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29th ANNUAL SCIENTIFIC MEETING

"A Progressive Philippines Anchored on Science:
***Building a Culture of Science in the Philippines*"**

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29th ANNUAL SCIENTIFIC MEETING

A Progressive Philippines Anchored on Science: Building a Culture of Science in the Philippines

11-12 July 2007
The Manila Hotel
Roxas Boulevard, Manila

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FOREWORD

AN ACCOMPLISHMENT REPORT ON THE 29TH ANNUAL SCIENTIFIC MEETING

The 29th ASM steered by the Chemical, Mathematical and Physical Sciences Division (CMPSD) with Acd. Evelyn Mae Tecson-Mendoza as chair, carried the theme "**A Progressive Philippines Anchored on Science**: ***Building a Culture of Science in the Philippines.***" The ASM focused on possible strategies that can accelerate the building of a culture of science in the country. These strategies include: a) a strategic change in science education in elementary schools which involves disco-very- and inquiry-based method of teaching; b) increasing support for young talent and genius; and c) strengthening institutions of research and scholarship.

There were six plenary sessions, each topic dealing with issues and concerns plaguing science and mathematics education in the country. The papers presented were subjected to analysis. debate, and discussion. These were: "Strengthening Basic Education;" "Government Support to Science Education", "Problems and Possibilities at the Heart of Science Education," "University-Industry-Government Linkages" and "Mentoring, Ethics and Media."

The six divisions of NAST each conducted concurrent technical session in the afternoon of 11 July 2007. Papers presented dealt with enhancing the competitiveness of the graduates of their respective fields and presentations on strategies and approaches in improving science and mathematics educations. Each division came up with their roadmaps to further strengthen the curricular programs and related matters in their fields respective of concern and make them relevant to the country's socio-economic needs. The roadmaps were presented in the sixth plenary session on 12 July 2007.

Acd. Bienvenido F. Nebres, SJ, Ateneo President and member of the Academy keynoted the affair while luminaries like Secretary Jesli A. Lapus of DepEd, Secretary Estrella F. Alabastro of DOST, Dr. Lee Yew

Jin of the National Institute of Education in Singapore, UP President Emerlinda Roman, and Ms. Cecilia "Cheche" Lazaro of PROBE Team, shared their expertise as plenary speakers. Participants included officers of the Korean Research Foundation, and members of the diplomatic community, researchers, scientists, educators, and students. The two-day affair presented scientific posters session that also featured the electronic poster version, investiture, and awarding ceremonies.

The 29th ASM was organized with the assistance from the Department of Science and Technology (DOST), Monsanto Philippines. Inc. Office of Senator Ramon B. Magsaysay Jr. and Science Education Institute (SEI) as patrons; Centro Escolar University, and Shoemart, Inc. as sponsors; Ateneo De Manila University, Department of Agriculture through its Biotech Prog-ram, ISAAA, PCASTRD, PCHRD, Resins, Inc., SEARCA, Unilab Laboratories, Inc., UPLB Foundation, Inc., Institute of Plant Breeding, UPLB, Aspen Multisystem Corporation, Biotechnology Coalition of the Philippines, Crop Life Philippines, De La Salle University, Dr. Lino Ed. Lim, Emilio Aguinaldo College, Mapua Institute of Technology, Manila Central University, National Research Council of the Philippines, Omnibus Bio-Medical Systems, PCAMRD, Pascual Laboratories, Inc., Philippine Women's University, PhilRice, Program for Biosafety Systems, RFG Photography and Souvenir, Syngenta Philippines, Inc., University of the East, and University of Santo Tomas as donors, exhibitors and advertisers.

The 29th ASM Steering Committee was composed of Acd. Evelyn Mae Tecson-Mendoza, (Chair), NS Lourdes J. Cruz, NS Bienvenido O. Juliano, Acd. Jose O. Juliano, NS Clara Y. Lim-Sylianco, Acd. Apolinario D. Nazarea, Acd. Bienvenido F. Nebres, SJ, Acd. William G. Padolina, and Acd. Caesar A. Saloma.

Scientific Posters. *There were 178 accepted entries for the scientific posters session: ASD - 47; BSD – 62; CMPSD – 26; ESTD- 10; HSD -22; and SSD – 11. (*based on 2007 Transactions, Abstracts Vol 29, Issue No.1*) The winners of the 2007 NAST Best Poster Competition were:*

Agricultural Sciences

Post-commercialization monitoring of Asia corn borer Ostrinia furnacalis (Guenee) Resistance to Bt corn in the Philippines and the impact of pollen dispersal on non-target Lepidoptera by: Bonifacio F. Cayabyab, Edwin P. Alcantra, Augusto C. Sumalde, Wilma R. Cuaterno, Blair D. Siegfried, and Ma. Charisma Malenab.

Biological Sciences

Species identification and genetic diversity analysis of yeast isolates from Philippine rice wine starters by DNA fingerprinting by Elaine V. Lim, Vivian Panes, and Gabriel Romero.

Chemical, Mathematical and Physical Sciences

Morphological evolution of diverse zinc oxide nanostructures by Ian Harvey J. Arellano, Eduardo R. Magdaluyo, Denis Aquino, Roland V. Samargo and Leon M. Payawan Jr.

Engineering Sciences and Technology

Automating the classification of tomato (Lycopersicon esculentum) maturity using image analysis and neural networks by Alona V. de Grano and Jaderick P. Pabico.

Health Sciences

Decreased invasion of respiratory pathogens in human pharyngeal cells due to subinhibitory concentrations of carboxymethy-lcystene by Ronald R. Matias, Frederick de la Cruz, Elena Tuano, Katherine M. Santiago, Leila M. Florentino, Rodolfo Pagcatipunan, and Alexander O. Tuazon.

Social Sciences

From Pailis to Pasungko: Negotiating the present, ascertaining the future (indigenous knowledge systems and opportunities for biodiversity management and conservation) by L.C. Sevidal Castro, Liwayway S. Viloria, Johanna E. Hanasan, and Reymund T. Bago.

Two resolutions were presented to the plenary and later endorsed to DOST Secretary Alabastro and DepEd Undersecretary Ramon Bacani. These were resolutions on **Requesting Congress to Enact an Animal Health Code and the Resolution for NAST to Actively Participate in the Implementation and Activities of Joint Resolution No.1 entitled "Joint Resolution Creating a Congressional Commission to Review and Assess the State of Competitiveness of Science and Technology, and Engineering Research and Development (R&D) Sector in the Country" and to Provide an Initial Agenda for the Proposed Congressional Commission on Science and Technology, and Engineering (COMSTE).**

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Building a Science Culture in the Philippines

Acd. Bienvenido F. Nebres, S.J.
President, Ateneo de Manila University
Member, National Academy of Science and Technology

Introduction

I am grateful that the topic of my talk is "Building a Science Culture" and not "Improving Math and Science Education in the Country." This talk of mine went through several versions. Eventually, I realized that I needed to emphasize

"Culture"

as much as or even more than "Science" if I were to help us make progress on the theme of our Annual Scientific Meeting: **"A Progressive Philippines Anchored on Science: Building a Science Culture in the Philippines"**.

You have heard enough about our situation in science and mathematics education, that we rank number 36 out of 39 in the TIMSS, that performance on the National Achievement Test (NAT) is below 50% in so many schools and school divisions and so on. The following slides from the presentation of Dr. Vivien Talisayon during the roundtable discussion last February 16, 2007, "Special Science Classes: Summary of Findings" show that even Philippine Science High School (PSHS), our top science high school, performs only at the mean of Singapore, Korea and Hong Kong in mathematics and significantly below the mean in science (Figures 1 and 2).

At the same time, we hear good news: our young people winning prestigious competitions abroad in science and mathematics. We will hear about the work of the Bernidos in Bohol. At the roundtable discussion last February 16, 2007, we were inspired by the work of the Mathematics Trainers' Guild (MTG) and the outstanding achievements of the students in their training programs.

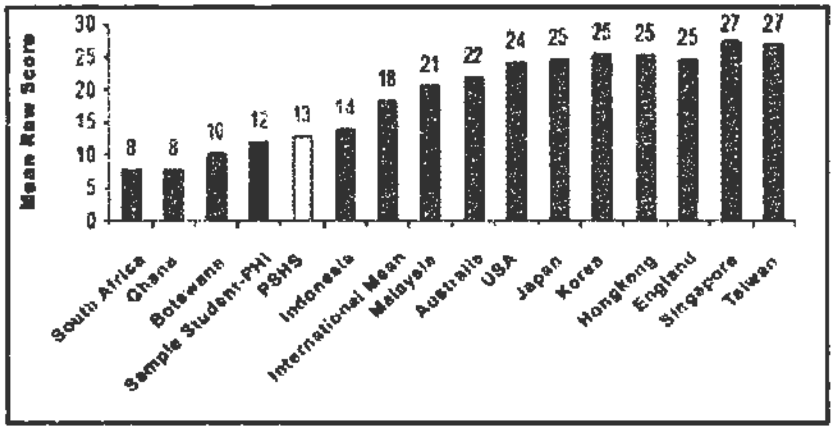

Fig. 1. Mean raw score in Science of PSHS vs sample students of Phil and selected countries.

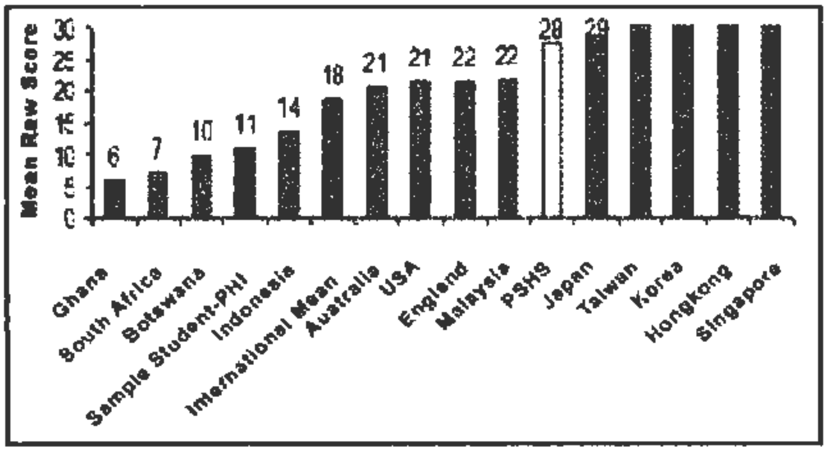

Fig. 2. Mean raw score in Mathematics of PSHS vs. sample students of Phil and selected countries.

We have been at this for a long time. There have been many interventions: the New Math of the 1960s, the Secondary Education Development Project (SEDP), the DOST -- DECS Engineering and Science Education Project (ESEP) and the recent Revised Basic Education Curriculum (RBEC). There have been many conferences like ours and many resolutions such as we have been making in our scientific meetings, addressed to DOST, DepEd, CHED and other institutions.

But the same pattern emerges --- a few bright lights and victories and a mass of poor performance. While we are proud of the bright lights and victories, I would like to recall a quote from a Japanese mathematics education colleague, who said, "We believe that a country can only march as fast as its slower members."

The Philippines will march as fast as the majority of our students and not at the pace of the few at the top.

The challenge for us then is to ask how we can make progress for

the majority of our students.

Part I: Defining a Solution

This address is on "Building a Science Culture". The culture of the natural sciences and mathematics is not to bewail or just describe a problem, but to solve them. If we are to be scientific ourselves in approaching the theme of our annual meeting, it is not enough for us to describe the problems or write resolutions about them. We should actually engage the problems and show that we are contributing to solving them. We have to engage Philippine culture and move it into a problem-solving mode, away from a blaming or complaining mode.

Assuming then that we are going to actually engage and help solve the problem, how do we proceed? Particularly, because years of effort and frustration have shown us that the problem is very difficult!

We have to begin by defining what we mean by a solution. Frequently, in research on mathematics and science education (or education, in general), the methodology is to propose an approach towards improving performance, then do a small scale pilot study, which normally shows that the approach works. The approach is then attempted on a larger scale and usually fails. The conclusion is usually to blame the teachers or the principals. But from our point of view of building a progressive Philippines anchored on science, the approach has to be considered a failure. It did not solve the intended problem of improving science or math education on a reasonable scale.

Since our goal is to improve mathematics and science education for the majority, a solution or a possible solution should have the following characteristics:

- be on a reasonable scale, at least a cluster of schools
- can be replicated successfully within normal parameters in the system (including the actual situation of teachers and principals)

Part II : The Way Forward on the Mass (Some Relative Success Stories)

In this address, I would like to share some relative success stories on a relatively large scale. I shall use as a framework a paper I wrote in 1983 for a conference in Japan.

Addressing the Social Context of Philippine Schools: Macro-Problems and Micro-Problems

After a decade of working on math education, I shared my reflections in a 1983 paper for a Regional Conference on Mathematics Education held in Japan:

> "We can classify problems of mathematical education into two types: the first we might call micro-problems or problems internal to mathematical education. These would relate to questions of curriculum, teacher training, textbooks, use of calculators, problem-solving and the like. The second we might call macro-problems. These are problems affecting mathematics education because of pressures from other sectors of society: economy, politics, culture, language, etc. One of the features of a developed society is a reasonable differentiation of sectors and functions of society. While given sectors are, of course, interdependent and affect one another, they also have some reasonable autonomy. School budgets may increase or decrease, but they have some stability and so it is possible to plan. Teachers get a sufficient (though not high) salary so they can concentrate on their teaching chores. But in contrast, structures in developing societies are not sufficiently developed to provide (for example) education and culture with sufficient freedom from the pressures of politics and economics. Teachers may be called upon to perform many civic duties -- to the detriment of their classroom work. Their salaries may not be sufficient for them to be able to concentrate on their work. Budgets may be unstable and information and opinion tightly controlled.
>
> In the first situation (of developed countries), it makes sense to concentrate on internal problems of mathematical education. One has enough scope and freedom within the educational system to study and plan changes with hope of implementation. In the second case, however, the problems which one experiences most intensely are not internal to mathematics education, but due to pressures

> from outside society. Until some structures are established to provide some scope and freedom for the educational system, it is less useful to concentrate studies and plans on curriculum or other internal concerns."

I then went through a more detailed analysis of the challenges of mathematics education from this perspective. In that same paper, I concluded as follows:

> "The improvement of mathematics education in developing countries such as those of Southeast Asia requires continuing improvement of teacher — training, curriculum, textbooks (the internal concerns of mathematical education). However, their improvement is only possible if mathematical education has enough space and freedom (within the pressures of economics, culture, organization of education) so as to be able to plan and implement. It is the experience of developing countries that pressures from other structures of society (economic, political, cultural) are often too strong for the system of mathematics education to work realistically on its internal concerns."

From the experiences that will be described below, we can look at this approach to improving education in the social context of Philippine schools as:

- Creating the absorptive capacity of schools and clusters of schools to take in and implement significant reform and improvement (attending to the macro problems)
- Targeted and focused interventions to address priority needs (academic and non-academic) (attending to the micro-problems). This means meeting the schools where they are, setting next level targets with them, and moving them to the next level.

Part IIa: School-Based Management in TEEP

Our first example of a large scale reform project that tackled the macro-problems (created absorptive capacity in the school and community) and micro-problems (teacher-training, textbooks, lesson guides, etc.) is the Third Elementary Education Project (TEEP).

Engaging the community and creating absorptive capacity and bringing in targeted inputs. The Third Elementary Education Project defines school-based management (SBM) as the decentralization of decision-making authority from central, regional, and division levels to individual school sites, uniting school heads, teachers, students as well as parents, the local government units and the community in promoting effective schools. Its main goal is to improve school performance and student achievement, where decision-making is made by all those who are closely involved with resolving the challenges of the individual schools so that the specific needs of the students will be served more effectively. Its objectives were to empower the school heads to provide leadership and to mobilize the community as well as local government units to invest time, money and effort in making the school a better place to learn, thus improving the educational achievement of the children.

School-Based Management is a framework that integrates several micro factors at play in SBM schools, namely,

- leadership (e.g. dynamic school heads)
- strong local government unit (LGU)-school or school-Parent Teachers Community Association (PTCA) partnership
- access to basic inputs like classrooms and textbooks
- focused teacher-competency development/INSETs (In-Service Training)
- support system at the district/division levels

The community has to be involved and TEEP would not proceed in a given community unless the community raised 10% counterpart funding. This would amount to about P10,000.00. There is a very touching story in Romblon. A community wanted so badly to get a School Improvement and Innovation Fund for their school (this was the overall name of the project support fund) that they each contributed funds from their own meager incomes. Their contribution was mostly in coins. Unfortunately, after counting all the coins on the deadline for approving projects, they had only P9,000 of the expected P10,000. The district supervisor was so moved by the community efforts that she gave the remaining money.

Impact. For the TEEP schools, school-based management has resulted in a bigger share of schools crossing the 75% mastery level and the 60% near-mastery level in the National Achievement Test. TEEP and non-TEEP schools started on the same level in SY 2002-2003 but relatively more TEEP schools attained mastery level in SY 2005-2006. Please refer to Appendix 1 for the comparator groups as well as the tables showing the percent surpassing the 75% mastery level as well as the 60% mastery level. in terms of overall performance as well as specific performance in Math and Science.

It is worth noting the following:

1. With the exception of Aklan+, all clusters experienced a decline in scores and rankings from SY2004–2005 to SY2005–2006. Nevertheless, TEEP SBM provinces sustained their lead relative to all other clusters (cf. Appendix1).

2. There is a relatively stronger improvement in mathematics: 22.6% 9 ELS and 18.2 Non-ELS achieving 75% mastery level, all others are lower, with Pampanga closest at 16.6%. At 60% mastery level, the performance gap is even clearer, with TEEP ELS at 59.5% and non-ELS at 46.3% (cf. Appendix 1).

3. The improvement in mathematics is much stronger compared to improvement in science (cf. Appendix 1).

The importance of addressing the implemented curriculum, the day-to-day work of teachers. What accounts for the significant improvement in mathematics? I received a phone call in August last year from Dr. Cynthia Bautista, excited about some results of their end-project evaluation of the Third Elementary Education Project. There had been significantly greater improvement in mathematics in the National Achievement Test (NAT) in several divisions of the TEEP. The resource persons in the study conducted by the Japan Bank for International Cooperation (JBIC), "Lessons from the Third Elementary Education Project: Transforming Education on the Ground" attributed the very good performance of TEEP in Mathematics "to the Math Teachers' Lesson Guide series prepared by DepEd and Ateneo which TEEP printed and distributed to all its teachers. Written by Master teachers in elementary and high school, the series drew from existing textbooks and improved on them.

Tables 1 and 2 show the scores in Mathematics and Science in the National Achievement Test of the TEEP schools and the comparator groups.

Table 1. Scores in Math in the National Achievement Test of the TEEP Schools and comparators group.

	Math			
	2002/3	2003/4	2004/5	2005/6
TEEP SBM	46.1	54.1	62.0	59.0
AKLAN+	49.9	52.0	58.2	56.4
CAGAYAN+	46.6	51.2	57.1	53.1
ILOILO+	42.1	47.5	54.6	49.7
PAMPANGA+	46.9	55.1	61.3	56.2
NCR	42.0	50.7	60.5	47.7
ARMM	38.4	44.1	44.5	41.8
Total	46.0	52.3	58.9	54.7

Table 2. Scores in Science in the National Achievement Test of the TEEP Schools and comparators group.

	Science			
	2002/3	2003/4	2004/5	2005/6
TEEP SBM	47.1	50.0	60.4	50.2
AKLAN+	46.7	47.5	58.2	49.1
CAGAYAN+	44.4	46.8	55.7	45.3
ILOILO+	41.3	44.4	54.5	44.7
PAMPANGA+	45.0	50.2	60.5	48.2
NCR	42.0	43.2	47.9	43.1
ARMM	40.5	40.2	46.7	37.2
Total	44.4	48.1	58.0	47.1

What are these Lesson Guides? The Lesson Guides in Mathematics were prepared during the term of former DepEd Secretary Raul Roco. He invited us to a meeting in July 2001 to discuss what might be done to improve the performance of students in the different subject areas. We shared with Secretary Roco that the central problems continue to be the lack of teachers, need for teacher-training, lack of textbooks, classrooms and other basic needs.

We then suggested that considering the situation in public schools, e.g.,

- congested classrooms (65 - 70 class size in urban areas)
- lack of textbooks

- lack of library facilities or library materials for teachers
- absence of experts teachers may consult,

the need is to provide textbooks for students and a self-contained reference material (guide) for teachers.

The DepEd was able to provide Math textbooks for all high school students (1:1 ratio) during the time of former Secretary Roco. The series that was reproduced for all students was the only complete series available. Moving from the previous SEDP approach (spiral approach) to the discipline based approach (Elementary Algebra – 1st year, Intermediate Algebra – 2nd year, Geometry – 3rd year and Advanced Algebra and Trigonometry – 4th year), meant literally tearing apart the existing books and putting together the algebra parts, the geometry parts, and so on. (Later on, we realized how much improvement is necessary for the Geometry part. The deficiencies in Geometry were not very evident in the SEDP spiral curriculum.)

