme importance in preparing young people for the complex demands of the 4th Industrial Revolution, we then cite selected elements of the CVIF Dynamic Learning Program that are geared towards addressing such demands.

I. CONTEXT AND MOTIVATION

Distributional analytics heavily guided the conceptualization, design and implementation since 2002 of the Central Visayan Institute Foundation (CVIF) Dynamic Learning Program (DLP) [1]-[3]. Data sources were in-school and national assessments starting in the School Year (SY) 1999-2000 when we started managing the school.

Why the emphasis on statistical distributions and probability curves? A study of educational theories and popular strategies revealed, and still reveals, wide discrepancies between pedagogical theories and real classroom issues that we encountered. Moreover, the literature abounds with reports of falling short of educational targets especially in the disciplines of science, technology, engineering and mathematics (STEM) in spite of big budget allocations [4]. There are schools in nations that achieve high scholastic goals but only at high financial cost at national and family levels, and high social and physical cost for the young learners and their families, including drastically diminished sleep time. As early as 1999 then, it was clear that there was a need for recalibrating a trajectory for educational management of our school depending on neither accepted dogma nor fashionable strategies. There was a need to start with a clean slate devoid of arbitrary assumptions and tenuous pedagogical axioms. Following the highly successful models of scientific research and development in the fields of hard natural sciences and medicine (e.g., the gold standard in medical research), we put premium on actual observations in real classroom situations and empirical data on measurable learning outcomes diligently accumulated and analyzed. We admitted the inherent stochasticity in learning outcomes from the micro (individual) to the macro (cohort) levels. In short, we 'let the numbers tell the story' since 'all opinions are equiprobably true or false in the absence of evidence.' However, mere accumulation and first-level statistical analysis of data would not be sufficient for robust inferences that could translate into significantly improved learning outcomes for a significant majority of every cohort that graduates from the school. Moreover, ethical issues preclude much of the methods of scientific research requiring control and experimental groups. This is where insights from big-picture big-data distributional analysis become important for insights and directional guidance.

As illustrative example, consider Figure 1 which shows trends in the performance scores of CVIF students in the National Career Assessment Examination (NCAE), formerly National

[1] Invited presentation, "*14th National Convention on Statistics*," 1–3 October 2019, Crowne Plaza Manila Galleria, Ortigas Center, Quezon City.

Scholastic Aptitude Test (NSAT), administered by the Department of Education (DepEd)[2]. The evolution of the skewed distributions shows a marked shift towards higher performance scores. The approximately bi-modal distribution for 2006 is particularly interesting since the point could mark a bifurcation: fast learners break away while challenged learners remain in the low-performance domain. Indeed, historically, such splitting had been observed in a number of schools which implemented independent learning fashionable in the country's urban areas in the 1980's and early 1990's. However, this possibility was already taken into consideration during conceptualization of the CVIF DLP, so there were built-in safety nets and boosters to avoid the splitting. Indeed, by the subsequent tests, there was observed merging and skewing for the desired heavier tails at the high performance domain. Moreover, the graphs show a truncation of the tail at low performance scores by 2010. This is significant since the CVIF is highly inclusive; it is not an exclusive science high school with competitive entrance examinations. At the CVIF, entrance examinations are for sectioning and scholarship purposes only and there have been cases of nonreaders and those with learning disabilities. Moreover, CVIF class sizes are within the 35 – 59 range for Junior High School (JHS), Grades 7 – 10.