This move could not be done for the elementary level since no complete textbook series from Grade 1 to Grade 6 was available.

The Lesson Guides prepared by DepEd and Ateneo were designed to help the teachers in their day-to-day teaching. Each Lesson Guide included:

- objectives for the lesson
- development of the lesson
- suggested examples and exercises
- suggested teaching strategies with provisions for higher order thinking skills (HOTS), multiple intelligences (MI) and values integration

All work in the preparation of the lesson guides was a team effort among the Master teachers from public schools, the DepEd curriculum specialists and experienced teachers from the Ateneo de Manila Grade School and High School as well as the other Jesuit schools.

The preparation of Math Lesson Guides was a large-scale effort within a short time frame. The Lesson Guides for High School Mathematics were completed within August 2000–March 2002 while the Lesson Guides for Elementary were prepared beginning December 2002 until April 2003. Teacher training was conducted for 1,971 high school mathematics teachers in 2002 and 2,210 elementary mathematics teachers in 2003.

The lesson learned from this initiative on Lesson Guides is worth noting:

Focusing on providing enough textbooks, teacher guides or workbooks and working patiently with the teachers to use these well (teacher training) is a way of making progress on a large scale.

It is also important to note that the success of the TEEP schools with the Math Lesson Guides depended in great part on progress in the social environment of TEEP schools brought about by school-based management. SBM created the environment for reform, the absorptive capacity to make change.

Part IIc: Capacity Building for Schools in Payatas Through Project SSPEEd and ACED

The second example is a smaller scale effort by the Ateneo Center for Educational Development to see what it takes to help bring up poor elementary schools, mainly in Payatas, Quezon City.

From research Ateneo had done in the early 1990s (led by Dr. Patricia Licuanan), it was seen that what differentiated high performing public elementary schools from low performing ones, given the same economic and demographic situation, was the leadership of the principal and the support of the community. We used this as a framework for our work with selected public elementary schools.

In 2001, Mr. Washington Z. Syeip, Mr. Alfredo Velayo and this author initiated Project SSPEEd or Sectoral Support for Public Elementary Education. Concerned with the declining standards of education in the country, this project aimed to provide support to particular public elementary schools patterned after the involvement and experience of Ateneo de Manila in the Third Elementary Education Project (TEEP). Project SSPEEd provided support to the following partner schools from 2001 to 2004: P. Burgos Elementary School (Manila), Payatas Elementary School (Quezon City), Bagong Silangan Elementary School (Quezon City), Payatas B-Annex Elementary School (Quezon City) and Kalayaan Elementary School (Caloocan City).

From this project, the Ateneo Center for Educational Development (ACED) learned significant lessons and insights on how to fuse macro-level goals and micro-level initiatives and involvement. Project SSPEEd provided a framework on how institutions can assist public schools develop and at the same time create impact in the surrounding urban poor communities.

When Project SSPEEd ended in 2004, ACED pursued a closer partnership with four public elementary schools in the 2nd district of Quezon City

- Payatas B Annex Elementary School
- Payatas C Elementary School
- Lupang Pangako Elementary School
- Bagong Silangan Elementray School

Given the population of Payatas, these are very large schools.

This closer partnership with the schools began with data gathering. Much work was then done to bring the community together (principal, teachers, parents, baranggay officials, students) and do strategic planning and prioritizing of goals and objectives with them. This partnership, which ACED has carefully nurtured these past years has led to notable results. Because the need for buildings and classrooms came from the shared and careful planning by the whole community, Mayor Belmonte was impressed and moved forward to build the needed buildings, classrooms and comfort rooms. The private sector also came in with other needed inputs, like textbooks, workbooks, etc. The principals and teachers have become more confident and effective in their areas of responsibility as a result of empowerment programs and teacher-training programs. Student achievement has improved in different degrees. The most dramatic improvement is in Lupang Pangako Elementary School where the ranking of the school in the division level has moved up from rank 94 in 2003 to rank 18 in 2004 to rank 16 in 2005 and to rank 9 for 2007.

From Project SSPEEd and the work of ACED in Payatas schools, we have seen two things: the crucial role of the school principal and the community and the importance of a holistic and collaborative approach in school development and improvement. We have also seen that local government, especially Mayors, are a major partner in improving the schools.

The lesson learned from the work with the public schools in Project SSPEEd and ACED is quite clear:

The way forward on the mass is to invest in capacity building for all major players: the principal, teachers, parents and barangay officials. When the principal and the community are organized and have good plans, there can be very good response from local government and the private sector.

Part IId: Building Leadership and Community Support Through Synergeia

The third example is the work of Synergeia Foundation.

Synergeia Foundation, Inc. is a coalition of individuals, institutions and organizations working together to improve the quality of basic education. Synergeia and its partners implement systematic programs to improve the provision of basic education in more than 115 municipalities in the country.

Synergeia has focused on building leadership and community support through the following:

- Focus on Local School Board (Provincial, City, Municipal)
- Engage whole community in assessing situation, setting goals, deciding on priority objectives
- Focus on elementary schools, beginning at Grade 1, especially, English and Mathematics
- Provision of basic instructional materials (lesson plans for day to day use of teachers, workbooks for children, audio-visual materials)
- In-service training for teachers and principals

The programs of Synergeia have already resulted in significant improvements in the reading and mathematics proficiency of elementary students, and more importantly, in local governance. In monitoring the performance of participating schools, Synergeia uses the following metrics:

- National Achievement Test (NAT) for Grade School of DepEd
- DOLCH Basic Sight Words Test
- English Comprehension Test developed by Synergeia

Synergeia in Bulacan. Synergeia began working in Bulacan in

2000 under the leadership of Governor Josie de la Cruz. Over 620,000 pupils from grades one to six in 496 elementary schools in Bulacan are participating in the Synergeia program. In the 2000 National Achievement Test (NAT), pupils had an average score of 39.40% in Mathematics and 40.23% in English. Six years later, after interventions of Project JOSIE, pupils achieved a NAT average score of 64.39% in Mathematics and 65.45% in English.

Synergeia in Lipa City, Batangas. Among the 17 communities that pioneered the reading proficiency program, the most dramatic gain was achieved by Project K in Lipa City, Batangas. At the start of the project, grade one pupils' proficiency was measured at 25%. This meant, children could read only 1 out of 4 words correctly. Mayor Vilma Santos-Recto was floored upon seeing the results. Fueled by the urgency of the education crisis, various stakeholders including De La Salle Lipa, the local DepEd, local school board and parents, worked together to improve the way children learn how to read in school. After one year, the Division Achievement test results showed that on the average, grade one pupils could already read at 54.0%, doubling their score in the previous year's exam.

In 2002 2003, Lipa City's NAT average was 44.85%, in 2006–2007, it was 73.55%. The English average in 2002–2003 was 40.15%, in 2006–07, it was 73.06%.

Once again, the way forward on the mass is to invest in capacity building for the entire community.

The most challenging area of work for Synergeia now is in ARMM. But that has to be for another report.

Part III: The Upper End of the Challenge

How can we close the gap between our top schools and the top schools in the region? Let me now turn to the upper end of the challenge. We have the top of the line, Philippine Science High School, other science high schools and leader schools. In ESEP, we worked to provide laboratories as well as a stronger curriculum and programs for these schools. We can add a list of private schools to these science high schools and leader schools.

As we saw earlier, based on the data given by Dr. Talisayon, even our best schools have a way to go to reach the levels of schools among our neighboring countries. The best way to move forward is to explicitly benchmark with the best among our neighbors.

A framework might be a proposal sent recently by Dr. DJ de Jesus on benchmarking the top schools in the region: Singapore, Thailand, Vietnam, Philippines. On the initiative of the Minister of Education of Singapore and the Deputy Minister of Education and Training of Vietnam, the proposal is to benchmark the top science schools of Singapore, Vietnam, Philippines and Thailand. This could be done by the students from the three other countries competing in the national exams for science and math conducted by Vietnam. Singapore has already accepted the proposal. This benchmarking will also be an opportunity to compare the performance levels that the different schools expect from their students and to see if there are significant differences among them.

You might be surprised to know that the country I would expect to top the group will be Vietnam. From my experience of comparing the development of top talent in the Philippines and in countries like Vietnam, China, etc., what emerges is that, we have to develop a much stronger problem-solving culture. In mathematics, this means problems on the level of the International Mathematics Olympiad. When we benchmark our top students with say. Vietnam, we will find that we cannot compete at their level. Vietnam even during the wars with the U.S. continued to produce teams that would rank among the top in the IMO. I checked on the rankings of the four countries and from 2002 to 2006, Vietnam ranked 5, 4,4,15 and 13 respectively; Singapore ranked 30, 36, 18, 14 and 27; Thailand ranked 21, 19, 35, 23 and 16; the Philippines ranked 74, 79, 79 and 68 (we did not participate in 2006).

We should encourage participation in mathematics and science competitions. We should encourage the work of the Mathematics Trainers' Guild and support its spread to all our science high schools and leader schools. I personally teach a mathematics problem solving course in Ateneo college and we try to develop competitive teams in our grade school and high school and annually hold a competition between them and teams from MTG.

Part IV: Postscript—Focus on the Day-to-Day Classroom (the implemented curriculum)

Teacher Training for Day-to-Day Teaching. We established the

Mathematical Society of the Philippines in 1972, the same year as the establishment of the Southeast Asian Mathematical Society. These societies from the start were involved in helping develop both university and research mathematics as well as mathematics education and teacher training. In our teacher training, I soon realized that our approach of providing generic training and enrichment materials or talks was not addressing the needs of the teachers. They needed something they could use in their day-to-day delivery of their classes. So, together with Sr. Iluminada Coronel, we began to work with their textbooks, providing support exercises, etc. MTAP continues to carry on this work and it was along the same lines that we carried out the work with textbooks and Teacher Guides under then Secretary Roco in 2001. As a side note, when we were discussing this recently with under secretaries and assistant secretaries of DepEd, they laughed and said that teachers have a comment about generic and enrichment type seminars, their Three T's: Tanggap, Tiklop, Tago. That is, they take the handouts, pack them and then put them away.

Benchmarking Using Tests Like TIMSS. One way to move forward is to use exams like TIMSS or College Entrance Tests in the Philippines or School Leaving Exams in other countries (like the Primary School Leaving Exams, O-Level Exams and A-Level Exams of Singapore) not just to compare performance, but to use them as a diagnostic. This means using the exams as a tool to identify the key areas where improvement or progress is most needed. Diagnose why students do poorly in these areas. Then, using the data, develop interventions: appropriate teacher training, workbooks, lesson guides, etc. to address these problems. Measure whether the interventions are working.

We have found it important to engage the teachers in this exercise:

- get the teachers to do the answer key (this helps them engage the challenges coming from the tests)
- get them to correct the students' papers or at least some of them(they will get a lot of "aha" experiences – seeing that what they thought they taught did not really sink in)
- then invite reflection on how to move forward

Conclusion

To move towards "a progressive Philippines anchored on science", it is important that we actually engage the problems that face us and show that we are contributing to solving them. While depressing statistical figures and reports on the state of education in the Philippines continue to discourage us, we look forward to a better future through the inspiring results from initiatives like the TEEP School Based Management Approach, the Math Lesson Guides, the focus of Synergeia on building leadership and community support, the work of Project SSPEEd and the ACED and the dedication of MTG in developing talent among the youth.

We realize the importance of giving attention to the social environment of our schools if we are to improve and develop our schools and educational system. We have seen that to move forward to the mass, it is important to invest in capacity building for the entire school community: principal, teachers, parents and baranggay officials. For the development of our top talent, we see that we need to benchmark explicitly with the best among our neighbors.

Finally, to move towards "a progressive Philippines anchored on science", it is important that we focus on the day-to-day classroom (the implemented curriculum) through teacher training and other interventions that give attention to the day-to-day delivery of lessons and benchmarking activities like learning from best practices of other schools and using reputable examinations to improve the standards of our schools.

Acknowledgements

I would like to thank Dr. Cynthia Rose Bautista for sharing the report and experiences of TEEP. I personally directed the planning that led to TEEP, the development of the Division Elementary Development Plan (DEDP) 1994-98 and it is a tribute to those who carried out the work, especially Dr. Malou Doronila, that we have achieved such significant results.

I would like to thank Ms. Anne Lan Candelaria for the outstanding work with the Payatas Schools. The work has now been taken over by Mrs. Carmela Oracion, who also led the work for developing the Lesson Guides for Mathematics.

Finally, thanks to Dr. Milwida Guevara, President of Synergeia Foundation, and her team for the outstanding work of Synergeia Foundation in engaging mayors and the community, revitalizing the local school boards, and truly improving education for public elementary school students in so many municipalities and cities. I would like to thank Ms. Trissa Manalastas for her patience in organizing the data for me for this presentation.

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Appendix 1: TEEP Comparator Groups and Percentage of Students Surpassing 75% and 60% Mastery Level (Overall, Math and Science)

To determine the comparator groups for TEEP/SBM, the Team examined how each province fared along four poverty indices:

- The Human Poverty Index (HPI),
- the 1997 and 2000 Fixed Level of Living or consumption-based measures and
- the 2000 official poverty line of the National Statistical Coordinating Board.

Comparator groups:

- **ARMM**

  Basilan, Lanao del Sur, Maguindanao, Sulu and Tawi-Tawi.

- **AKLAN+** the clearly poor provinces that satisfied the following criteria:
  - province HPI > median HPI for the country
  - falls below the poverty line based on consumption levels in 1997
  - falls below the poverty line based on consumption levels in 2000
  - falls below the official NSCB poverty line.

  Aklan, Camarines Norte, Lanao del Norte, Northern Samar, Sarangani, Sorsogon, Western Samar and Zamboanga del Norte

- **CAGAYAN+** provinces that satisfy two or three of the above criteria: Agusan del Norte, Albay, Bohol, Cagayan, Camarines Sur, Camiguin, Catanduanes, Cebu, Compostela Valley, Davao Norte, Davao Oriental, Isabela, Oriental Mindoro, Occidental Mindoro, Marinduque, Misamis Occidental, Quezon, Siargao, Siquijor, South Cotabato, Sultan Kudarat, Surigao del Norte

- **ILOILO+** provinces that satisfy only one of the above criteria Bukidnon, Davao Sur, Iloilo, Negros Occidental, Nueva Ecija, Nueva Vizcaya, Occidental Mindoro, Palawan

In addition to the poor provinces, TEEP schools were also compared to non-poor provinces, cities and the National Capital Region.

- **PAMPANGA+** Bataan, Batangas, Bulacan, Cavite, Ilocos Norte, Ilocos Sur, La Union, Laguna, Misamis Oriental, Pampanga, Pangasinan, Quirino, Rizal, Tarlac, Zambales and all cities outside NCR
- **NCR**

Note the relatively stronger improvement in mathematics: 22.6% 9ELS and 18.2% Non-ELS achieving 75% mastery level, all others below, with Pampanga closest at 16.6%. At 60% mastery level, the performance gap is even clearer, with TEEP ELS at 59.5% and non-ELS at 46.3% The improvement is also much stronger compared to improvement in Scienee.

Percent Surpassing 75% Mastery Level: Overall

GROUP8	2002/3	2003/4	2004/5	2005/6
TEEP ELS	2.6	7.3	16.1	15.0
TEEP NON-ELS	3.2	4.9	13.6	11.2
AKLAN+	4.7	3.3	9.4	8.7
CAGAYAN+	3.5	2.9	9.1	7.0
ILOILO+	1.0	1.0	5.3	1.9
PAMPANGA+	3.5	6.7	15.8	11.0
NCR	0.0	1.3	6.1	0.4
ARMM	0.9	0.2	1.4	0.5
Total	3.1	4.1	11.3	8.3

Percent Surpassing 75% Mastery Level: Math

GROUP8	2002/3	2003/4	2004/5	2005/6
TEEP ELS	7.31	5.0	32.6	22.6
TEEP NON-ELS	8.0	13.4	24.3	18.2
AKLAN+	10.8	10.5	18.5	14.4
CAGAYAN+	8.3	10.1	17.8	11.8
ILOILO+	4.1	5.6	12.0	4.7
PAMPANGA+	8.8	15.6	26.5	16.6
NCR	1.1	7.4	17.3	2.2
ARMM	0.5	5.4	4.3	2.2
Total	7.7	11.7	20.8	13.5

Percent Surpassing 75% Mastery Level: Science

GROUP8	2002/3	2003/4	2004/5	2005/6
TEEP ELS	2.9	4.7	22.0	5.9
TEEP NON-ELS	2.8	2.9	17.2	3.7
AKLAN+	3.9	1.9	14.7	2.1
CAGAYAN+	2.9	1.5	11.8	1.8
ILOILO+	0.9	0.6	8.1	0.6
PAMPANGA+	3.1	3.3	19.5	3.4
NCR	0.9	1.8	11.7	0.0
ARMM	1.4	0.2	2.9	0.2
Total	2.7	2.2	14.8	2.5

Percent Surpassing 75% Mastery Level: Science

GROUP8	2002/3	2003/4	2004/5	2005/6
TEEP ELS	2.9	4.7	22.0	5.9
TEEP NON-ELS	2.8	2.9	17.2	3.7
AKLAN+	3.9	1.9	14.7	2.1
CAGAYAN+	2.9	1.5	11.8	1.8
ILOILO+	0.9	0.6	8.1	0.6
PAMPANGA+	3.1	3.3	19.5	3.4
NCR	0.9	1.8	11.7	0.0
ARMM	1.4	0.2	2.9	0.2
Total	2.7	2.2	14.8	2.5

Percent Surpassing 60% Mastery Level: Overall

GROUP	2002/3	2003/4	2004/5	2005/6
TEEP SBM ELS	15.5	39.3	65.1	59.5
TEEP SBM NON-ELS	15.8	29.3	50.3	46.3
AKLAN+	22.4	24.4	43.3	44.0
CAGAYAN+	16.5	22.4	37.5	32.3
ILOILO+	8.9	14.7	32.3	24.9
PAMPANGA+	16.4	31.9	49.9	40.3
NCR	6.7	19.5	49.8	19.7
ARMM	11.6	13.6	11.1	10.4
Total	15.5	25.6	43.3	37.0

Percent Surpassing 60% Mastery Level: Math

GROUP	2002/3	2003/4	2004/5	2005/6
TEEP SBM ELS	20.5	46.9	66.6	59.5
TEEP SBM NON-ELS	22.5	38.5	54.3	48.9
AKLAN+	31.4	34.0	47.8	43.9
CAGAYAN+	23.0	32.1	44.8	34.9
ILOILO+	14.2	23.9	37.9	25.2
PAMPANGA+	22.9	41.2	53.9	41.8
NCR	10.5	27.8	55.6	17.9
ARMM	5.6	20.4	19.7	14.8
Total	21.8	34.9	48.5	38.6

Percent Surpassing 60% Mastery Level: Science

GROUP	2002/3	2003/4	2004/5	2005/6
TEEP SBM ELS	15.0	33.7	68.6	31.7
TEEP SBM NON-ELS	13.7	24.0	52.3	24.5
AKLAN+	19.5	19.3	47.9	21.8
CAGAYAN+	14.4	17.2	40.6	15.5
ILOILO+	8.5	11.7	35.7	9.8
PAMPANGA+	14.5	25.9	53.0	21.1
NCR	6.1	16.8	52.7	6.5
ARMM	12.4	8.3	20.6	4.8
Total	13.8	20.5	46.5	18.4

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Strengthening Basic Education

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Science and Technology are integral to our capacity—as individuals and as one nation—to move ahead in this fast-paced technology-based world. They are, without doubt, integral to our daily lives.

Our ability to improve our capabilities in Science and Technology begins with improving science and mathematics at the basic education levels.

These two key areas have long been a concern for us in the Department of Education. This stems from decades of underinvestment in education—something that we are now beginning to address with unprecedented increases in the budget of the education department, and of both Technical Education and Skills Development Authority (TESDA) and Commission on Higher Education (CHED).

And we have noticed some significant improvements in some areas, providing us with some ray of hope that the dire situation can be addressed in due time. For us at DepEd, we find solace in the fact that some of the best performers in these key subjects come from our public schools. As was earlier mentioned, the individual topnotcher in last year's NAT with a perfect score in mathematics, 100, comes from a small islet in the province of Bohol. That boy had to take a banca everyday of his life just to go to school and back to his home in that islet where there is not even electricity, besting more than one million students from both public and private school students.

When I was asked by media saying, "Now you know who did well, can you not replicate that in Manila?" I said, we will try. Let me talk to the mayors, let me ask them to close all arcades, video game arcades, maybe get to parents at home all the time and approximate the situation in Bohol.

But as was earlier mentioned a common characteristic of all the topnotchers and the best schools in the NAT consistently, number one is very strong family and community participation in education. There is even one if I am not mistaken, in Catbalogan, perfect attendance, perfect retention, no dropout public school. But a school bus given by the LGU picks up the students everyday and takes them home. Most of the schools have benefactors. Most of the schools have local government unit (LGU) or private sector benefactors. And therefore class sizes are about 30 students to a classroom.

Still on the recent math challenge of the Mathematics Teachers Association of the Philippines, majority of the winners come from the public school system. This of course, we can say that the public school system in the elementary education accounts for 92% of the entire population. This is not to say that the private schools are not in the winning circles.

However, this is a testament of our effort to improve science and math teaching in all our 42,722 public elementary and secondary schools nationwide. But why do have various success stories in many localities and while we continue to pursue proactive programs in improving student performance in these subject areas, we are still a long way in raising achievement levels on a nationwide scale. The average NAT remains to be dismal including the National Career Assessment Examination (NCAE) since we instituted this test for graduating students in January of this year. This can be attributed also to the fact that many of our science and math teachers are not specialists in the subjects they are teaching.

As of the last measure, for instance, 66% of chemistry teachers and 73% of physics teachers are not majors in chemistry or physics. Mercifully, only 20% of our math teachers are not majors. But as you know, the ideal situation requires us to have all our teachers to be experts in their respective fields.

Needless to say, we have spared no expense to provide extensive and expensive in-service training for these non-majors. But frankly, I wonder how many summers and how many years it will take us to retrain the thousands of teachers who are not majors? And how many more millions of student-casualties in the school system must suffer, must we incur before we get into that level?

So I venture to define in one simple sentence the main challenge in basic education. The challenge to my mind is "How to deliver the same high quality education to all the schools or to the 43,000 schools spread all over the archipelago at the soonest, earliest possible time?" In one sentence— that is the Herculean task that all nations are constantly trying to solve, trying to meet, because it is hard to explain that we have teachers and students who are among the best in the world, yet on the average, we are number 23 out of 25 in science and math. So the challenge is to improve the scale to make the best teachers benefit the most number of students, start to make all students even those in the remotest barangays receive the same quality education, materials, instruction, methodology, and content nationwide.

We are at least trying to streamline the curriculum and developing standards to provide focus and improve mastery. We are pilot testing the standards based on the curriculum in 23 secondary schools nationwide. We are constantly engaging the private sector to invest in ICT for education through our adopt-a-school program. As you know, the likes of Intel, Microsoft, and Knowledge Channel have been actively involved in the public schools. Among their efforts, of course, is the annual national science fair sponsored by Intel Corporation.

We are providing our teachers and students the opportunity to compete in international competitions and we have won many including the recent Math and Science Olympiad in Jakarta, the World Robot Olympiad in China, the Intel Excellence in Teaching Award, and the Microsoft Innovative Teachers Leadership Award.

We are now banking on our ability to move forward on a nationwide scale through the flagship initiative—the Cyber Education Project.

The CyberEd Project shall provide us the ability to bring various excellent interventions in education to state. Using satellite technology, each project will create one national network for education: 12 independent television channels linking to 38,000 or 90% of public elementary and secondary schools and providing them with teaching and learning resources that will enable each one to be at par with the rest of the world.

While we continue to retrain our teachers through extensive in-service training, CyberEd will enable our students to benefit from our best teachers. Through CyberEd, our world-class master teachers will teach in virtual classrooms and their classes will be beamed via live satellite in real time to most of the classrooms that require their expertise the most. And this will be an interactive system.

And while we continue to provide computer laboratories and libraries for schools, CyberEd will connect our students to the worldwide web as well as the rich menu of resource materials currently unavailable in the public schools. Through CyberEd high-speed satellite transmissions will provide our remote schools with the same information on demand that are accessed only by the best private schools. Of course this technology is not without precedence. We have seen excellent models of satellite-based education technology in many parts of the globe in such countries as the United States, Canada, Mexico, Chile, India, Indonesia, Thailand, China, and many more.

Our own CyberEd model is patterned after the e-education project in China currently being managed by Xinhua University, which most of you know is China's number one technology university and ranks number 17 in the world, and is a world pioneer in distance learning. As our major partner in CyberEd, Xinhua University is providing us with the expertise to successfully implement this project in our shores.

Ladies and gentlemen, CyberEd is the most effective and inexpensive way to narrow the economic divide. It is the best way to realize our dream of quality education for all Filipinos. And by all, we also mean the out-of-school youth, the indigenous people, and the technical-vocational objectives of DepEd.

CyberEd is an all-out campaign to fast track much needed improvements on the ground. As firmly presented by Fr. Ben Nebres, we have to move on from implementing one good pilot project after another with no hope of ever going to scale considering the massive requirements of the ground. Several pilot success stories such as the Primary Education Development Program (PEDP), Secondary Education Development and Improvement Program (SEDIP), Basic Education Assistance for Mindanao (BEAM), and various private sector initiatives on reading, teacher training, Math, Science and English, ICT, TechVoc and many more now have the chance of being put to scale.

We can ill afford to continue doing the same way and we refuse to accept that we cannot do better. For we want results, dramatic results in most if not all of the 42,000 schools. We have 19 million Filipino students now in our basic education system. Our dream of a science-oriented Philippines can become an absolute reality in the very near future through the CyberEd and the various initiatives I have mentioned as well as other efforts both in and outside of the Department of Education to create a science and technology culture among our young.

As I was reminded, for example, of the very comprehensive presentation of Fr. Nebres. If that particular presentation is stored in multimedia and made available in all 40,000 schools, not only will the participants of this annual meeting be benefited by resource speakers but the same can now be viewed on demand by the math and science teachers of all the schools nationwide. The potential for e-communication in our archipelago is only limited by our imagination and creativity.

With your support and with the support of all other stakeholders throughout the country we can expect to succeed in this effort.

Rest assured my dear friends from the Academy, DepEd is prepared and anxious to try to think out of the box for this we must do now in order to reverse a trend of a nationwide drop in achievement while showing pockets of global excellence. We must now fill that gap and I ask everybody to work with government, work with the community so that we can create a bright future for our country and for our children.

Thank you very much.

About the Author: Hon. Jesli A. Lapus is the Secretary of the Department of Education. A certified public accountant and MBM graduate of the Asian Institute of Management, Mr. Lapus was a top professional manager in private sector, a three-term member of the Philippine House of Representatives and has served the executive arm of government under three presidents. More information on the programs of the Department of Education is available at: www.deped.gov.ph

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Government's Support to Science Education

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Abstract

Recognizing the importance of science education to power economic growth, the Department of Science and Technology has set specific targets to accelerate the development of S&T human resources and to upgrade the quality of basic education through its visions outlined in the National Science and Technology Plan (NSTP) 2002 -2020. In support of said visions. various programs are being pursued over the short, medium and long-term to meet the targets. The programs include components covering improvement in teachers' capability, learning environment and infrastructure as well as promotion of S&T awareness and consciousness. Notable among these programs are the implementation of various undergraduate and graduate scholarship programs by DOST and its sectoral agencies and councils, training of elementary and secondary science and math teachers, improving access to ICT facilities, and participation in various local and international science and mathematics competitions, science projects and exhibitions.

The success of the government's support programs to science education depends on the degree of effectiveness of the aforementioned program which, on the other hand, requires the proper alignment of the visions and values of the people managing the system and delivering science instruction to the learner. Good leadership and management of the system, both at the macro (national and regional) and micro (schools) levels is a primary prerequisite.

Science education has always played an important role in the development of a country. It has been instrumental in imparting the 'hard' skills and knowledge to our students to enable them to make a living. For many years now, science education has helped the Philippines develop a workforce to support the demands of industry, agriculture, service and the academe.

Recognizing the role that science and technology play in bringing about economic growth and development, nations are taking steps to strengthen its science and technology capabilities. But for a developing country like the Philippines, the daunting challenges of reconciling the increasingly limited availability of resources, escalating costs of research and development, and the rapid pace and complexity of technological innovation still continue.

The DOST however, with the mandate of formulating S&T policies, programs, and projects in support of national development priorities has remained steadfast in employing its strategies and program thrusts, inspite of the magnitude of challenges involved. This is because DOST is driven by three guiding "visions" stated in the NSTP, namely:

- By 2004, S&T shall have contributed significantly to the enhancement of national productivity and competitiveness, and to the solution of pressing problems;
- By 2010, the Philippines shall have carved niches and become a world class knowledge provider and user in selected S&T areas, and shall have developed a vibrant Filipino S&T culture;
- By 2020, the Philippines shall have developed a wide range of globally competitive products and services which have high technology content.

In support of the aforementioned visions, the Department has likewise established explicit targets/ goals of producing quality S& T manpower, enhancing the teaching of science and mathematics at the basic level, as well as science, mathematics and engineering at the tertiary and graduate levels. Moreover, DOST is also promoting the use of state-of-the-art information and communications technology to enhance the teacher-learning process.

INTERVENTION PROGRAMS

In recent years, several programs have been initiated by DOST and councils/agencies, aimed at improving S&T education. It is overwhelming to note that its programs and projects and collaborative efforts with both public and private sector partners have borne fruit that not only indicate the effectiveness of the interventions, but more importantly, provide much-needed encouragement to continue on regardless of the many obstacles faced.

Developing S&T Human Resources

In her speech delivered at the PAASE Meeting "MTPDP Key Challenges in Science and Technology", early this year, President Gloria Macapagal Arroyo emphasized the need to "enhance competitiveness of the country's human capital and develop a critical mass of scientists and R&D personnel". Towards this end the DOST has been implementing various S& T undergraduate and graduate scholarships.

1. Undergraduate scholarships

Republic Act 7687

This program provides scholarships in priority baccalaureate degree programs and post secondary courses to high school graduates inclined towards S&T, yet are hampered financially. Strong budgetary support allows the program to serve on a massive scale, on the average 10,000 or more students from various congressional districts and municipalities all over the country. Currently there are a total of 6,442 scholars being supported under this program.

Merit Scholarship Program

DOST's longest running scholarship program which is available to students who are academically talented and inclined towards science and mathematics. There are 810 scholars currently supported under this program.

Junior Level Assistance Program (JLAP)

The JLAP scholarships are awarded to qualified third year college students who are enrolled in priority engineering courses and other basic and applied sciences. As of SY 2007-2008 there are 65 scholars under this program.

Grant for Educational Assistance on Technology and Science Teaching Courses for Mindanao (Project GREAT-M)

A scholarship program for technical courses aimed at improving the quality of life of Muslim youths and enabling them to contribute positively to national development. Implemented in Mindanao provinces which either consistently did not have qualifiers in the S& T scholarship exam or had examinees with very low passing score in the said exam. To date, there are 41 scholars under this program.

2. Teacher scholarship programs

The DOST also supports various scholarship programs aimed to fill in the gaps in the number of competent science and math teachers, specifically in the areas of Physics. Among them are:

Cooperative Pre-Service Education for Science and Mathematics Teachers (Project 8102 Ed) in cooperation with the PNU, DLSU and TUP Manila

Partial Scholarship for BSE Major in Physics (Project 9001 Ed.)

Scholarship Program for Science and Math Education, Major in Physics (RSTC Project 8901 Ed)

3. Graduate Scholarships

- DOST Human Resource Development Program offers scholarship grant for graduate studies in the fields of natural sciences, physical sciences, engineering and social science courses.
- PCIERD Scholarship Grant aims to uplift the quality of engineering education and increase the number of highly trained engineers needed in the industrial, educational and research institutions.
- PCARRD Scholarship Grant aims to upgrade the capability of the staff of NARRDS (National Agriculture and Resources Research and Development) member agencies through its Human Resource Development Program.
- PCHRD Scholarship Grant aims to develop research competence in the country and to produce a pool of human resources capable of implementing the priority programs of the National Health Research and Development Plan.
- PCASTRD Local Scholarship Grant covers both MS and PhD programs taken on a full-time or part-time basis. It supports programs offered by local flagship institutions identified by PCASTRD
- PCAMRD Research Fellowship provides graduate scholarships to researchers and extension workers from the National Aquatic Resources Research and Development System (NARRDS). NARRDS is composed of over 40 institutions implementing R & D in the fields of aquatic and marine resources.
- SEI Accelerated Science and Technology Human Resource Development Program is a graduate scholarship program which

is a partnership initiative of the SEI and the Semiconductor and Electronics Industries in the Philippines, Inc. (SEIPI) which is the leading and largest organization of foreign and local semiconductor and electronics companies in the country. It aims to train high level human resources needed for S&T activities initially in the semiconductor and electronics industry sectors.

- Faculty Development Program is a three-year scholarship program for Ph.D. in Science Education majoring in Physics, Chemistry, Biology and Mathematics. This project aims to bring to a much higher level the competence and knowledge of science and math faculty in the RSTCs, and to develop their ability to plan, manage, implement and evaluate pre-service and in-service for teachers. The program is offered in two modes—the residential program, implemented through the UP College of Education (UPCE) and Dela Salle University College of Education (DLSUCE) and the distance education mode through learning centers at the UP Open University (UPOU) and University of San Carlos. As of SY 2007, there were 44 ongoing scholars
- Graduate Program Science Education Consortium: The declining number of qualified science and math teachers has come to an alarming level that DOST deemed it necessary to set up more effective and strategic interventions to address this problem. In 2006, SEI-DOST spearheaded the establishment of a common consortium of four universities designed to provide a system for human resource development in the regions and to continually develop a pool of future leaders in S&T education. In this consortium, SEI is developing a common curriculum for a straight masters/doctorate program in science and math education with specialization in biology, chemistry physics and math. The consortium is composed of the University of San Carlos in Cebu City, West Visayas State University in Iloilo City, Mindanao State University in Zamboanga. The project targets to support 10–15 new scholars per university per year for five years and is expected to produce from 150–225 PhD in science education degree holders by 2012.
- The Master's Program for Faculty members of TEIs provides graduate scholarships in science education to teacher educators with specialization in Biology, Chemistry, Mathematics and Physics.

4. Developing teacher's capability

There is a constant need to provide in-service training to equip teachers with both content knowledge and teaching skills for subjects like physics, chemistry, biology and integrated science. Of all these areas of specialization, the most wanting of trained teachers is physics, where more than 92% of those already in the teaching force are neither majors nor minors in this discipline.

The DOST has been implementing new teaching and learning approaches to prepare our young to cope successfully in a knowledge -based economy and at the same time to create a challenging learning experience for both teacher and pupil:

- e-Training for Science and Mathematics Teachers is an online training designed to upgrade the competence and confidence of public and private science and math teachers in the elementary and secondary levels. This 10- month pilot online training program commenced in November 2005 and concluded in August 2006. Selected TEIs served as nationwide training venues where participants were trained simultaneously using on-line mode and printed modules.
- Project MUST. Launched in 2001, MUST is a 90-hr non-degree teacher training program designed to enhance content knowledge and to update teaching strategies of elementary science and math teachers who serve Muslim pupils and youth from other ethnic groups in Mindanao. A total of 6,331 participants were trained under the program from 2001–2005.
- Project RISE. Begun in 1997, this project is a massive non-degree training program designed to improve teaching competence and increase teaching confidence of science and math teachers both in the elementary and secondary levels. Implemented at the Regional Science Teaching Centers (RSTC) and other selected teacher training institutions in the country, Project RISE provides teachers a 180-hr training program for the subject area that each one is to specialize in.
- This program is intended to train physics teachers of selected science high schools in the use of computers and robots and integrate this in teaching physics concepts, theories and principles. The participants as well as the trainers were provided with individual Robolab kits. Hands-on activities included software programming and robot assembly. They were also taught how to integrate robotics concepts in topics on energy, light and optics, electronics and magnetism, force, power, work and motion. After the training, they are expected to introduce these concepts to their respective students, using robotics.
- Training program on new technologies and IT applications embedded systems and robotics aims to train innovative and

motivated students to eventually design their own electronic inventions. Teachers are exposed to the three aspects of robotics (programming, electronics and mechanical design) empowering them to assist students' research projects, and/or update the electives offered in their respective schools.

Developing ICT Infrastructure

DOST's emphasis on ICT began in the early 90s. The development of ICT as an economic sector which has the potential to provide a large number of jobs and entrepreneurial opportunities to many Filipinos, was given new impetus when the President declared in her SONA that ICT will be a leading engine for economic growth. The DOST aims to make the country a world class provider of ICT services and products.

- Mobile Information Technology Classroom (MITC) in the Regions. The MITC represents an innovative and highly effective approach, one which brought ICT to thousands of students. Through a rationalized sharing of the state-of the art computer technology, the MITC enhances school-based science and mathematics learning through interactive courseware experienced in 32-seater fully airconditioned MITC bus, equipped with notebook computers, audio-visual facilities, and teachers who have undergone specialized MITC-facilitator training. Initially intended for Mindanao, it was eventually expanded to other regions.
- Development of computer-aided instructional (CAI) materials for elementary science and mathematics. These are locally developed CDs for science and math intended for distribution to elementary schools with computers. The project aims to disseminate CAI materials for use in science and math teaching at the elementary level, thereby helping improve the quality of science and mathematics teaching. At the same time, it aims to minimize the purchase of costly educational software from other countries. A total of 340 CDs were distributed as of first quarter of December 2007.

Promoting S&T Awareness and Consciousness

The average school and the larger society do not nurture science-oriented students. Science is taught in elementary grades, primarily as absorption of information from textbooks and the teacher, with little emphasis on observation, information gathering and the sense of discovery. At the tertiary level, the introductory science courses do not serve to recruit students into science careers. A very low percentage of high school students eventually proceeds to major in science. The usual perception of science and mathematics as being difficult subjects is carried over and perpetuated in college, hence, has not resulted in producing a critical mass of scientists for the country. For DOST, a skilled and informed citizenry makes for a competitive nation, which is why it continues to invest heavily in the extensive promotion and awareness of the value of science and mathematics.

- Gawad LIDER. This is a recognition and incentive program for individuals and/ or institutions that are able to make exemplary contributions to the development of science education, or the development of science and technology-based innovations or inventions that will improve education. The Gawad LIDER which stands for Leadership and Innovations for Development Relevant to Science Education is designed to be a biennial award.
- DOST-BPI Best Project of the Year Awards. The DOST has undertaken a joint project with BPI Foundation, Inc, the philanthropic arm of the Bank of the Philippine Islands. This project gives recognition and incentive to students who excel in the fields of science, mathematics, physics, chemistry, engineering, computer science and biology. This is exclusive to graduating students from the 10 BPI accredited universities.
- Australian Mathematics Competition (AMC). The AMC provides meaningful venue for secondary students to test their mathematical skills with their international counterparts. An annual international correspondence math competition organized by the Australian Mathematics Trust and sponsored by the University of Canberra and Westpac Banking
- Corporation, the AMC vigorously encourages the participation of schools from countries in the Asia Pacific region as a way to establish professional and cultural linkages through mathematics. The DOST and the Math Society of the Philippines have been supervising the participation of the Philippines in this competition.
- Philippine Robotics Olympiad-DOST-SEI organized the Philippine Robotics Olympiad for the past 5 years following the successes of the past events. This science activity aims to challenge the intellectual and critical thinking skills of elementary and high school students and support the Philippines' aggressive campaign in promoting robotics as one of the new alternative media of effective S&T learning among the youth.

RECENT PRESIDENTIAL S&T INITIATIVES

President Arroyo in her SONA stated "to step into the future, a country that wants to be a player in the global economy needs bold and well-funded research and development initiatives of its own. To this end, we will continuously increase the budget for science and technology and education. For in today's global economy, knowledge is the greatest creator of wealth." Towards this direction, PGMA issued a presidential proclamation on the creation of a science complex with a technology incubation park in a 21.9-hectare area in UP Diliman. The President then ordered through the DBM a release of a PhP 500 million as initial funding for the science complex.

- Proclamation No. 1132 on Sept 1, 2006 creating and designating two parcels of land in Brgy. UP campus as ICT park.
- Release of PhP 100 M for human resource development

The DOST Accelerated Human Resource Development Program (ASTHRD) is a collaborative program of DOST, its sectoral agencies and councils to help improve the country's global competitiveness and capability to innovate through alternative approaches on HRD in S& T and to accelerate the production of high-level human resources needed for S& T activities particularly in the area of R&D. There were a total of 400 slots available for SY 2007–2008. Out of the 363 applicants evaluated, 229 qualified for the 1st semester SY 2007 2008.

CONCLUSION

While the Department of Science and Technology has already put in place intervention programs to bring about improvements in S&T education, much work has yet to be initiated and done. Moreover, the success of the government's support to science education cannot just happen without proper alignment of visions and values of the people managing the system and delivering science instruction to the learner. It requires commitment and involvement of all sectors in society. Appropriate programs on human resource development, improvement of science laboratory facilities and their maintenance, curriculum and instructional materials development efforts must be properly aligned. Good leadership and management of the system, both at the macro (national and regional) and micro (schools) is a primary prerequisite.