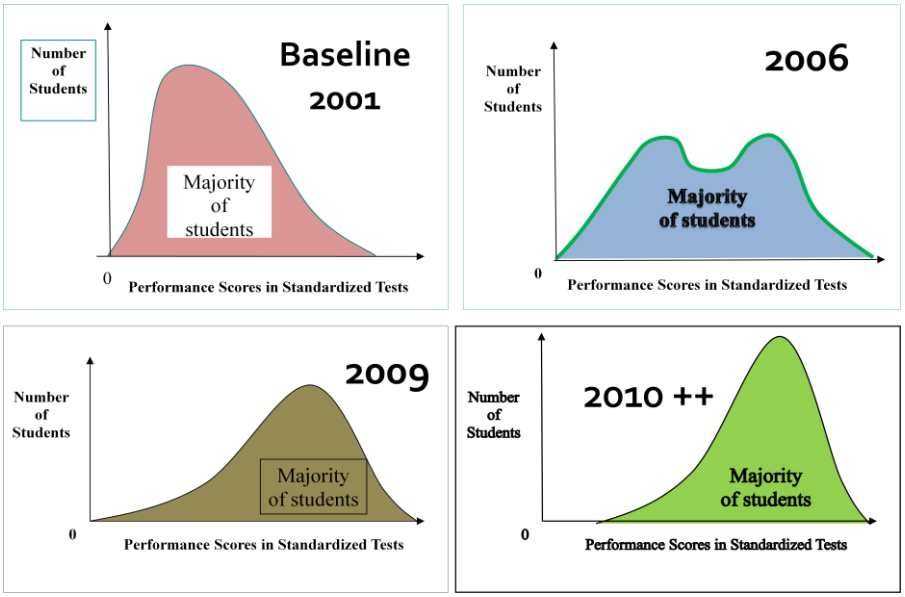

Figure 1. Number of students versus Performance Scores (NSAT, NCAE). The plots show the distribution before (2001) and after the implementation of CVIF-DLP (2002 - present).

Such analysis of data, performed in a triangulation approach with sources coming from national level exams, proved helpful in achieving performance targets for a large number of our students since 2002.

Is the CVIF DLP still applicable at the present time in light of the much talked about 4th Fourth Industrial Revolution (4thIR) [5]? Are the features of the program suited to the education and training of young people in this age of artificial intelligence, machine learning, Internet of things, robotics and widespread automation taking over jobs? With technology evolving at intractable speed, workers are expected to learn new skills every few years to keep abreast with developments. The competitive global labor markets also demand increasingly higher levels of training and professional expertise. Thus, not only should the younger generation develop a

[2] We take the NCAE rather than the National Achievement Test (NAT) since individual NCAE scores are regularly made available unlike the latter where only school mean performance is given. Although the NCAE is for career assessment, there are parts useful for analysis such as those that assess basic learning outcomes in Science, Mathematics and Reading Comprehension.

mindset of independent learning of increasingly complex skills, but at the workplace, they are expected to be problem solvers and creative thinkers who know how to collaborate and communicate. These requirements set very high standards for educational systems, but their attainment is undermined by the debilitating lack of qualified and mature teachers not only in advanced countries but also in developing countries where trained teachers are incessantly lured by nations with advanced economies.

At present, as in the past, there is a global proliferation of learning strategies from which educators could choose those that could address the core issue of the requirements of the 4thIR. In a complex learning environment with many intractable factors – ranging from teacher qualification to global demands, from web-based peculiarities of learners to a wide spectrum of parent-home backgrounds – there is a need for a program that would allow the highest number of learners to reach the highest possible performance levels in the shortest time and at minimal financial and social cost. Remaining attuned to the incessant learning and re-learning cyclic demands of 4th IR and beyond, the CVIF DLP was created precisely to develop a mindset among students for independent learning with built-in features to develop discipline, stamina, and collaborative skills to achieve a goal. In the CVIF DLP, learners also have a daily exposure to how topics are communicated in a concise yet comprehensible way not only in Science, Technology, Engineering, and Math (STEM) subjects but throughout the learning spectrum all the way to the humanities and values education.

II. 4TH IR REQUIREMENTS VIS-À-VIS ESSENTIAL FEATURES OF THE CVIF DLP

The CVIF-DLP is a system-based process-induced (in contrast to teacher-induced) learning program that bypasses the lack of qualified mature teachers. The CVIF-DLP has four main components: (a) Parallel Classes Scheme; (b) Activity-Based Learning by Doing; (c) In-School Comprehensive Portfolio; and (d) Strategic Rest. We briefly discuss in the succeeding sections each feature of the program and cite sample recent neuroscientific studies [6,7] that validate the particular component.

A. Mindset for Independent Learning: Parallel Classes Schedule

In the CVIF-DLP, developing a mindset for independent learning is fostered by the daily routine of learning new topics without an introductory lecture, and initially unassisted by a subject teacher who by design is not inside the classroom roughly 70% of the allotted period. This is implemented in a sustainable way all throughout the school year from Grades 7 to 12 by a structure we call the Parallel Classes Scheme. This means that if a Chemistry teacher is assigned to teach three sections for one hour each, all sections will be taught Chemistry simultaneously for one hour (see, Figure 1). The Chemistry teacher will then have to strategically divide the one hour period to be able to visit each classroom. Hence, whether the Chemistry teacher likes it or not, intervention with the learners in each class is limited to around 20 minutes or roughly only 30% of the one-hour Chemistry class. The Parallel Classes Scheme prevents a slide back to the traditional teacher-centered classroom where teachers stay in the class 100% of the time. In the CVIF-DLP, with 70% of the time for independent learning, students can explore, meditate, wonder, or think deeply about a topic that has not been explained and without teacher intervention. Note that, as shown in Figure 2, a class is never without an adult, however, since there is a teacher facilitator if the expert teacher (subject teacher) is not around. The facilitator is there only for classroom management and does not interfere with the subject (e.g., Chemistry) content. What then should the students be doing when the subject expert teacher is not in the classroom and they are with their teacher facilitator? This brings us to the next component of the CVIF DLP.