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Problems and Possibilities at the Heart of Science Education

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Widespread science education is a necessary though not sufficient enabler for national development. Nation states increasingly recognize that the foundation for such highly desirable knowledge is first laid in schools and therefore, the provision of quality science education is critical. In order to improve science education, what we need is not more science but better science, what we really need is not so much knowing what to teach but knowing how to teach, and how to teach it well. Inquiry-based science amply fulfils all these stringent criteria for it is at the heart of science instruction. However, implementation always poses many challenges, which I will illustrate with some case studies from Singapore. Three ideas are proposed that might facilitate successful implementation of inquiry science in schools (a) continue teaching science as inquiry and believe that it works, (b) search for indigenous solutions and success stories, and (c) fully support the efforts of local teachers.

Science Education and National Development

Let me first begin by parking out the importance of science education and its relation to national needs to briefly set the context.

It is widely acknowledged that one explanation behind the large disparities between north-south countries is the level of national involvement in science and technology. Those countries which were lucky enough to be caught up in the first Industrial Revolution or its recent equivalents have seemed to maintain a robust technological, and hence, economic edge. Economic prosperity in these nations seems to function in a virtuous cycle with both political stability and advanced technological innovation.

It is no wonder that a recent Asian Development Bank (ADB) article asserted that

> **A concerted effort to improve education, science and technology, and innovation capacity is needed. It requires education specifically for the knowledge economy, for research and development, to foster development and innovation in science and technology, and for policy reforms. (ADB Review 2006, p. 6)**

All nation states increasingly recognize that the foundation for such highly desirable knowledge is first laid in schools and therefore, the provision of quality science education is critical. A good grounding in science among young people will allow countries to participate in the knowledge-driven economy. We need to remember too that science education is a necessary though not sufficient factor for economic development (Caillods et al, 1997; Shofer et al, 2000). I think this is one thing we all can safely agree on.

It is therefore rather perplexing to see call after call for reforms in science education. Everywhere we turn, there seems to be some sort of crisis in education. This situation has apparently gotten out of hand in the United States where it has been said that the field of "science education… has been plowed and replowed, but the topography remains much the same from decade to decade" (Ponder and Kelly, 1997, p. 244). James Rutherford, former Chief Education Officer of the American Association for the Advancement of Science, put it this way,

> **In the half-century after World War II, we did some good work in science education, but the lasting results were meager. Science curricula, science teaching materials, science teaching, science teacher education, science education research remained much as they were before the war. (Rutherford, 2005, p. 385)**

What Rutherford and other historians have found is that so-called reforms in education are problematic, there are persistent problems in how we teach science that refuse to go away. Understandably, this state of affairs is troubling both to policymakers and practitioners alike, which has thus led to recent efforts by the international science education community to search for evidence-based practices—"what works"—that lend themselves to concrete change on the ground (Lee et al, 2006).

Given the theme of this meeting, "A Progressive Philippines Anchored on Science: Building a Culture of Science in the Philippines," I want to make a somewhat controversial statement now. We already know that reform in (science) education is hard. Changing a culture is truly a Herculean task. In order to improve science education and by extension assist national development, what we really need is not more science but better science, what we really need is not so much knowing what to teach but knowing how to teach, and how to teach it well (Yager and Lutz, 1994). As Reinders Duit (2007, p. 10) summarized the trends in the literature, he said that the "major emphases are now on improving practice, i.e. on the development of powerful teaching and learning environments and teacher professional development."

What Is Inquiry and Why It Matters

By now, it is obvious that good teaching practices, especially those associated with inquiry-based learning (IBL), are at the very heart of a good foundation in science. Over the last five decades, IBL has been recognized as an essential component of a sound education in science (Bybee et al, 2006). Inquiry-based instruction is a very broad umbrella term and would include related practices such as the investigative approach, hands-on science, laboratory work, the scientific method, problem-based learning to name but a few (Grandy and Duschl, 2007). Inquiry-based learning is, however, not easy nor comfortable for teachers and students who are exposed to it for the first time. For most people, their initial reaction would be something like what the philosopher Nietzsche once said, "If you desire peace of soul and happiness, then believe; if you would be a disciple of truth, then inquire."

I think Nietzsche has hit upon an important fact here; many want peace of soul and happiness, which person enjoys hard work, sweat, puzzlement, and mental disequilibrium? Nonetheless, we neglect the explicit teaching of inquiry, and the using of inquiry to learn science at our own peril. Remove inquiry and we are left with a very impoverished and emaciated form of science; remove inquiry and students are incapable of asking the most basic questions concerning the universe.

Implementation of Inquiry-based Learning Is Difficult

We seem to know what inquiry is, how it works, why it is so successful, why it is something as incredible as holidays, apple-pie, and mothers. But, and this is a very big but, inquiry science is also notoriously difficult to implement effectively. Inquiry science is not easy and poses many challenges for classroom teachers all over the world. Inquiry science as how I understand it, is really at the heart of science education, full of possibilities for real change and improvement but it is also something that presents us with much grief at the same time (Anderson, 2007).

It is said that a chain is as strong as its weakest link. The chain for inquiry science as an effective teaching strategy is strong, the chain for evidence that inquiry-based learning boosts students' interest in science strong, and the chain for coherent curricular frameworks that are based on inquiry are plentiful. What persistently has been found to be wanting and identified to be the weakest link in the whole chain is the actual implementation of inquiry science by the teacher, either through lack of resources, time, or inadequate training or discomfort with inquiry and other reasons. These obstacles are sometimes imagined, and oftentimes real.

For the curriculum leaders and educators here in our audience, you would agree with me that successful implementation is always contingent upon numerous (unforeseen) factors that revolve around people, policy, and place, the three deadly "P"s (Cohen, 1990; Honig, 2006; Keys and Kennedy, 1999). Teachers can be told what to do, teachers can be shown what to do, and they even can speak about what they will do but ultimately whether people are doing inquiry science in the classroom remains an empirical matter. And because inquiry is such a weasel word that refuses to conform to one simple definition, there are as many interpretations of what is inquiry as there are teachers. And thus we can be lulled into believing that I'm teaching in a constructivistic manner when in actual fact the dominant pedagogy in my classroom is very didactic.

Inquiry Science Implementation in Singapore

This very danger has in fact happened occasionally in Singapore. Because change is always hard, educational reforms including those in science education have experienced uneven adoption and successes after a decade of Thinking Schools, Learning Nation (TSLN) reforms in Singapore (Lee and Luo, 2006; Tan and Ng, 2005). TSLN is a major reform movement that encourages critical and creative thinking, a radical questioning of old ways of teaching and a valuing of children and their diverse talents. Local teachers, as with their counterparts elsewhere, are hesitant or unsure about the value of implementing some of these new pedagogies despite a host of creative initiatives such as Project Work, School-based Science Practical Assessment, Strategies for Effective Engagement and Development, Learning Circles, generous professional development opportunities for teachers, and physical infrastructures in schools that are world-class.

What we are realizing is that some teachers lapse into familiar transmissive and didactic modes of science instruction albeit now conducted with greater sophistication using technology (Lee, in press). This has resulted in a hybrid situation in Singapore; traditional forms of instruction are entrenched alongside emerging pedagogies (Hogan, 2006; Venthan, 2006). That transition periods are characterized by flux is to be expected although we believe that the progressive momentum in TSLN can stagnate thereby frustrating national attempts at cultivating widespread 21st century knowledge and skills among young people. The sense of ambiguity among teachers and school leaders is tangible for

> **when one considers how central a successful school system is to Singapore's economic strategies...it seems that there is little scope for a radical freeing of the education system and especially the curriculum. (Sharpe and Gopinathan, 2002, p. 163)**

I would now like to share three stories about implementing inquiry science in Singapore.

Helen the Guerilla Science Teacher: A teacher running ahead of the system

Helen, a primary school teacher whom I worked with is an excellent teacher, full of passion for the kinds of discovery learning that inquiry science brings. However, a number of years ago, she was running ahead of the system and her ideas and passion for inquiry science were not appreciated. Let me now tell part of Helen's story in the form of a self-narrated story or vignette.

> **Hi, pleased to meet you, I'm Helen, a fully certified elementary school teacher, and I do use very didactic methods and rely on the textbook. Ok, I lie but let me qualify that. I do use chalk-and-talk but only when the kids request for learning something that's out of the official syllabus. My goodness, I could go on for two hours and everybody's fully alert, no eye is shut. The next day, these kids will come back with their self-initiated research and questions concerning what I've taught, which is simply amazing to read. Textbooks? They're a double-edged sword now. During those times when I ask the kids to bring out their textbooks, they have the cheek to say, "Huh, we're using the textbook?" And I say, "Of course, I have to bring your attention to something important in the book" but they get very disturbed and most of the time they cry, "But we didn't bring any, you never used it before!" Cunning monsters that's what they are, not book smart but street smart!**
>
> **Let me elaborate how sneaky they are. Once, they requested me to teach them powerpoint and winword. I suspected they just wanted to play on the computer but they vehemently denied that and insisted on learning animation and stuff. I told them I would only teach them for an hour because I was rushing to complete the curriculum, and they agreed. Some time later they requested**

> **30 minutes from me to have their "time," which I again thought that they would do something crazy. Boy, did they surprise me when they made an incredible presentation on animals using all the skills that I had taught them! They even had quizzes and candy for prizes at the end, can you imagine that? It was then when I realized that, "Okay, it's worth it after all". In fact, they were getting more and more demanding after being exposed to my teaching methods over the years. You might say that I'm using a lot of open or guided inquiry methods, that I'm very constructivist but I don't care about labels 'coz I think this is how teaching ought to be whether in science or math or whatever. Nobody in my school however is going to stick her neck out and do what I'm doing. When I tell the other teachers that MOE has officially loosened up and encouraged innovative teaching strategies, my colleagues reply, "It's just too risky! I don't want to slip up on the work review. And it's worse when the kids are poor behaved so it is really not worth the effort. Now, it's not that I don't want to give the kids a good education mind you, it's just these other things."**

I think by now you would have realized that Helen was a teacher who was running ahead of the system, pushing for inquiry science when others were not prepared to go this way. She did excellent teaching, but in guerilla fashion, which is what my new article about Helen is all about. This article will be published next year in the Springer journal, *Cultural Studies of Science Education*, where I am one of the editorial board members.

Miss Chen & problem-based learning: A teacher navigating the educational system

Now, the educational climate in Singapore has changed and inquiry science is strongly encouraged. I'm going to tell the story of a high school teacher who attempted to use problem-based learning in her class recently. Problem-based learning (PBL) follows a process whereby groups of four or five students, presented with an ill-structured authentic problem, work collaboratively to generate hypothesis, identify relevant facts, analyze results, and finally present and analyze their findings. As you can immediately see, the process of PBL resembles the inquiry process that scientists use for knowledge creation where scientists use whatever tools and knowledge at their disposal to solve problems (Hmelo-Silver et al, 2007). Well and good, but how does the introduction of PBL look like when first introduced to students more comfortable with traditional didactic modes of teaching?

The following is an excerpt of a transcript from Yeo et al (2006) and shows an exchange in a PBL classroom with the teacher, Miss Chen (MC) and two students, Sandra (S) and Eric.

S:	Basically, protein has four structures.
Miss Chen:	Okay.
S:	That means different protein has different structures.
MC:	At different levels.
S:	Okay.
MC:	Mmm?
S:	At different levels. And basically, the first one is the primary structure, the second one secondary structure, the third one tertiary structure, the fourth one quaternary structure.
MC:	Okay. Tell me about the primary structure.
S:	The primary structure
MC:	**This one ah, time out. This one must know ah.**
Eric:	Okay.
S:	This is a picture of the protein structure.
MC:	Okay.
S:	And it is made up of amino acids.
MC:	Okay. Amino acids.
S:	And is made of a chain of peptide bonds. So if I'm not wrong, these are the peptide bonds, is it? (pointing to the picture on the tablet screen)
MC:	Ya. They just show bonds by lines lah. Essentially, your amino acids like that right? Primary structure focuses on the fact that there are amino acids connected to each other by peptide bonds. Do you know the structure of amino acids? (pause) **Okay, you need to know.**

We observe that the dynamics of this kind of exchange stopped later when the "crux" of the problem was discussed. For example, we see Miss Chen moving the monologue by terse "OKs" as Sandra explained the structure of protein. This elicitation was interrupted at critical junctures whenever important content matter (i.e., the structure of molecules) that was required for the impending examinations was raised. You see, Miss Chen knew the right answers, and she both explicitly and subtly indicated to the students which were the right answers.

We are only showing you this short exchange but we found that at many other places, this kind of marking and flagging of what was tested for the exams were common. These served to indicate, unconsciously, what the real objective of the initial PBL lesson was—content mastery. One particular phrase that stood out was when Miss Chen assured the class during a long debate among the students this statement, "Don't worry, I'll do damage-control later." It basically meant that students could discuss freely however they thought about the problem at that point although the real authoritative source of information from Miss Chen would eventually come later. And the students, being bright people, caught on, and thus waited for Miss Chen's model answer to come later.

The primary conflict here can be attributed to the tension between the exchange value and use value of the object—exam grades (Lave and Wenger, 1991, p. 112). Problem solving skills and metacognition are useful and essential skills in dealing with everyday problems but may not be so crucial in getting by in the high-stakes examinations in Singapore, which test mainly recall and procedural knowledge. In other words, Miss Chen's PBL classroom activity was embedded within a larger system that values good grades in examinations. Although teacher and students worked through the PBL stages, they were very much constrained by the latter and seemingly more entrenched system. What Miss Chen did was to balance, as well as she could, the ideals of authentic learning using PBL versus the demands of a schooling system slowly undergoing change. Underneath the observable PBL approach to science learning lay the "invisible" system that ultimately drove the action of all the participants—teacher and students alike.

Clementi Town Secondary School – A departmental approach to inquiry science

One Singapore school, Clementi Town Secondary School (CTSS), has gone ahead to spearhead an innovative IBL curriculum for all their secondary two pupils (ages 13-14) since 2006. Called ScienceAlive! (Active Learning through Inquiry, inVolvment & Exploration), pupils in Term 3 have the choice of choosing one of four IBL science units in physics, chemistry and biology (Teo et al, 2007). Traditional paper-and-pencil assessment are removed in favor of alternative testing built into the curriculum although the earlier part of the school year follows normal teaching and assessment practices. Explicit teaching of higher-order process skills such as argumentation/reasoning and planning investigations are infused throughout the 10-week program as well as showing pupils the relevance of science in their everyday lives. Active engagement in learning content is further facilitated through laboratory work, field trips, journal writing and group discussions. Similar to other impactful inquiry-based curricula (e.g., Roth and Bowen, 1995), ScienceAlive! culminates in pupil presentations of investigative projects after the 10 weeks.

From teacher conducted pre- and post-course survey and focused interviews, it was found that there was a significant increase in students' perception of skill competency while a high percentage of students indicated that they had increased awareness of the relevance of science for daily life. From these experiments in breaking out of the curricular straightjacket, CTSS was therefore held out as an exemplar for other schools as part of Teach Less, Learn More, which is a new engaged-learning reform by MOE this year (MOE, 2007). Compared to IBL in other countries (see Abd-El-Khalick et al., 2004), this teacher-designed program might not seem remarkable but when we realize that only about 15% of 44 science lessons observed by Venthan (2006) in Singapore schools performed some kind of laboratory experiments, small group work, or demonstrations at some point then the sheer novelty of thoroughly IBL in ScienceAlive! becomes apparent.

Are there problems to be ironed out? Certainly! At the moment, ScienceAlive! is only confined to grade 8 pupils for one term. What has to be empirically established is whether the excellent teaching practices which I have observed in these past few weeks are likewise present earlier in the year. I suspect that they are but this has to be confirmed in 2009 when we follow the teachers through the whole school year by performing the type of research that I like best, a thick ethnographic study of classrooms, long-term participant observations of classroom interactions. While there are plans to introduce similar programs to the grade 7s in CTSS as well as in grades 7 and 8 for other schools, you would immediately realize that Singaporean educators are reluctant to tinker and experiment with introducing IBL to graduating classes where high-stakes examinations loom on the horizon. Similar to Miss Chen's situation, many teachers and parents are understandably concerned about the adequate coverage of subject matter in our very rigorous examination system. Being once a high school teacher myself of graduating classes, I realize that my teaching methods were heavily didactic for these were the most efficient in terms of delivery of subject matter, a power-packed vitamin pill that was just the thing for scoring well! However, I have since repented of my pedagogical sins, and I have now seen the light, I have found inquiry science! Yes, inquiry science is difficult, inquiry science takes time, but we need to know that learning from inquiry science is enduring, it is interesting, and it raises student achievement in the long run.

The Road Ahead for Inquiry Science

Whither inquiry science now? I have illustrated my claim that implementation of IBL is hard by three short case studies in Singapore. I suspect some of these stories of success and difficulties would crop up once schools begin to be really serious about placing inquiry at the heart of their science education programs, whether in Singapore or in the Philippines. Can inquiry science be sustained in the face of all sorts of pressures and resistance from within and without? Let me end by showing three guiding principles, interrelated beliefs that give us a fighting chance of success in planning for a solid grounding in science education.

i. Continue to teach science as inquiry and believe that it works

IBL is really at the heart of science education, we simply cannot continue stuffing the heads of kids with facts. It is more crucial that students know how to think for themselves. We cannot concentrate too much on the memorization of discrete factoids without knowing how all these things fit together. If we think of facts as bricks and big scientific theories or concepts as buildings, then we need to be able to zoom in and out, to see the bricks and the cathedral that the bricks form depending on the need. Unfortunately, school science too often has focused on the bricks thus many young people leave school disliking science or failing to see its big picture relevance (Millar and Osborne, 1998). A piece of good news is that Helen and Miss Chen have not lost faith in IBL, they are now thriving and pressing on with inquiry science in a more committed fashion. Their students like, no love IBL, and the kids have also done well in the exams, which is a vindication that inquiry science will pay off ultimately. And theirs is not the only case I know where these payoffs have occurred.

ii. Search for indigenous solutions and success stories

Change is always difficult, we know that and we've seen how in Singapore the implementation of new curricular initiatives face obstacles and roadblocks. One might therefore legitimately ask whether it is a question of more action/effort by practitioners or more research on the part of researchers to find workable solutions? We would affirm that both are needed but what has been recently identified by MOE as the most vital factor in convincing teachers in Singapore about the long-term efficacy of effective pedagogies such as IBL is the availability of local success stories (Lau, 2007).What is sorely lacking are the local---not foreign no matter how impressive their outcomes—evidence-based research findings showing that IBL actually does work despite the many real or perceived constraints in Singapore schools (e.g., the lack of time, accountability issues, high-stakes assessment regimes, and parental expectations are common discourses). Without these kinds of indigenous breakthroughs and subsequent transformations in practitioners' acceptance of inquiry science, it is felt that our best efforts at science education reforms will be resisted or adopted half-heartedly by teachers. Because teacher adoption of IBL is paramount, having a detailed set of guidelines about how IBL should be taught is no guarantee of success in improving the quality of science education as the US experience has shown (Rutherford, 2005); more so, a better understanding is required of the mediating factors that lead to contingencies and therefore to the uncertainty about success/failure of new curricula in particular settings. Indeed, the problem in Singapore is all the more acute as teaching science via inquiry modes is now being actively promoted at the macro level across all syllabuses and textbooks but so little is actually known in the local literature about IBL implementation. It is likewise the case in the Philippines too I dare say, and I would dearly love to hear these stories so that we in Singapore can learn from you.

iii. Fully support the efforts of local teachers

One of the initiatives recently adopted by the Singapore MOE is "Top-down support for bottom-up initiative." This speaks volumes. I think it signals that change has to come from the bottom, but this change needs a supportive climate and well-positioned champions that are willing to take risks and allow failures to happen. We also know now that the emphasis has shifted from the adaptation of curricula and materials to the strengthening of local capacity and the development of partnerships among institutions. This present assembly is an enlightened one for it brings together scientists, educators and policymakers into one place over a few days for intense face to face discussions. This is knowledge management at its very best, which we in Singapore can profitably learn from.

In Conclusion

Thus, we envisage that teachers need forms of professional development in inquiry science that meet the needs of their community. I acknowledge that the challenges facing urban and rural teachers in the Philippines are vast, at least in Singapore we only deal with one type of school and resource provisioning is not really an issue. At the end of the day, we can be guided from the experiences of others in a similar situation concerning the implementation of new science curricula (e.g., Rogan 2005 in South Africa) but I don't think anybody has all the answers.

Nobody knows the local situation and its problems better than the

Filipino teachers themselves, please listen to them and support them as best as you can, they are your best possibilities in reforming science education! Thank you very much.

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Building a Culture of Science in the University of the Philippines

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Let me start by thanking the Academy for inviting me to this meeting to share with the science community our ideas and thoughts on a topic which we in the University of the Philippines (UP) very much believe in — building a culture of science in the Philippines. It is a theme which UP itself is committed to. It is a theme that is a prominent part of our ten-point agenda for UP for the coming years.

This morning I shall divide my talk into two parts: first, I shall share with you what we have done to strengthen our science and technology programs in UP. Then I shall discuss our partnership with the private sector in developing our Science and Technology Parks in Diliman.

I shall be the first to say that it is not only during our term that UP has focused on science and technology. That we have a very strong science and technology program is the product of the vision and leadership of many UP presidents before me. When we took over in 2005, we thought it extremely necessary to continue to stress the role of science and technology as contributor to increased productivity, competitiveness and economic growth. What this country needs is a large scientific manpower base—an ingredient so very crucial for a country's progress and development. And UP, being the national university, must take the lead in building up the country's scientific manpower.

If one were to examine the country's college enrollment profile, one would see that 41% of our college students are enrolled in business-related or teacher/training and education programs. UP's enrollment profile, on the other hand, is quite unlike the national profile. At present 42% of our students are enrolled in science and technology programs. This is a profile we would like to maintain, if not improve. Many countries have achieved economic prosperity because they have invested heavily in the sciences and their applications. Guided by the experiences of these countries, we in UP deem it important to continue to strengthen our existing science and technology programs, in particular, our information and communications technology and biotechnology programs, and develop initiatives in emerging science and technology fields.

Today we are happy to report that we have moved forward, pursuing major programs and projects to support a science culture in UP.

First, we have put in place an Agenda for Emerging Fields in Science and Technology.

The objective of this agenda is to develop cutting-edge fields that need to be advanced at the highest possible level of inquiry in order to generate new knowledge, building on our existing resources—i.e., our rich pool of scientists, our updated infrastructure and high-tech equipment and laboratories acquired from unexpended balances and through the support of government agencies mostly from the Department of Science and Technology (DOST) and its various Councils, the Department of Agriculture, foreign donors, and industry collaborators.

Given our limited financial resources, we have decided to focus our research thrusts and directions on some priority projects, selected on the basis of the following criteria: emerging fields that have high scientific/ technological and social impact; the possibility of inter-/multi-disciplinary involvement of different departments/colleges/constituent universities; the presence of existing and potential expertise and facilities, financial sustainability; competitive advantage in human resources and raw materials; and potential economic value.

The following have been identified as specific fields: (1) materials (like bio-materials, biofuels, nano materials, pharmaceuticals and molecular medicines); (2) biotechnology (like nanotechnology, food sufficiency, bioinformatics, and biodiversity); (3) pervasive computing (advanced microelectronics and computational algorithmics, "systems on a chip," and environmental monitoring); and (4) measurement and instrumentation in support of the first three.

We are determined to provide the necessary working environment and financial support for the implementation of this agenda. The UP Board of Regents has established the Emerging Fields in S&T Grant Fund which has two components: (1) the Institutional Development Grant—for the acquisition of equipment and for maintenance and operating costs to be used by existing as well as proposed R&D programs; and (2) the Emerging S&T Research Grant—for the undertaking of research projects in support of the emerging S&T fields agenda.

We have so far approved funding for 12 projects for Diliman, Los Banos, Manila and Mindanao. In Diliman, for example, projects that will boost the research capabilities at the College of Science, in materials and in ultrafast and high resolution optical signal measurement, which is a core technology in nanoscience and nanotechnology R&D are now ongoing.

The emerging fields chosen by UP are well within the National Science and Technology Plan 2002–2020 of the DOST. In fact the DOST was among the first institutions that we consulted when we were formulating the agenda, aware of the need to move side by side with government in the effort to promote science and technology.

The identification of these emerging S&T fields has important implications on the University's curricular offerings, on its teaching and learning approaches, and on its research and extension directions. But at the same time that we are instituting the necessary changes, we are deeply aware that the University needs to remain responsive to the demands of the knowledge-based economy without compromising its social responsibility.

Second, we have established the UP Scientific Productivity System

The UP Scientific Productivity System (SPS) is both an award system and an incentive system, designed to encourage scientific productivity for national development. Deserving scientists among our faculty and research staff in the natural and physical sciences, medicine, agriculture, fisheries, engineering, and the social sciences may earn the rank of Scientist I, II, or III. The rank is a recognition given by UP as an Award, called the UP Scientific Productivity Award.

Evaluation of applicants is based on a set of high standards that will enable "UP Scientists" to occupy their rightful place in the international community of scholars. Only the best and the most deserving are conferred the title which they will hold for three years, and which may be renewed depending on their performance.

The following criteria are used for evaluation:

- scientific publications in refereed reputable journals and books
- peer-reviewed technological output and discoveries
- scientific standing in the international science community
- professional standing in the international science community

The Scientist rank carries monetary awards of P96,000, P120,000 and P144,000 annually for UP Scientist I, II and III respectively. This program is funded from the UP Scientific Productivity System Endowment Fund established by the BOR in 2005.

The Scientific Productivity Award was given for the first time in 2006. In the entire UP System, twenty-three scientists received the award: three faculty members were named UP Scientist III; five were named UP Scientist II, and fifteen were named UP Scientist I.

The SPS is UP's version of the Scientific Career System (SCS) of the Civil Service Commission and the DOST. In fact, the Scientific Career Council helped us craft our SPS which now serves as model to revise/ upgrade the SCS rating system.

Third, we are fast-tracking the development of the National Science Complex.

The National Science Complex and Technology Incubation Park was established through Executive Order (EO) 583, signed by President Gloria Macapagal Arroyo on 8 December 2006. President Arroyo also directed the Department of Budget and Management (DBM) to release P500 million for the project. This initiative was the result of lobbying by Filipino scientists including UP alumni, based both here and abroad, with the support of the DOST, legislators from both chambers of Congress, and other government officials.

The Science Complex hopes to "serve as the national hub for the generation and application of new scientific knowledge in the natural and applied sciences and mathematics."

It is organized, managed, and operated by the College of Science, UP Diliman and will harness the resources of nine (9) of UP's leading research institutions: the National Institute of Geological Sciences (NIGS), the Marine Science Institute (MSI), the National Institute of Physics (NIP), the National Institute of Molecular Biology and Biotechnology (NIMBB), the Institute of Biology (IB), the Institute of Chemistry (IC), the Institute of Environmental Science and Meteorology (IESM), the Department of Mathematics (DM), and the Natural Science Research Institute (NSRI).

The National Science Complex and Technology Incubation Park will be completed on a 21.9-hectare lot in UP Diliman. We hope to complete soon the NIP and Mathematics buildings and start the construction of the Chemistry building with funds from government.

Fourth, the College of Engineering has finalized its proposal for the infrastructure development of the Engineering Complex.

In 1996, President Fidel V. Ramos signed an Executive Order creating the National Graduate School for Engineering. The NGSE was created to consciously build up the number of advanced degree holders in engineering. We have invested P200 Million for the construction of two buildings --the Department of Electrical and Electronics Engineering and the Engineering Library and Computer Science Building. Plans for the construction of new buildings and the repair/renovation of existing buildings have been finalized and have been presented by the Dean of the College of Engineering to President Gloria Macapagal Arroyo, who has committed to provide funding support to see through the completion of the NGSE.

The challenge to promote and develop science and technology is enormous. It requires huge amounts of resources—human resources, physical resources and financial resources -- which universities alone cannot provide. We must assume that government funding in the future will be tight. An alternative is to establish strategic partnerships with the private sector, with industry, in areas where collaborations can result in win-win situations.

The UP-Ayala Technopark

In 2000, UP partnered with the Ayala Foundation to establish a Joint Experimental Facility on Technology Development and Technology-based Entrepreneurship. With this partnership, the UP-Ayala Technopark was established. This project is an academe-industry collaboration that features a network of SMITES (small and medium IT enterprises) located in a PEZA declared information and technology zone in UP Diliman. The facility exists in an environment where interaction, innovation and entrepreneurship are encouraged via idea-exchange and shared access to human resources and information. The building which now houses the project was built in 1993 with support from the Department of Science and Technology. Today, the place is booming, with 9 locators engaged in hardware/software development. The most notable of the projects is the Java Education Development Initiative, a courseware project that makes free, high-quality IT and Computer Science instructional materials, which have been translated into Portuguese, French and Bahasa. The modules are now being used in the US, in Brazil and France. The Philippines used to just be among the so-called "others" that produced Java developers. Now, we are among the top ten countries. In the Philippines, the JEDI program has at least 160 partner schools or 52,000 students and 1600 teachers using the training modules.

The North Science and Technology Park

Construction on the North Science and Technology Park on the

38.6-hectare property in UP Diliman, in partnership with Ayala Land, Inc., is now underway. The project, begun in 2000, culminated in the signing of a long-term lease and development agreement between UP and Ayala Land Inc. in October 2006.

Initial development includes the construction of ten (10) low rise buildings for lease to office tenants in high-technology fields. i.e. telecommunications, telematics, IT and biotechnology and high value business outsourcing (BPO) industry, i.e., accounting, animation, software development, design and engineering services, as well as start-up companies or incubators.

The S&T park is envisioned to be the most prestigious and dynamic example of industry-academe collaboration, and is expected to contribute significantly to national growth. Governments all over the world have recognized the all-important link between scientific expertise and economic development, and universities have set up S&T Parks adjacent to their campuses. The most famous examples are: Bangalore and Hyderabad of India, Tsukuba Science City in Japan, Haidan Science Park in Beijing, Singapore Science Park adjacent to the National University of Singapore, and, of course, the by-now legendary Silicon Valley in the United States.

At the same time, the S&T Park reinforces the University's status as the country's national university, and strengthens its image both locally and globally. We foresee that it will not only be providing a venue for the transformation of innovative ideas into cutting-edge commercial products, and providing faculty members and students access to world-class learning laboratories, but also that it will offer competitive employment opportunities.

For many years now, there has been widespread concern over the phenomenon known as brain drain. Our University has not been exempt. At present, the Philippines cannot adequately provide first rate PhD training in S & T, and this forces students to go abroad for their graduate degrees. Were UP to offer more "world-class" graduate degree programs in terms of program offerings, faculty, facilities, and total environment, we believe that this could prove to be the key to reversing the brain drain. This will also allow for the further training and updating of existing PhD holders in the faculty, as they serve as thesis/dissertation advisers, a must if the UP is to offer world-class graduate degree programs.

We also believe that if comparable job opportunities are available right in their own backyard, our students will opt to stay and honor the commitment they made when they entered the University.

Finally the S&T Park is the best possible use for our idle assets. It will expand our academic prerogatives, and help us to fulfill our mandate of being truly a national university, serving the interests of the nation.

We plan to set up more of the same in our other campuses.

The role of UP in manpower development cannot be overemphasized. Today's students must build upon their mentors' accomplishments, and raise scientific research to higher levels. It is this kind of manpower which can innovate and respond to the needs of society in this swiftly changing world. And even as they contribute to national S&T development, they will strengthen UP's presence in the international scientific community, through extensive publication in reputable peer-reviewed journals, as well as research dissemination through various international scientific forums.

Through these programs, UP also plans to strengthen its partnership with government and industry to ensure that research undertaken will result in products of economic and commercial value, as well as social relevance. The social impact of such technologies will lead to a greater appreciation of S & T on the part of the larger community which the University serves.

Colleagues, ladies and gentlemen, as you can see, the University of the Philippines has accepted its share in the responsibility for creating the country's next generation of scientists. These young men and women will be on the forefront of the country's development in the 21st century.

About the Author: Dr. Emerlinda R. Roman is currently the President of the University of the Philippines (UP) and holds the distinction of being its first woman president. She is a Professor of Business administration and was Chancellor of UP Diliman for two terms. More information on UP's programs is available at www.up.edu.ph.

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Role of Media in Propagating Science

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This morning I would like to speak to you briefly about the role of media in propagating science, as a talked-about topic. Queena was telling me as I sat down with the panel this morning that, "you know Cheche, you are the only non-scientist," and I said yes, that is why it is so intimidating because when I was growing up and at school, I did not like Science. And the aversion really comes from a wrong perception. I have only come to appreciate science recently.

Science is around us

When you speak of science and scientist, the immediate reaction of people is '*Aah, mga nerds!*', 'they are nerds, you can't talk to them in normal people-speak, you have to talk in science geek language, you can't communicate with them, they belong to another stratosphere that does not belong here on earth, they are flying somewhere up there. We liken them to vegetables; you know it is good for you, but we rather not take it. We just go for the dessert: it is more frothy, it is sweeter, it tastes better, and is also a lot more attractive than vegetables. One time I was with some friends from TOWNS, they were scientists from Los Baños and they were saying, "Cheche, *tulungan mo naman kami* to try and popularize science" and I asked a stupid question, "What is science?" Their answer to me was so appropriate and really put me in my place. They said, "Everything around you is science." I said, everything? And I looked around and said yes, everything. The light bulb, the making of the rug, the circulation of the blood in my body, the reason my brain does not work. I don't know if it also includes why the economy is so artificially inflated or why politicians behave the way they do or why elections turn out in the Philippines the way they do. Maybe there is a scientific answer to that.

But in today's atmosphere you begin to wonder if science as a subject for media can be made more attractive, in fact, hopefully as attractive as the gossip stories are on TV, the way on *Star Patrol* or *Star news*, or *Chikaminute* as watched and waited for by people maybe including yourselves. Since this is a scientific meeting, I will not embarrass you by asking you if you watch the news for Star Patrol, or for Chikaminute. How many of us watch the news for this reason? You don't have to raise your hands, just say yes at the back of your mind. The reason is—because there is a certain special quality that these two sections of the news bring which the rest of the news have not been able to mimic with as much success.

The new media

But before going to that, I would like to give a brief picture of the nature of media today. Today, we are faced with two kinds of media; one is called traditional media or trimedia: print, radio, and television. They have been re-classified by today's newer forms and referred to as old media. They are not as exciting as the current and still evolving "new forms" that now challenge the traditional forms we grew up with. Of the three, print radio, and television, the most credible is television and the most sought after as career paths when you go into teaching is television. As the Canadian communication guru Marshall McLuhan said, "the medium is the message." It is the mesmerizing kind of allure that television has. Today, the ownership of television sets is at 96% of all households in Metro Manila, and this translates to 2.2 million homes. In urban Philippines which includes the major cities, 85% of households or 6 million homes have television sets. In Luzon minus Metro Manila, it is 77%, and in the Visayas, 83%. Critics tell us that we have now moved away from the age of information to the age of empowerment.

We know about the web and all its wonders. From emails to blogs to social networking sites like facebook, Twitter and Multiply. From podcasting to MP3 to text messaging to uploading videos of your favorite pet and conducting online research on any topic including the basics of how to zap a pimple on your face. "How to zap a zit?" This is one of the most watched videos on YouTube, Can you imagine? I do not know if there is a scientific connection there, but it is the most watched YouTube video. To google means to do instant research for students who have a paper due tomorrow or maybe 12 hours from now.

We know from observation and now officially recognized is the fact that the Philippines has been named the texting capital of the world. There are 45 million cell phones now in circulation in the Philippines. That is more than half of our population. There are 1 billion texts that are sent out everyday. 1 billion. I do not know what are inside those texts but 1 billion of texts is a lot of news going around.

The Internet population is described as urban, young, and professional, and of the 1.5 billion users, 45% belongs to the age group of 12–19 years old. I was quite impressed by this figure because it shows that the Internet is really a venue that the young are now calling their own. While of the 40–60 age group where some of us here belong to, although some of us are in great denial, there are only 8% of us who use the Internet, whereas with the younger kids 12–19 years old, a good 45% are into it on a constant daily basis. You have seen people who are constantly on their telephones including ourselves today, and you have seen people who check their websites, blogs, emails, facebook, twitter, and multiply accounts on a daily basis without fail. The buzzword today is convergence, whereas in the past when I was growing up with television, we used to depend on a schedule. When is this cartoon coming up, when is this news coming up. Today, that is no longer true. Statistics show us that there are less people watching television today. It is not because there are less people who watch the shows, but because they watch video on demand. Young people or those who are savvy with the Internet or computers, watch television shows when they want to, and in the manner they want to watch it. Some can watch it on the Internet; others can watch it on their iPod while travelling from one place to the next. Watching of television is no longer predetermined by where your television is sitting; whether it is in living room, your bedroom, or your bathroom, is of no consequence. You can now take it to your car and you can take it to bed right on your iPod.

"Prosumers" vs consumers

The young people today are not called consumers; they are now called "prosumers" and have access to more options than they ever did in the past. They can produce their own content. They can produce their own television shows if they want to. If you check all of the websites, YouTube most especially, there are many videos uploaded by young people who choose the topics they want to talk about, to do it in the way they want to do it and they do it without the help of large cameras which we in the industry are so used to operating. In the past, we used to walk around with all those huge bulky cameras, with microphones with all kinds of mixers. Today, one little camera like this one in front of me can take shots, without intruding within the private space of those who they are trying to shoot.

The young people are comfortable with all the new technologies, computers, websites, videocams, digicams, cell phones, and iPods. They are not intimidated by the medium. There are many of us, or many of our older members of the family who will not touch a computer even if you taught them how to use it. My own mother, who is very media savvy, refused to touch a computer. She loved to write and she loved to express herself, but when I was trying to teach her how to use a computer, she said, "No Cheche, I can't, I'd rather use a typewriter." So the movement into the new media has been so swift that today when you ask young people if they have seen a typewriter, some will tell you that they have not. In our own office for example, we have no more typewriters, and when one young intern who joined us recently said "is that for the museum?" I thought, my goodness this was just in use 15 years ago and this kid cannot recognize a typewriter anymore.

Bringing science to its target audience

The young people today have more avenues for self expression; they are more open to new ideas and ways of doing things. They are no longer tied to the ways of television sets. However, I would like to posit here that even with the new media, the traditional forms of media, radio, television, and print, are still the agenda setters in this country. The agendas for news, the agendas for what are talk about are still set by the traditional media which brings me to the point of where science comes in.

In the beginning, I said that science has the general impression of being only for nerds, only for people who are equipped with PhD's and teach at the university. Earlier, UP President Roman said that they are trying to remove from the mindset of the academics the idea of not mixing in with business persons because they have totally different objectives in life. In today's world because of the globalization efforts and because media is now an all- pervasive partner, if you will, in everything that they do, it is necessary for the idea of science to come in to the mainstream of media. How do we do this?

Target audience and choice of media

If media has the impression that science is too high-brow, too unreachable, "*di maabot, di maintindihan*," what can be done about this? The first thing we have to do is to identify the target audience. Who are we trying to reach? What are these groups that we are trying to get interested in what we have to say? Once we have identified who we're trying to reach then we choose the medium that accesses these target audiences. Not all media forms reach specific target groups that we want to address. Second, we have to bring down science from its very high ivory tower where it now stands, where everybody thinks that the only people who can become scientists are those who top their classes.

Speak the language that connects

I understand today that, if science is broken down into its lowest common denominator, it can be as interesting and as sexy as gossip in entertainment news. I always asked the question "Why is it that the break-up of Ruffa and Ylmaz can stay in the news for a week and a half? Why is it that everybody in this room knows every bloody detail of that break-up? But nobody or only a few of us know about ethical questions that our science leaders spoke so eloquently about. Why is it that everybody knows what Paris Hilton wore, when she came out of prison?" But not everybody knows, for example that Dr. Toto Olivera was awarded by the Harvard Foundation as Scientist of the World of the Year in 2007. Why is that so? Is it because it is boring news? Is it because it is not universal in theme or is it because we don't package it like dessert, in the same way Ruffa and Ylmaz, although they have no personal effect on our lives, we know every detail about it.

In the media today we talk about what we call sensational journalism. In the past, it used to be a bad word. If you sensationalize, it means you are not telling the truth. You're exaggerating. But many people argue that the reason stories like showbiz stories rate so highly and are watched so intently is precisely because they are sensational. They hasten to add that sensational journalism is not necessarily bad. They define sensational journalism as focusing on the details and blowing it up, making something small big, but of necessity, sticking to the facts. So if in one showbiz news item, somebody was seen on a cell phone kissing somebody else, it is blown out for all its worth. It is talked about in great detail. What are the emotional effects of being seen kissing somebody on a cell phone. Are there political implications for this act of kissing somebody who was not your husband? What is the physical position of the person when he was kissing the other mouth? When they try to exaggerate little details and make a story out of it they call it sensationalism. But the effect is everybody gets curious, everybody gets interested and everybody watches. And those of us who are against sensational journalism, rail against it and say these should never happen in media. But sometimes the question that should be asked is "does the message get across? And if it answers yes, sometimes the solution should be taken as a way of getting the message across.

So if science is taught as a boring subject, we should identify our target audience, bring it down from its ivory tower, and bring it to its lowest common denominator. Something that Juan de la Cruz can answer, not only Dr. De la Cruz but Juan the carpenter. It is important to speak in the language that connects. If we use scientific words or scientific language, we will put people to sleep. But if we use a language that people will understand, whether it is rap, whether it is rock, whether it is geek speak or sward speak, whatever it is to reach your audience, you have to speak the language that they understand.

Break down big concepts to chewable size

Then big concepts that could be broken down into chewable parts, parts that people can digest easily, not big stuff but small stuff. Because that is what sensational journalism is all about. Talking about small bits and blowing it up so people will remember what you are saying. Package it to look like dessert, so that people are attracted to it and when they bite to it, they will realize "*ay*, vegetables *pala ito*", but it is already in their mouth. And that is the first objective, get into the consciousness of your target audience. Once they bite into it, they have no choice, they can't spit it out. But initially if they don't go into the dessert you won't get it into the mouth. Keep the message short and simple. Once you keep the message short and simple, its easier to digest, it will sick to their minds.