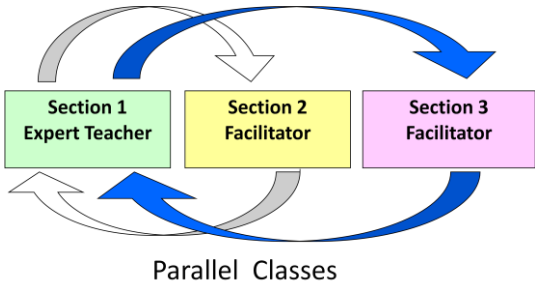

Figure 2. The Parallel Classes Scheme has classes for a subject simultaneously up to a maximum of three sections. The expert teacher is the assigned subject teacher who moves from one section to the other exchanging places with a teacher facilitator. The main task of teacher facilitators (who are expert teachers of other subjects) is classroom management.

B. Writing for Deeper Learning: Activity-based Learning by Doing

Copying concept notes and questions on their Learning Activity Sheets (LAS) *by hand* as a way of learning a new topic automatically engages a student by activating the visual, psychomotor, and cognitive faculties of the brain. With advances in neuroimaging through positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), there have been quite a number of recent scientific researches done on the role of writing by hand and its impact on learning [6]. The CVIF DLP optimizes writing as a means of absorbing new topics every hour in every academic day in a sustainable way. In the absence of a prior lecture at the start of the period, each student copies from the screen or a blackboard a Learning Activity designed such that: (a) There is only one topic/concept per Activity; and (b) Each Activity fits into one page (long bond and encoded in font 14 for high school, bigger font size for younger school children) to ensure that learning is bite-size (avoids information overload) and step-by-step (see Figure 3). While students are writing, answering questions, and accomplishing the Activity, the expert (subject) teacher need not be inside the classroom. The absence of an expert teacher while learning is on-going breaks a student's dependence and reliance on a teacher in the learning process. This Activity-based learning by doing is the second essential component of the CVIF DLP apt for the 4th IR. For any subject, drawings and illustrations clarifying a topic are encouraged and students are also allowed to creatively embellish their Activity sheets as a way of expressing themselves and lessening the anxiety often associated with learning a new topic.

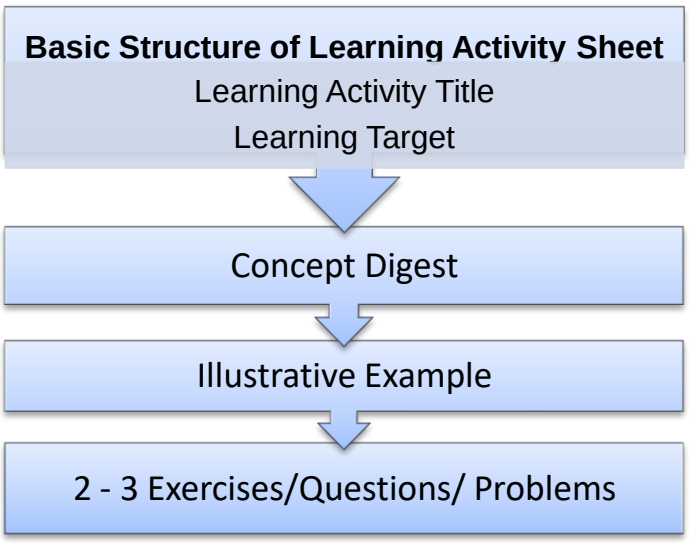

Figure 3. The one-page Learning Activity Sheet (LAS) starts with an Activity Title and a Learning Target to be written by the learner. This is followed by short Concept Notes – a digest of the topic to be learned, an example/illustration, and ends with an exercise or two to three questions.

C. Fostering an Organized Mind: Student Comprehensive Portfolio

Being organized is a basic skill that translates to success or failure in the workplace. In the CVIF-DLP, this habit-of-the-mind is fostered by requiring each LAS that students have accomplished to be sequentially and neatly filed by the student in the Student's Comprehensive Portfolio. Aside from the series of LAS in the student's own handwriting, the Portfolio contains all the quizzes and exams. This thorough documentation imbues a student – whether a challenged learner or high performer – with a sense of accomplishment often translating to better behavior. From the administrative and teachers' perspective, the Portfolio is a piece of documentation which records the day-to-day and hour-by-hour progress of learning of a student.