Filipino role models for science

I would like to present now a sample of a story that we did last night on the Probe Team. This is not exactly dessert, but it is a short message that I like to demonstrate. [Note: A 3-4 min video clip by the Probe Team on Dr. Baldomero Olivera was shown at this point.]

The objective of the piece was to talk about these new discoveries, but more importantly, we wanted to show our audiences that there are Filipino role models, that there are heroes of science that we can be proud of, that the world recognizes as first class/first world scientists.

Targeting the youth as specific audience

Some of the suggestions that we have for making science chewable and eatable for the general public is of course to make it as interesting for the public as entertainment news is. And the way to do this for example is to target specific audiences. My personal suggestion is to go into the youth as a specific target audience because that is where interest in science begins.

During the last campaign, we had occasion to ask some of our would-be candidates what they would do to make science a priority project for the Philippines, because we are lagging behind. And some of them focused on the educational system as the main source of engendering science an interesting topic. But I posit here, you must link up with media to be able to make these stories interesting and more sellable as items that they can use.

One specific situation I have, targeting the youth, is to make them interested using new media as an outlet for their creative uses even if they do not have a specific interest in science. It might do well for the academy for example to sponsor a contest which is open to all young people to produce videos for the internet on specific topics that they are interested in, and to provide role models for would-be students who would like to go into science that they can identify with, preferably young role models that they can say, "*kaya kong gawin yan.*" Because when they think of scientists or when they think of science, they always think of the older learned scientists. If you can get a young, hip-looking scientist, then I think it will make the case much better for science. It would be great if at the future time, young people will say, "*ano gusto mo maging?*" The answer could be, "*paglaki ko, gusto kong maging* scientist *kagaya ni*…" a scientist role model. In the same way people will say, "*paglaki ko gusto ko maging artista kagaya ni* Paris Hilton."

Let us get better role models because there are better things to do in this country than become a movie star. To end, I would like to show you a video that I think is the kind of video that should be produced on scientific topics, making it more interesting, more palatable for everyone.[At this point, a short music video (Bloodstream, AB+) was shown.]

Thank you very much. I hope science would be as sexy as that.

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Mentoring Mentors Explicitly

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Introduction

This paper is on mentoring mentors. In addition, an introduction to explicit instruction will be given and this may be able to inform the mentoring process in you own contexts. At the UP College of Education, we do not have a formal structure about mentoring. It is an attempt to put together experiences on mentoring and describe a systematic manner of going about mentoring of students during their thesis/dissertation work.

Can Mentors be Mentored?

The first question that needs to be answered is: "Can mentors be mentored?" When one is perceived to be a mentor, can s/he still be mentored considering that he is already at the top of his game and presumably, there is nothing else for him to learn. The answer is, yes. Certainly, mentors can still be mentored. There is always someone who can mentor a mentor.

However, there are certain obstacles. First is that the prospective mentor might be too busy with his/her own research. In the context of the UP College of Science, in the laboratories of the National Institute of Physics or any research laboratory, one might actually think that mentoring takes too much time away from his or her own research activities.

The second obstacle is that the expert might not really know how to be a mentor. He many not know where to start. How does this process begin?

The third obstacle is that the authority may not be facilitative of another's learning. It may be the case that since the mentor is the expert in a given area or in a particular discipline; the mentee may have the tendency

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[1]*First presented during the NAST Round Table Discussion on Mentoring, March 21, 2007 at the University of the Philippines Diliman.*

to bow to the ideas of the mentor. Thus, instead of facilitating learning, the mentoring relationship might be restricted to a learning subject matter or mastering techniques or approaches in a particular area.

Fourthly, a teacher may not know how to share power and teacher-student is a power relationship. Here, I decided to specifically use the word teacher because it does not have the focus of research advising and mentoring a younger colleague, but only teaching.

Different Academic Relationships

The different academic relationships are master-apprentice, mentor-protégé, adviser-advisee, supervisor-student, tutor-tutee and coach-trainee.

Let us begin with the master and apprentice relationship which is most relevant in the arts. In this type of relationship, the mentee is someone who is watching and observing. Then, the master (or mentor) teaches the apprentice to construct what the mentee wants to construct.

The second relationship is between protégé and mentor. The mentor tutors the protégé who is selected from a pool of people. A protégé is one who is considered special and the only one worth mentoring from among this group. I do not think that the academe has the luxury of selecting only one person to mentor.

The third academic relationship is the adviser-advisee relationship. The advisee asks the adviser on what courses to take, which teachers are excellent, and how the research will proceed. This is similar to supervisor-student relationship. It is not really clear what the differences are between adviser-advisee and supervisor-student arrangements. I suspect that these are just different names for the same type of arrangement and that the nomenclature changes depending on what part of world the mentoring is being done.

The fourth one is tutor-tutee. In education parlance, when we say tutee, it means someone who needs additional support or instruction. Therefore, this would be the opposite of the mentor-protégé. A tutee is someone who needs extra attention, extra time, or extra explanation. Therefore, the tutor would be one who has the qualities and competencies to address such needs.

Finally, inspiration from the business and sports areas brings use to the coach-trainee relationship. In sports, the coach and the trainee would have the implicit supervisor-student relationship. In business, they pretend that they are peers. The coach is just a mentor for a particular skill and s/he can become a trainee in another skill area under another coach. More often than not, however, the coach has a higher position in the hierarchy of company. But the bottom line is that it is still a student-teacher relationship.

These arrangements have different emphasis regarding the type of relationship which will progress between the teacher and the student. Nonetheless, as in all student-teacher relationships, in the mentor-mentee arrangement, someone has to manage the learning.

Mentoring, Mentors and Mentees

Who are the mentees?

I will start with junior colleagues, since my topic is on mentoring mentors. There will be greater multiplier effect if we mentor younger faculty members or junior colleagues first. The second group of people to mentor will consist of the novices, novices in the position or the laboratory. Novices are those who are considering and are not quite decided yet on their area of study and therefore the mentoring will only be on an informative and exploratory level.

Mentees can be students and research advisees, and beginning professionals. In education, we mentor beginning teachers and the process is quite unique. When we mentor novices, we focus our efforts on training them to make good instructional decisions. This will help them convey or impart content or skills better. Teachers need to know how to attend to spontaneous situations occurring in the classroom so that they can apply "fix-it" strategies to help their students understand and gain the competencies they are aiming to teach.

Then, finally, and this includes all of us, mentees are persons who need introduction to a new area of study or endeavor. For example, if I decide to go into boxing, I will have to find a trainer or coach for boxing. I'm sure that while he is teaching me how to box, I will eventually teach him to give better instructions.

Here are two definitions of mentoring:

1. a relationship between two people in which one offers support, guidance, and assistance to the other who is a learner in the senior person's field (Hoover and Frieman, 2002); or
2. an intense caring relationship in which persons with more experience work with less experienced persons to promote both professional and personal development (Caffarella, 1992).

The first idea presented in the two definitions is that it is a relationship, and because it is a relationship, it goes back and forth and is interactive. In this relationship, one person is more knowledgeable and more experienced than the other. This other one is the junior one and is the "recipient."

The first definition limits mentoring to the scope of professional development. The second definition, however, includes both professional and personal development.

Characteristics of successful mentoring

The characteristics of a successful mentoring are: (1) it should be reciprocal. It is not just one person doing all the talking. (2) It should be creative. It is a thinking process: the two minds must meet. (3) Both mentor and mentee should be connected to a vision. In education, when I mentor, I always think of how to make the teaching good, what will make the learning by the children more fun, more meaningful. (4) The mentoring should be informed by disciplinal understanding. (5) It should be guided by professional and ethical practice. (6) Mentoring should be transformative: the mentor should become a better mentor and the mentee should grow and develop depending on their goals and arrangement. In a transformative relationship, both parties change.

What happens during mentoring?

The following usually happen simultaneously during mentoring. The mentor can be: (1) giving direction or guidance, (2) giving instructions, (3) giving feedback, (4) critiquing of performance or work, and/or (5) collaborating on projects or outputs. These particularly happen during thesis advising, checking lesson plans, discussing a paper. They happen all the time. How do these happen during the mentoring process?

Mentoring in the academy can have different levels of involvement from the mentor. In Figure 1, the intensity of the involvement of the mentor is rather low. It is really the student who selects. The mentor can become a role model or a source of inspiration or the epitome of particular character and professional traits that are valuable to the student.

When the mentor is actually contributing into the professional advancement of the mentee, s/he looks at the career development. A mentor may say that certain career paths are available and that one or two are preferable. In Figure 1, this is the second type of mentoring arrangement and the involvement of the mentor is from middle to high. Often times, the thesis/dissertation adviser becomes involved in this manner with a student's research. When a mentor aims to advance the career of a mentee within a given organization or institution, the intensity of his/her involvement becomes stronger. The mentor may actually be seeing the mentee as a protégé rather than just a subordinate with promise.

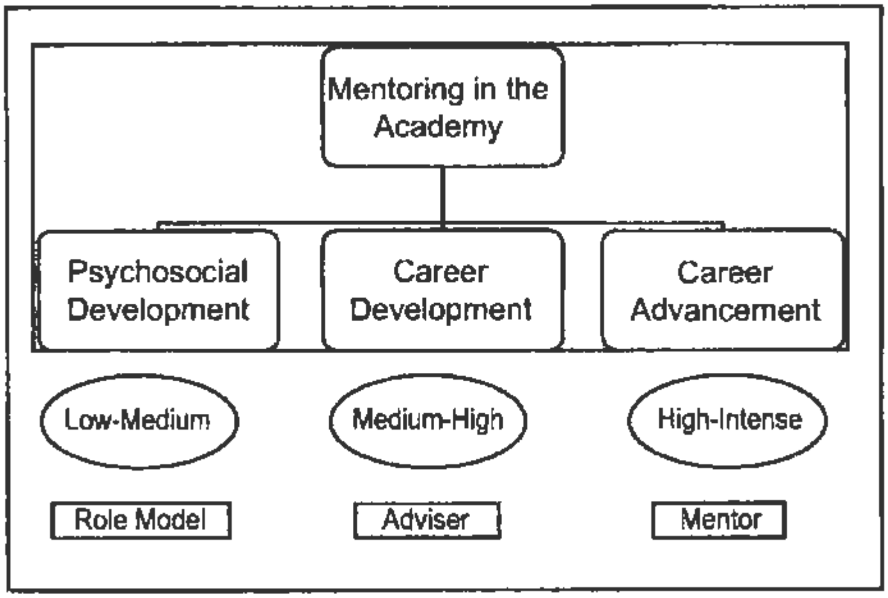

Figure 1. Role of mentor in the academy (From Mertz, 2001)

Who is a mentor?

A mentor is one who (1) can lead us along the journey of our lives; (2) is an expert or an authority; (3) is a willing collaborator; (4) is a guide who is not only concerned with the present (as in a thesis adviser) and (5) is one who not only shares what she knows now but helps the mentee acquire the skills to know more (looks towards the future).

The first definition is so demanding of a mentor and covers everything! With good mentors, we associate certain qualities such as those of willingness to serve as a mentor, genuine concern which does not begin or end with the thesis. A professional mentor looks towards future collaborations with a mentee and thus involves the student in writing papers or in conceptualizing or working on future projects.

Informal and formal mentoring

There are two types of mentoring, the informal and the formal.

We all engage in the informal mode more frequently because it usually occurs during undirected, incidental discussions. For example, when we come across an article in the papers or journals about an issue one of our students in interested in, we usually bring it up when we see them. Sometimes, such informal mentoring can overlap with social events or over a meal.

In the formal mentoring system, there is agreement between mentor and mentee. It has distinct phases and it may exist without the psychosocial considerations. It is usually focused on career advancement. However, this agreement may not actually be explicitly discussed. Sometimes, mentors or mentees, by virtue of their personalities or schedules, strictly limit range of their mentoring conversations to business or work.

This formal agreement has four domains: First, respect and trust, which people always have trouble with. Second is power which people may not always appreciate. Third are boundaries which people always cross. And fourth is profession, which is dictated by the ethics of the profession.

Action points and stances for the formal agreement

Each of these domains may be translated into action points and stances. For example, in the domain of respect and trust, the mentor should trust the student to be a maturing professional and to be serious about the discipline. Additionally, the mentor has to behave respectfully towards the student. A good example is when a mentor critiques only the student's work and not the student. Sometimes, it is difficult to distinguish between the two. When this confusion happens, students leave our offices feeling emaciated and shredded. Some no longer want to continue writing up their research anymore. There are students who drop out of programs because they feel that their mentor attacked them as persons or researchers. Sometimes, this convinces them that they will never make the cut as researchers and academics in their chosen field.

There has to be counterparting of stances. The student, on the other hand, has to remember that his work is being evaluated and that concern is at the professional level. The mentee must trust that the mentor is actually looking out for his development into a competent professional. Furthermore, the mentor will have the best interests of their profession in mind. He should treat his professor with respect due a more experienced professional.

The second domain is power and this is central to decision making. Mentors should let their students develop their thesis in their own style. Otherwise, we will develop or rear clones who will only do the same research that we do. The student also has to take responsibility for the way and the pace he or she will learn. Students should not blame their adviser if their paper is not finished in three years. The student has to take responsibility for that. And taking responsibility means acknowledging his or her power in this relationship. There should be no passing the buck.

Third are boundaries. This is where the line blurs. In some or perhaps many cases, professional boundaries flow into personal boundaries. Therefore, the mentoring relationship has to turn to more explicit avenues, or else, it will become convoluted. The mentor has to make a decision to discuss only about professional matters with the mentee during the mentoring session. In Reading Education, there are only four of us who can advise doctoral students. Thus our consultation schedules with students are quite tight. When we set an hour for the discussion of the dissertation with a student, we therefore need to discuss only the dissertation during that hour, and then the next five min after the first hour can be for anything under the sun. There has to be some structure or else even the faculty member will be carried away.

The last domain is in relation to the profession. The mentor should regard mentoring as a high priority responsibility and should be a model of the highest professional ethics to the mentee. On the other hand, the mentee should respond to the mentor's constructive comments and work to integrate them in his work. He should also learn and apply the profession's code of ethics.

Table 1 summarizes the action points and stances for the formal agreement between mentor and mentee.

Table 1. Action points and stances for the four domains of the formal mentoring agreement.

Mentor	**Mentee**
Respect and Trust	
1. I will treat each student with respect. 2. I will criticize only the work; not the student. 3. I will trust the student to be a maturing professional. 4. I will trust the student to be serious about the discipline	1. I will treat the professor with respect due a more experienced professional. 2. I will take all concerns about my professional growth to my professor before I talk to other people. 3. I will trust that my professor is concerned with my development into a competent professional. 4. I will trust that my professor has the best interests of our profession as his concern.
Power	
5. I will use my power as the gate-keeper of the profession fairly. 6. I will let the student develop in her own style. 7. I will let the student make her own decisions and set her own priorities.	5. I will take the responsibility for my own learning and growth. 6. I will deal with the consequences of my decisions. 7. I will recognize my professor's responsibility to push for high standards in my professional performance.

Boundaries	
8. I will recognize the autonomy of the student in handling her family and social life. 9. I will focus on meeting the student's needs and not my own. 10. I will focus on putting my students in the forefront and staying in the background.	8. I will only ask my mentor for help with professional matters. 9. I will take full responsibility for the consequences of my own life choices. 10. I will set my own career goals based on my own values.
Profession	
11. I will place mentoring as a high priority responsibility. 12. I will model the highest professional ethics.	11. I will respond to my mentor's constructive comments and work to integrate them into my work. 12. I will learn and apply my profession's code of ethics.

Explicit Teaching

The explicit teaching cycle is shown in Figure 2. Allow me to emphasize that explicit instruction is actually very useful for mentoring because it provides the context in which the actions and stances discussed above can happen. Explicit instruction, like all instruction, begins by setting the objective. The process itself begins with the introduction, then the teacher models, provides practice—guided practice first and then independent practice, and finally evaluates. After this, a new goal is set. By keeping to this sequence, the mentor is able to stay on track and the mentee knows exactly when is happening in the mentoring process.

Here is an example of how this process might be implemented. Help the mentee identify the goals of the mentoring relationship. Make sure that the goal identified is the appropriate developmental need of the student at that particular time.

For example, let us assume that the objective is to gain competence in writing a journal article. Once the objectives are agreed upon, the mentor instructs through a variety of strategies, and methods. By modeling, the mentor is able to show how a problem may be solved or how to analyze data. Once the mentee has grasped what must be done, the mentor should provide numerous opportunities for the student to practice the new competency or skill. For instance, if the enroute objective is to write an abstract, then the mentor should instruct the student on the qualities of a good abstract. They can evaluate some abstracts using the criteria and even improve badly written ones. To increase their competencies even more, ensure that the student has multiple opportunities to write abstracts. For example, provide the student with an outline so that they practice writing. They can also practice writing abstracts using extant journal articles.

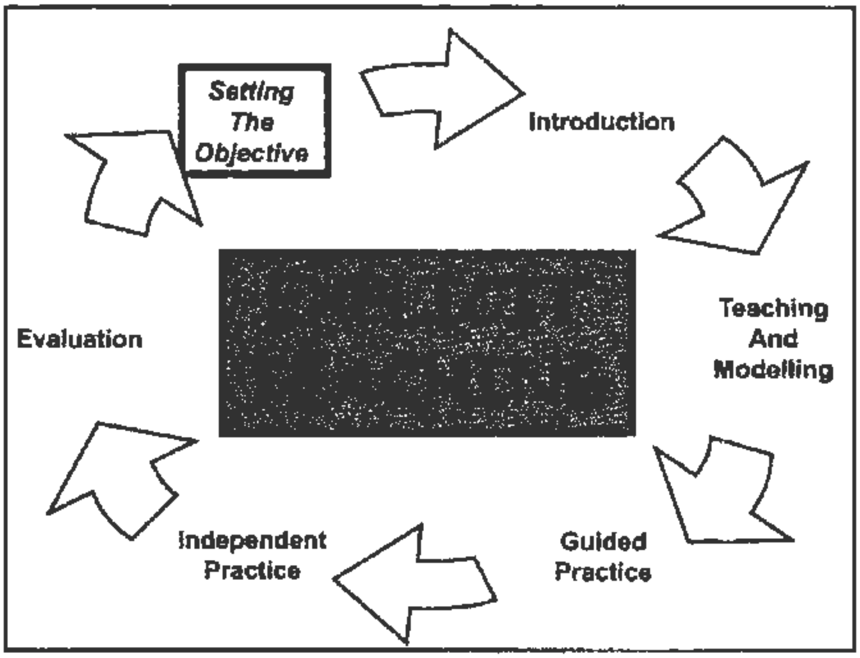

Figure 2. Steps in explicit teaching cycle.

An important element of practice is the use of scaffolds to learning. These should be introduced and used to assist the student during the beginning of instruction. Gradually, these should be withdrawn until the student shows that they are no longer needed to optimum performance. Good mentors scaffold, increase expectations, scaffold again until the learning goals are met. For both parties to know the progress of their mentoring arrangement, it will be important to integrate assessment venues and avenues—self, collaborative, critiquing, feedback giving. Some mentors are more critical than others. However, whether focusing on the weaknesses or the strengths of a student's work, make sure that the student understands what he or she has to do next to improve the work itself. Therefore, each level or form of assessment should inform the student about the progress of his or her work while at the same time enabling the mentor to reflect on the instruction or mentoring arrangement.

Table 2 summarizes these little steps that can help us in effective mentoring.

Table 2. Little steps to help mentor more effectively.

1. Allow for some informality
2. Meet frequently
3. Manage the agenda and the agenda setting
4. Offer alternatives
5. Demonstrate how these can be done/attained
6. Acknowledge the benefits of mentoring to you, as mentor to your mentee
7. Encourage self-assessment

In addition, here are a few more suggestions that might make the mentoring arrangement more productive. One is to allow some informality whilst engaging in a structured or explicit mentoring arrangement. Another is meeting frequently. What is good about this is that each meeting need not be too long. Third, make sure that every mentoring meeting has an agenda which ideally the student should propose.Though the agenda is usually negotiated, encouraging the student to set it actually fosters the development of responsibility and self-direction in the student. Finally, I would like to stress that it is also important to make the student realize that the mentor benefits from the meeting as well as the mentee. I believe that this anecdote will make my point. Several years ago, I had a student from a university in the South who was doing his PhD in Reading Education. While writing his dissertation, he resumed his teaching post and was only able to come to Manila during the summer term. Obviously, this was the only time we could discuss his work in person. Yet I noted that he rarely set an appointment, though we would bump into each other in the library or the corridors of the Benitez Hall. Finally I asked why he was not coming to see me?

His explanation shocked me. He said, "I do not come for consultation because you are a doctor and I do not have enough funds to pay for consultation fees." After overcoming my surprise, I explained that it does not work that way in UP. As an enrolled student, he could meet with his research adviser as often as needed so that he can finish. In addition, I also emphasized that he was helpful to me because his research data helps me understand students even more. Apart from being clarified about the nature of a dissertation adviser-research student relationship was, he needed affirmation that he was not wasting my time. I operationlized this by asking him to write a synopsis of our mentoring sessions. Each entry had two parts namely, "What I Learned" and "What I Shared". These logs helped him get over his preconceived notions that mentoring only benefited the student and most importantly, the log was able to help him assess his own progress as a research student.

I hope this helps in answering your own developmental needs in mentoring student research. Thank you for inviting me today.

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Teaching High School Physics Effectively

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The Ascending Levels of Learning and Pedagogical Maxims that could guide effective teaching of physics are presented. As an example of how these may be applied, the Dynamic Learning Program (DLP) of the Central Visayan Institute Foundation is briefly discussed. The DLP, together with 21st century technology, provides a scenario where the perennial lack of high school physics teachers in the Philippines can be bypassed.

Introduction

The breadth of topics that may be covered in teaching physics can be extremely wide. After all, physics probes the smallest things in the universe (the quarks and leptons), all the way up to the "biggest" subject one can think of—the birth, death, and fate of the universe itself. One definition for physics states that it is the study of matter and energy. Most everything in the universe is either matter or energy, and this can make physics quite interdisciplinary. No wonder, therefore, that sub-areas in physics may be referred to as Biophysics, Geophysics, Chemical Physics, Mathematical Physics, Astrophysics, Nuclear Physics, Econophysics, etc., and one also has the physics of sports, the physics of art, and so on. Because of its breadth, there is always the danger to learn physics by rote. How then do we approach the teaching of physics?

Ideally, high school physics should awaken the innate curiosity that resides in each student. It should spark the inquisitive mind and allow the learner to experience the thrill of knowing the unknown. The student should

[1] *Parts of this paper draw heavily from other presentations of the authors, e.g., in "Best Practices in Basic Education in Asia Pacific," organized by The Coordinating Council of Private Educational Associations (COCOPEA), Century Park Hotel, Manila, 9 Nov. 2006.*

feel the joy and frustration that characterizes the process of discovery, and acquire an appreciation of the predictive power of science. To accomplish this is not an easy task. To help a physics teacher, we discuss the Levels of Learning in the next section, and discuss the following pedagogical maxims: (i) Learning by doing, (ii) Sound fundamentals, (iii) Mastery not vanity, (iv) Adaptability, and (v) Honesty. We then look at the realities in Philippine education and present a 21st century scenario for learning physics.

Ascending Levels of Learning

Being conscious of the four Levels of Learning (Figure 1) could provide useful insights in the teaching of science and math. At the base of the triangle is Visual-Kinesthetic Exploration. In trying to understand an object for the first time, one may look at its shape, color, its touch and smell, etc., almost like the way babies do. For example, one may be observing how a rough red ball falls to the ground. In the absence of the higher levels of learning, however, one may be led to think that the velocity of the falling ball has something to do with its red color.

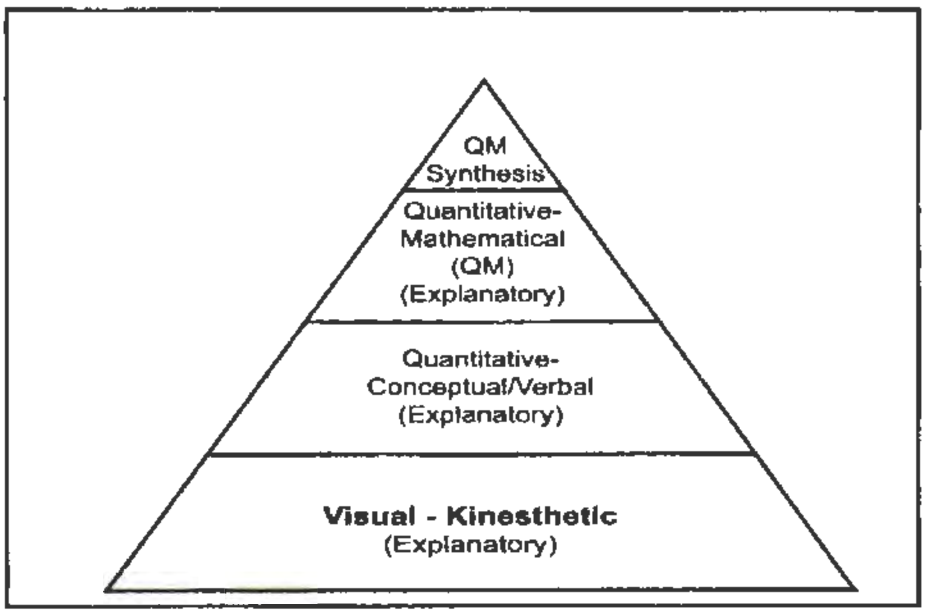

Figure 1: Levels of Learning

A step higher in the Levels of Learning is the Qualitative-Conceptual/ Verbal explanation where one ventures to provide a rational understanding of a natural phenomenon. A common anecdote is often used to illustrate the inadequacy, though seemingly logical sense, of conceptual-verbal explanations. Consider a child watching a cow munching grass. The child has had the chance to play with grass, pulling it out, bunching it up, and letting it fall back to the ground. Asked why the cow does not fly even if it wanted to, the child answers, "The grass has tiny magnets inside and, therefore, once the cow eats the grass, the magnets are attracted to the earth's magnet. So the cow cannot fly." Another example is a curiosity. While introducing a lesson on gravity in a first year science class (typically 13-year old children, numbering around 45 in the class), we were surprised to see that more than half of the class initially explained gravity in terms of magnets. Somehow, their exposure to the magnet impressed them with its attractive power. In any case, the key idea here is that stopping at qualitative-conceptual explanations of observable phenomena is clearly insufficient and can be misleading. It is difficult for the layman to test the validity of premises and check the logical consistency of a chain of arguments. College students may recall the Aristotelian view that a heavier object falls much faster than a lighter one. Almost 1,900 years passed before this was disproved by Galileo Galilei through actual observation and experimentation. A popularized erroneous theory accepted for centuries is the Ptolemaic model of the universe. Galileo (again!) was involved in the dispute on the earth-centered versus sun-centered models.

Of higher order is quantitative-mathematical explanatory learning. Here, we take quantitative to mean numerical description or measurement of observables. One has to know how to measure, calculate and manipulate equations to get numbers that can be tested in the laboratory with precision. It is here where we can confirm that the velocity of a falling red ball has nothing to do with its color. This level, in fact, has enabled mankind to progress technologically by leaps and bounds. It has allowed us to explore the depths of the ocean and put men on the moon. Quantitative-mathematical learning enables us to appreciate the predictive powers of science and equips the inquisitive mind with a tool to explore the unknown. We recall, for example, what D. Halliday and R. Resnick have written :

> "...a deeper understanding of the power and beauty of this theory [quantum theory of the hydrogen atom] is not possible without a full mathematical treatment."

Galileo's thoughts on this issue are also revealing when he wrote :

> "Philosophy is written in this grand book – I mean the universe – which stands continually open to our gaze, but it cannot be understood unless one first learns to comprehend the language and to interpret the characters in which it is written. It is written in the language of mathematics, and its characters are triangles, circles, and other geometrical figures, without which it is humanly

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[2] *D. Halliday and R. Resnick, Fundamentals of Physics (Wiley & Sons, New York, 1981) p. 818.*

[3] *Galileo Galilei, in Il Saggiatore, Ed. L. Sosio, Feltrinelli, Milano (1965), p. 38. (trans. by S. Drake); underscoring ours.*

impossible to understand a single word of it; without these, one is wandering about in a dark labyrinth."

What would be the pedagogical implications of the hierarchy of learning in Figure 1? We have noticed a trend emphasizing the conceptual part of physics teaching and learning over its mathematical structure. This trend started in the 1980s and has progressed to alarming levels at present. ('Alarming levels' being taken to mean that physics learning is confined to classroom or garden demonstrations and verbal explanations of physics theories and principles. Computations and derivations from first principles, so-called formulaic manipulations, are given less attention.) Of course, this trend towards popularized physics is understandable in view of the efforts to make physics learning "fun" and more manageable. Then, too, a number of physics teachers themselves have difficulty in the rigorous mathematical aspect of physics. However, there is the risk of a backlash—weaker preparation for the rigor of college and graduate level physics and math. The rigorous approach has historically been the determining factor in the strength of a science and engineering program. And this is expected to remain so in the science-and-technology-dominated 21st century. We therefore seek a healthy balance or rather, a progressively ascending program of learning, indicated by the pyramid in Figure 1. Here, clearly the apex depends on a solid base of conceptual understanding and empirical evidence (visual-kinesthetic, which may be technologically enhanced, e.g., the use of the electron tunneling microscope in probing materials of very small dimensions).

The apex, quantitative-mathematical (QM) synthesis, is difficult to achieve but is the fountainhead for high-impact creativity and accelerated technological advancement. The quantitative-mathematical synthesis is best exemplified by the history of physical theories (see Figure 2).

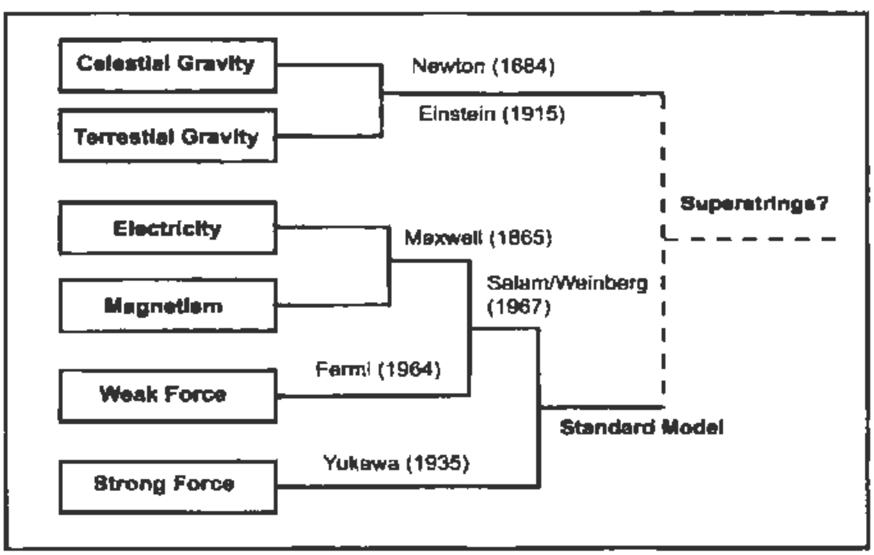

Figure 2. Historical trends in Physics

Before the 1600s, celestial gravity, which is responsible for the motion of the moon, stars, galaxies and other heavenly bodies, was believed to be governed differently from motion occurring on earth, such as a falling rock. Isaac Newton, however, proved that the trajectory and motion of the moon and a falling rock obey the same equation. Figure 2 indicates this synthesis by joining celestial and terrestrial gravity with a solid line. This view was superseded when Einstein introduced his special theory of relativity (1910) and general relativity theory (1915) with another synthesis: Space and time can be equally treated as coordinates of a four-dimensional world.

Electricity, exemplified by lightning, and magnetism exhibited by lode stones were for many centuries considered unrelated. A series of discoveries in the 1800s culminating in the mathematical formulation of James Clerk Maxwell showed that electricity and magnetism obey the same laws and equation. They also travel with the same speed which is the speed of light. Hence, today, we refer to the two as electromagnetism.

The macroscopic phenomena described by electromagnetism would later be unified with two microscopic, sub-nuclear forces: The weak force and the strong force. This unification is best explained and demonstrated by the Standard Model based on a theory first introduced by C N. Yang and R. Mills. The trend in the history of physical theories has led many physicists to believe that all the forces in nature may, perhaps, be understood in a unified form. Various attempts, e.g. Superstring Theory, have been made, but for now, we indicate this presumed unification with a dotted line in Figure 1.

To foster creativity and help develop more students up to the apex of a pyramidal hierarchy of learning (Figure 1), the Central Visayan Institute Foundation (CVIF) in Jagna, Bohol, implemented in 2002 a Dynamic Learning Program (DLP). There are pedagogical maxims, however, that guided the choice of functional strategies for the DLP. We discuss these maxims in the next section in relation with the CVIF-DLP.

Pedagogical Maxims

(i) **Learning by doing.** *For science and math, students need to think with their own minds and work with their own hands.*

This Learning by Doing maxim is most manifest in the CVIF-DLP . At the CVIF, lectures are given only 20% to 30% of the time, while the rest

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[4] *M. V. Carpio-Bernido and C. C. Bernido, in Proceedings of the 26th Annual Meeting of the National Academy of Science and Technology (NAST), July 11-12, 2004, Manila Hotel.*

of the period is left for students to accomplish the pre-designed Activities. In general, no prior lecture is given when a new topic is introduced. Once the students have acquired the habit of learning on their own they can, in fact, study and apply physics principles, solve physics problems even without any lecture.

To help teachers avoid reverting back to the traditional way of teaching, i.e., lecturing 80% of the time, the CVIF-DLP makes use of Parallel Learning Groups (Figure 3). This means that all Physics classes are held simultaneously. Since the

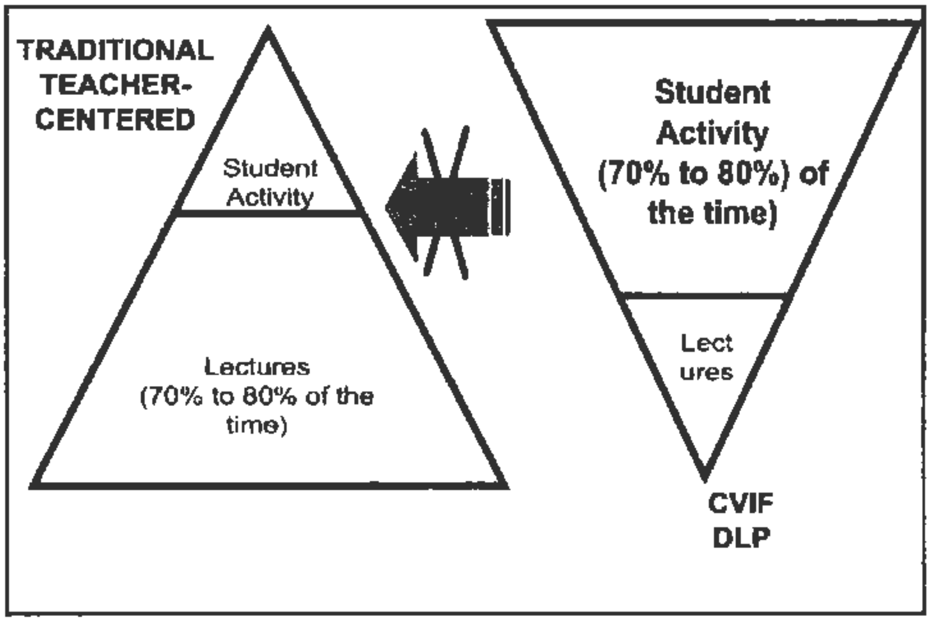


Figure 3: The parallel classes scheme provides an impenetrable barrier to prevent sliding from the learner-centered CVIF DLP back to traditional teacher-centered strategies in the course of the school year.

physics teacher cannot be in two or three places at the same time, this prevents the teacher from lecturing more than 30% of the time.

(ii) **Sound fundamentals**. *Virtuoso levels are reached only by being well-grounded in the fundamentals.*

In the teaching of science, sound fundamentals can manifest in being well-grounded in (a) the required mathematics, and (b) the scientific method.

As emphasized in our discussion of the Levels of Learning, a certain amount of mathematics is required to appreciate science. To illustrate the importance of mathematics as the language of physics, we show in Figure 4 some areas in physics and the kind of mathematics used.

Moreover, being aware of the scientific method helps eliminate errors that may proliferate at the Qualitative Conceptual/Verbal Explanation level (Figure 1). In essence, since various hypotheses are created equal in the absence of evidence, experiments have to be performed. An acceptable physical theory is one that agrees with replicable experiments.

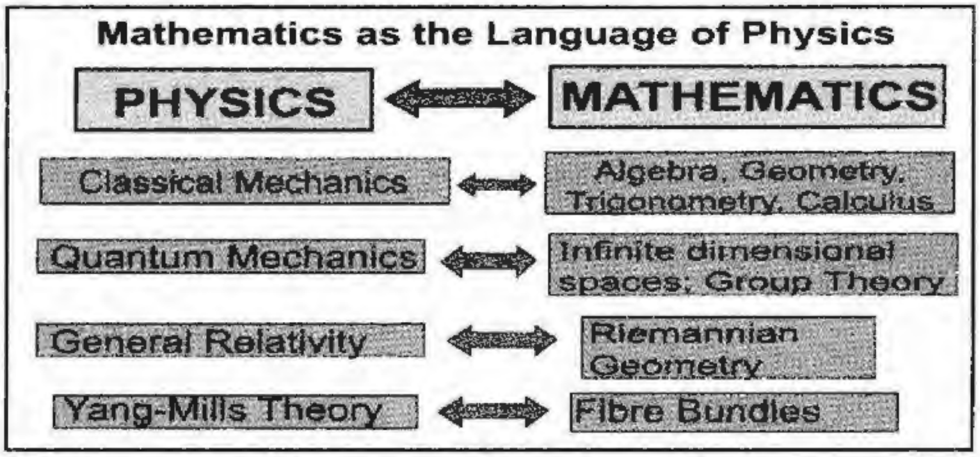
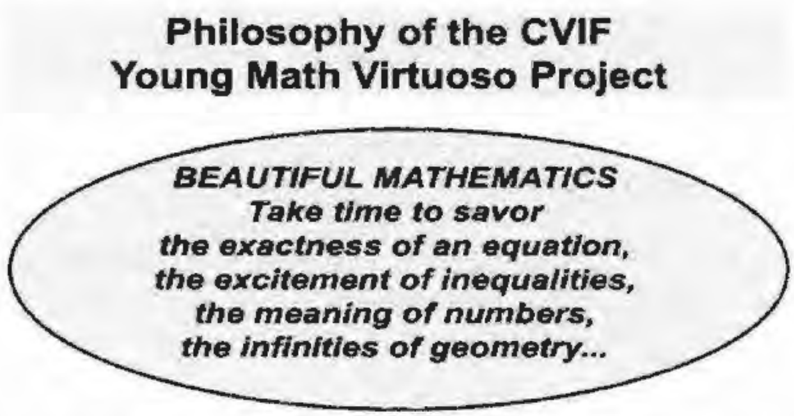


Figure 4. Mathematics as the language of physics.

(iii) Mastery not vanity. Simple problems completely and clearly solved have greater educational value than advanced problems sloppily analyzed with forced final answers.

In implementing this maxim we can cite, for example, the philosophy of the CVIF Math Virtuoso Project:



(iv) **Adaptability.** *An educational program must be adaptive because no two learning situations are ever completely alike.*

In view of the varying resources available to a school, a certain amount of adaptability should be exercised by a teacher without compromising the goal of bringing the students up the apex in the Levels of Learning (Figure 1). It may be instructive to quote a comment given by a noted Dutch physicist who was visiting the Research Center for Theoretical Physics, CVIF, for three weeks. Since the RCTP is by the sea and he had plenty of time to gaze at it he commented that, "one could actually teach the whole of physics just by looking at the sea." The deep implication of this is that effective teaching of physics need not require expensive sophisticated equipment.

Take for example a simple pendulum (Figure 5) which virtually anyone and anywhere can make. Just by tying an object with a string, one could already demonstrate the concepts of acceleration due to gravity, force diagrams, conservation of energy, simple harmonic oscillator, circular functions, wave motion, etc.

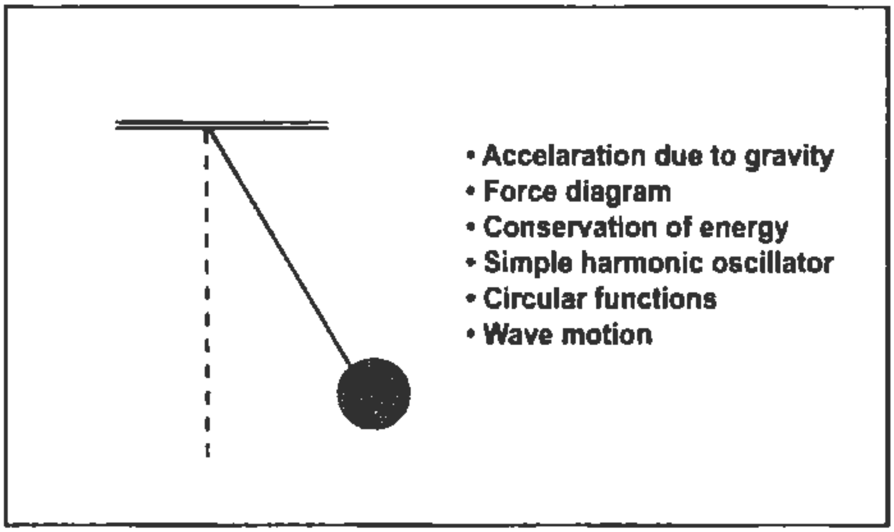


Figure 5. The pendulum.