D. Optimized Learning: Strategic Rest

There is a sweet spot for optimized learning [7]. It is generally when the mind is rested and refreshed, and anxiety is at its lowest. This learner disposition is what the CVIF-DLP aims for and, hence, the need for strategic rest. The Strategic Rest component of the CVIF-DLP is highlighted by two features: (a) the No-Homework Policy from Grades 7 to 12 (which includes the policy on school projects to be time bound and done in school); and (b) a mid-week day for non-academic or soft course classes, where students are involved in learning music, the arts, health, and physical education (P.E.), with all students and teachers in their P.E. uniforms every Wednesday. Sundays are for religious obligations and family time.

III. OTHER FACTORS, OTHER STUDIES

Aside from the four components of the CVIF DLP, deemed non-negotiable, we have also looked at other factors that influence the progress of learning of students. These include quality of in-school and national assessment instruments, matching of prescribed (tested), desired, and implemented curricula, as well as home and peer influences, cultural and language factors. For example, our administrative decision since 1999 was not to follow the common policy of requiring students to speak only English in school, purportedly in aid of enhanced world class learning. For majority of our students, English is a second or even third language, and rarely spoken at home or with friends. Indeed, the choice of medium of instruction for science and mathematics, whether mother tongue or English as global lingua franca, remains a contentious issue in the Philippines. This is especially so since school administrators desire higher performance levels in science and mathematics, while policy makers wish to increase the number of bright young people enrolling and graduating from the science, technology, engineering and mathematics (STEM) courses at university, and eventually pursuing research and innovation as career choices. It is interesting to see that although there is some correlation between the different NCAE component tests: Scientific Ability, Mathematical Ability, Reading Comprehension, and Verbal Ability, the relation is not strong enough [8], leaving enough margin of flexibility for school administrators. We thus get validation of our decision not to sacrifice deep learning of science and mathematics for language proficiency, while having safety nets for English learning from other parts of the curriculum.

IV. OUTLOOK

Whatever the peculiarities of a given educational landscape, we advocate continuous monitoring through distributional analytics, without precluding analytics for outliers and interpolation for individual differentiation. Given the complexity of the 4th IR, systematic data gathering for statistics and analytics could guide design innovations and check the effectiveness of an educational program. Whatever success the CVIF-DLP has had in its 17 years of existence rests on faith in numbers well-gathered and well-interpreted. Being based on healthy analytics,

the four basic non-negotiable elements of the CVIF-DLP appear to remain relevant and robust in spite of the advent of the 4th IR among other potentially disruptive scenarios.

REFERENCES:

[1] Carpio-Bernido, M. V. and Bernido, C. C. (2004). Science Culture and Education for Change, Part I: Innovative Strategies for Secondary Education in the Philippines. *Transactions of the National Academy of Science and Technology* **26** p.243.

[2] Carpio-Bernido, M. V. and Bernido, C. C. (2011). CVIF Dynamic Learning Program: A Systems Approach to Process-Induced Learning. *epiSTEME 4: International Conference to Review Research on Science, Technology and Mathematics Education*, eds. S. Chunawala and M. Kharatmal (Homi Bhabha Centre for Science Education, Mumbai) 269 - 273.

[3] Carpio-Bernido, M. V., Bernido, C. C. and Carpio, J. A. Z., CVIF Dynamic Learning Program Reference and Management System Manual, Version 2.1 (CVIF, Jagna, 2011).

[4] Read, e.g., 'State of the Nation Addresses' of heads of state, and reports of national educational councils.

[5] Schwab, K. (2015) The Fourth Industrial Revolution. New York: Crown Publishing Group. ISBN 9781524758875.

[6] See, e.g., Mueller, P. A. and Oppenheimer, D. M. (2014). The Pen Is Mightier Than the Keyboard: Advantages of Longhand over Laptop Note Taking. *Psychological Science* **25**, 1159-1168.

[7] Mander, B. A., Santhanam, S., Saletin, J. M., and Walker, M. P. (2011). Wake deterioration and sleep restoration of human learning. *Current Biology* **21**,183-R184.

[8] Carpio-Bernido, M. V., NCAE Analytics: Insights for Language Choice in STEM Education, *plenary lecture at the 2017 SPVM National Physics Conference, University of San Carlos, Cebu City*.