(v) **Honesty.** *Cheating is unscientific. Fraudulent data invalidate evaluation and assessment.*

These are the five empirically based maxims which have served as a compass for the choice of strategies in the CVIF Dynamic Learning Program (DLP).

Learning as One Nation: A 21st Century Scenario

The problems which hound Philippine education range from large classes, and error-ridden textbooks to ill-equipped teachers. A Department of Science and Technology (DOST) survey, for example, showed that only 27% of physics high school teachers are qualified to teach (with a full undergraduate education/science major). The situation is further exacerbated by the massive outflow of our better teachers to foreign countries.

For schools with available physics teachers, there still exist weak links in the teaching chain. Figure 6 shows a sample teaching chain from the physics principle to be learned up to the student's understanding and application of the principle. Dashed lines show how steps may be bypassed. Clearly, any weak link in the chain can cause distortion in the teaching and learning of the principle. Any inadequacy of preparation, obscurity of presentation, or personality aberration in any part of the teaching chain can impede learning or cause physics phobia. Recognition of this fact can help us solve the problem of poor performance in physics, and science in general, of Filipino students.

To address the serious lack of qualified physics teachers in the Philippines, the "Learning as One Nation," scenario has been proposed . This involves live televised lectures by Ph.D. degree holders in the subject area. The technology needed to implement this project already exists and has been readily available to the masses. In fact, game shows have been widely exploiting them for some time now. It is feasible to bring together the experts, the school systems, as well as private and government agencies, to apply this technology to a more worthwhile endeavor: the proper education of future generations of Filipinos.

The project involves a televised live 30-minute lecture by a National Expert Teacher (NET) to be beamed to secondary schools around the Philippines at a specific time. As in many secondary schools in advanced countries, the NET should be a Ph.D. degree holder in the subject area. All the participating schools can then tune in simultaneously to allow students to watch the lectures. Students can then text, call or e-mail their questions and receive feedback from the expert teacher in real time. Teachers from the individual schools will serve as Facilitators during the forum. This project allows a short and medium term solution to the worsening problem of poor math and science preparation of students due to under qualified teachers at the Secondary level. There are excellent professors in universities in math and the sciences. What is needed is to bring their expertise to the secondary schools in the most efficient way possible, and that is through mass media and instant messaging via text or internet, or through phone calls.

Since lectures by the NET are only once a week, the rest of the time will be spent by students doing the Activities designed by the Expert Teacher. This emphasizes the fact that mastery in the subject area, especially science and math, can only be acquired following the "learning by doing" principle. The "Learning as One Nation" project is, in fact, an offshoot of the positive experiences derived from the CVIF-DLP. In particular, students can acquire mastery even if lectures on a subject are limited to only 20% to 30% of the

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[5] *M. V. Carpio-Bernido and C. C. Bernido, "Learning as One Nation," Philippine Daily Inquirer, p. A16, Nov. 20, 2005.*

time complemented with pre-designed Activities.

In view of the huge cost involved in a live lecture, a scaled down version is now in preparation with the pilot phase to be implemented in school year 2008-2009. The "Learning Physics as One Nation: the Physics Essentials," funded by the Fund for Assistance to Private Education (FAPE) will utilize videotaped 15-minute lectures and demonstrations of national experts in VCD format. Learning Activities to be accomplished by students would be in an accompanying Physics Essentials Portfolio.

With additional support from the private sector and the government, the impact of this project may still be expanded.

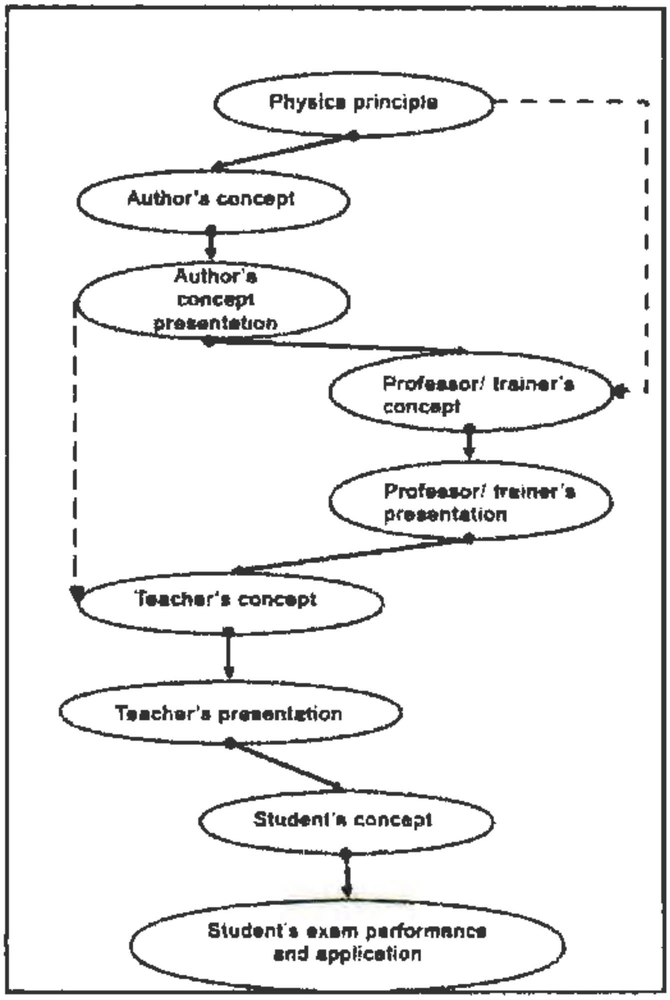

Figure 6. Weak links in the teaching chain.

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Teaching Innovative and Inventive Thinking: An Educational Imperative Towards Building a Culture of Science

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The pop culture on science, as popularized by the entertainment industry, shows that it deals with inventions. This culture, showing science as capable of outrageously inventing something whether good or bad, is etched in the consciousness of students. The preconceived notion developed by students is that when they study science, they too will be able to invent something. But how do we teach inventive thinking? The Philippine culture of complaining is reflective of the lack of proper training in problem solving skills, i.e. attacking a problem with the aim to be the first one to find the most viable solutions to the problem. This paper will tackle the promotion of improved problem solving skills among students towards innovativeness and inventiveness. The Theory of Inventive Problem Solving (TRIZ) is a powerful methodology for improving thinking processes, producing systematic innovation and creating novel inventions. The application of TRIZ has shown tremendous impact in the industry for decades (most new innovative products available in the market today are likely a product of TRIZ thinking). However, due to its developmental history which is tied to the industry, TRIZ is relatively unknown to educators especially in the Philippines. The potential of TRIZ principles and tools in developing innovative and inventive thinking among Filipinos is very promising and its applications have enormous benefits to society. This paper introduces TRIZ to Filipino educators and describes the initial attempt of integrating TRIZ in the academic setting. It also attempts to put creative and innovative ideas into inventive actions hoping to ignite the Philippine educational system thereby creating a culture of science.

Keywords: inventive thinking, innovation, TRIZ, science education

Introduction

The current curriculum in science teaching demands the integration of technology. Technology integration in science teaching does not only mean the use of technological tools in teaching, but the integration of technology like explaining the metal manufacturing process or showing the concepts in food production, etc. The technique also deals with explaining, in relation to the concept, how a certain technology works like a refrigerator, microwave oven, pressure cooker, etc. This requires that teachers are able to bridge the gap between the abstract concept and the practical applications.

Concept → Technological Application

The approaches in technology integration in science teaching are commendable in a sense that students get to see the relevance of the concepts being taught to real life situations. From an abstract model, the concept becomes real as can be seen by the wonders of the technology being integrated. However the essence of technology integration in this context is limited to appreciating the existing technology thereby promoting passive thinking among the students. There is a need to transform this practice to a more productive endeavor giving students the opportunity to solve problems, drawing on knowledge and skills from several disciplines and developing the capacity to apply knowledge and produce alternative solutions to real life problems.

In promoting a culture of science among students, this paper posits that science teaching should go beyond the mere integration of technology. Students should be able to sense that science and technology are continuously evolving and that they, as young as they are, can be a part of the next wave of concept that provides ultimate solutions to existing problems and improve the current state of technology or be the first to introduce the next level of technological application that will change the playing field.

Concept → Technological Application → Solves Problem via Innovation/ Invention

The learning process should therefore provide students the necessary tools, skills and opportunities so they are able to contribute to the body of scientific knowledge via inventions, innovations and ideas. Being able to do so can be promising, fulfilling and satisfying for students. This approach is anchored on Abraham Maslow's pedagogical model [1] that the highest level of learning is self actualization where students reach a level of extreme satisfaction via realization of self-development, as well as satisfying the esteem needs through recognition of their scientific contributions.

Developing a Nation of Problem Solvers

The Philippine culture of complaining is reflective of the lack of proper training in problem solving skills, i.e. attacking a problem with the aim to be the first one to find the most viable solutions to the problem with minimal costs and harmful effects. This is in contrast to the Japanese culture of aggressively finding solutions to even the most mundane problems like eating super hot noodles. Educators as well as government and business leaders are therefore asking the question: "How can we teach our people to be creative and innovative?"

The discipline of creativity and innovation however is not well understood. A well accepted notion is that creative and innovative thinking is the result of good luck or chance. Another school of thought is that inventive solutions are developed by people who are gifted in some special way. Educators who have taken interest in creativity and innovation education have offered methodologies like brainstorming through group dynamics. Others follow the "1%-inspiration-99%-perspiration" formula of Thomas Edison which calls for trial-and-error approach.

The trouble with luck, genius and trial/error approaches is that there is no reliable or repeatable method of teaching or achieving innovation. Contrary to popular belief, inventiveness, creativity and innovation can be taught and learned. Invention does not have to be an accident, and is not necessarily restricted to a few individuals with special talent. Invention and innovation are thought processes that can be studied, modeled, and reproduced — usable by all. Edward de Bono [2] demonstrated that creativity is a skill that can be taught and developed by individuals regardless of the race and he promotes direct teaching of thinking as a basic skill. While de Bono's psychological activation methods[1] are widely accepted, it is very beneficial to have innovation tools—tools that are readily available for people to innovate. A more distinctive approach to innovation called the Theory of Inventive Problem Solving (TRIZ) is available but relatively unknown (vide infra). TRIZ provides systematic method in solving problems and enhances decision-making.

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[1] *De Bono's methods include: Brainstorming, Lateral Thinking Methods, Six Thinking Hats, CoRT, etc.*

The application of TRIZ has shown tremendous impact in leading industries[2] for decades and its benefits to society is very promising. Most innovative products available in the market today are likely a product of TRIZ thinking[3]. However, due to its developmental history which is tied to the industry, TRIZ is relatively unknown to educators especially in the Philippines. It is with this perspective that the integration of TRIZ in Philippine academic setting is explored. By incorporating these inventive principles to science education curriculum, the problem solving capabilities of teachers and students will be developed towards innovativeness and inventiveness thereby developing a nation of problem solvers. This paper attempts to put creative and innovative ideas into inventive actions hoping to ignite, in the Philippine educational system, a culture of science and invention.

Teaching Innovative & Inventive Thinking through TRIZ

The current imperative of education is aptly echoed by Dr. Jim Killian, the former president of Massachusetts Institute of Technology, "The basic aim of education is not to accumulate knowledge, but rather to learn to think creatively, teach oneself and seek answers to questions as yet unexplored". But how do we teach creativity? How do we teach inventive

[2] *Many Fortune 500 companies use TRIZ to design better products, simplify processes, understand disruptive market trends and improve their handling of intellectual property. Companies known to embrace TRIZ are: Siemens, Samsung, Delphi Automotive, LG, Christian Dior, Procter & Gamble, Dow Chemical, DuPont, BMW, Dutch State Mines (DSM), Motorola, Boeing, Kimberly Clark, ABB, Whirlpool, HP, Intel, Unilever, Colgate Palmolive , AMD, Chrysler, Daimler-Chrysler, Dura Automotive, Eastman Chemical, Ford, GM, Hitachi, Honeywell, IBM, Johnson & Johnson, Lockheed Martin, Kodak, McDonnell Douglas, NASA, National Semiconductor, Navistar Nortel, Otis Elevator, Panasonic, Parsons, Peugeot, Rockwell, Shell, Rohm & Haas, Rolls Royce, Teck Cominco, Toyota, TRW, UNISYS, United Technologies, Visteon, Xerox, etc.*

[3] *More companies are intensifying the TRIZ training of their personnel to strengthen their innovation capabilities. Engineers at Dow Chemical have developed new polymers with TRIZ. Otis Elevator used TRIZ to prevent escalator belts from wearing. Proctor & Gamble developed Crest Whitestrips™ and incorporated micro-motor inside the Crest SpinBrushTM using TRIZ. TRIZ solved automotive transmission problems at Peugeot. LG Electronics, eradicated noise problems in air conditioners using TRIZ. Despite success stories in industry, still little is known about TRIZ. These success stories would have attracted attention to the TRIZ methodology but due to the proprietary nature of the TRIZ projects in each company, these information are suppressed resulting to vast majority of people unaware of it.*

thinking?

Introducing TRIZ. The teaching of inventive skills can be achieved through a proven algorithmic approach called the Theory of Inventive Problem Solving or popularly known by its Russian acronym TRIZ (Teoriya Resheniya Izobretatelskikh Zadatch) [3, 4]. It started in 1950s when Genrich Altshuller, the founder of TRIZ, studied thousands of patents. Through patent analysis, he noticed that there are similar solutions for seemingly unrelated problems in different industries. Even intriguing is the existence of time gap between applications where similar solutions appeared years apart. For example, the generic concept of "increasing the pressure then suddenly dropping the pressure" has been shown to be applied in sweet pepper canning, shelling cedar nuts, shelling sunflower seeds, producing powder sugar, cleaning filters and splitting imperfect diamond crystals. While the inventive solution is conceptually similar, the date of innovation is years apart as shown in the 27-year gap between the patent for pepper canning (1968) and the patent for splitting imperfect diamonds (1995) [5]. This time gap could have been eliminated had the solutions been "accessible" to inventors.

Altshuller also noticed that inventive problems can be codified, classified and solved methodically. By identifying and categorizing the innovative solutions from these problems in patents, Altshuller realized that one could gain access to solutions that would normally be unavailable due to one's area of specialization or narrow field of vision. Hence he devised the 40 Inventive Principles by which most, if not all, problems can be solved. He also discovered that the evolution of a technical system is not a random process, but is governed by certain objective laws [5]. These laws can be used to consciously develop a system along its path of technical evolution.

How does TRIZ work? In TRIZ, the approach in problem solving is to raise the specific problem into a generic TRIZ problem (Figure 1)[4] which would lead one to sets of potential standard inventive solutions. Since the TRIZ inventive principles and general solutions are available, one can generate ideas easily (even outside one's area of expertise) reducing the time significantly. This approach is directional as opposed to the trial and error techniques where any attempts at solving the problem requires longer time, limited by one's area of specialization and may lead to more errors for every trial with more chances of problems not really solved.

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[4]*Figure 1 is adapted with modification from Souchkov, V. 1999. TRIZ: A Systematic Approach to Innovation Design < http://www.insytec.com/TRIZApproach.htm> (Accessed on 2007 June 4) and from TRIZ Basic Course Material, Intel Corp.*

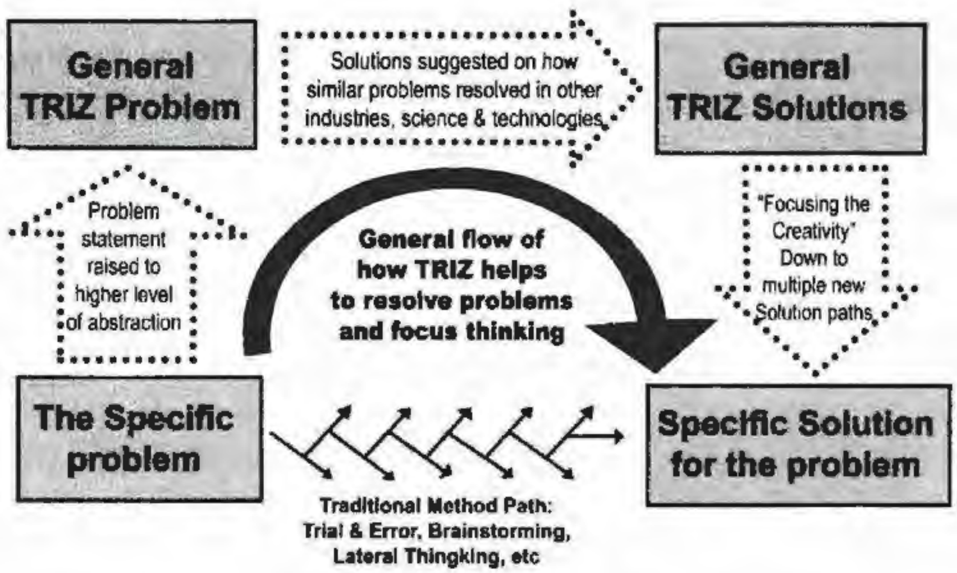

Figure 1. Directional path for solving problems in TRIZ as compared to traditional methods.

In raising the abstraction level of the specific problem, one needs to dissect the problem to the function level such that a functional model by which the problem occurs is built. Each technique in TRIZ consists of a number of guidelines, rules or principles which indicate how to cope with a specific problem or situation. Unlike the well known techniques for psychological activation, like brainstorming, TRIZ provides a systematic methodology for innovative solutions to a wide range of scientific, engineering, organizational or societal problems [6].

TRIZ Principles

TRIZ provides a set of principles that encourages people to think at a different level and to think outside-the-box. The following description of TRIZ is brief and is not meant to be comprehensive. Available books abound for complete description of principles.

Ideality Principle. When confronted with any problem, one is faced with two possible approaches. Clarke [7] aptly describes the two approaches: For any problem, one can look at improving the current undesired situation by asking: "How can we improve the current situation or process?" The second approach looks at a vision of ideality and asks: "What is the ideal solution?" The distinction is critical, since each point of view leads on different paths and toward different sets of possible solutions. TRIZ attacks problems from the second point of view.

"In the concept of ideality one imagines the Ideal Final Result (IFR) – the ideal state of the system where the desired function occurs but the problem is absent. Ideality is a qualitative representation of the ratio of the sum of a system's useful functions to the sum of its undesired factors or effects (Figure 2). It optimizes all the useful functions while eliminating all possible harmful effects including cost."[5] This is a result of Altshuller's discovery that all technological system evolves towards increasing ideality. Hence the objective of TRIZ is to strive for ideality but achieving it is very rare. Innovations nearing ideality are high level innovations. Using ideality as a goal is very effective in reducing psychological inertia[5].

$$\text{Ideality} = \frac{\Sigma \text{ Functionality}}{\Sigma \text{ Costs} + \Sigma \text{ Harm}} = \frac{\text{All USEFUL functions}}{\text{All HARMFUL functions}}$$

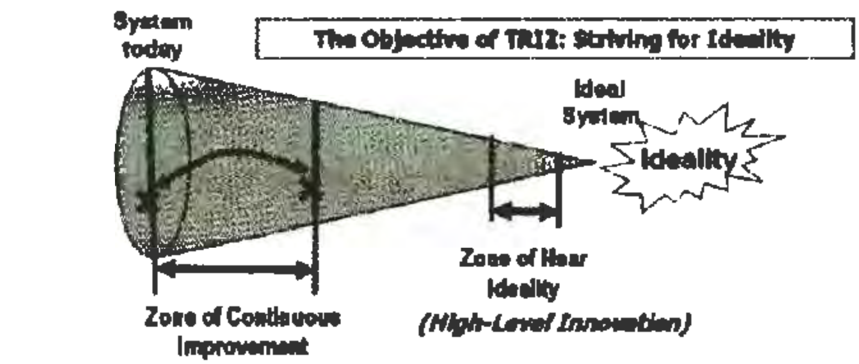

Figure 2. Ideality principle[6]

The ideal system performs a required function without actually existing. For example the IFR for a machine is that the function of the machine is

[5] *Kowalick defines the psychological meaning of the word "inertia" as a state where one is indisposed to change due to human programming - a certain kind "stuckness" due to the way humans think. It represents the inevitability of behaving in a certain way because it has been indelibly inscribed somewhere in the brain. It also represents the impossibility, as long as a person is guided by his habits. Psychological Inertia (PI) represents the many barriers to personal creativity and problem-solving ability, barriers that have as their roots "the way that I am used to doing it." In solving a problem, it is the inner, automatic voice of PI whispering "You are not allowed to do that!" or, "Tradition demands that it be done this way!" Kowalick, J. 1998. Psychological Inertia. TRIZ Journal August 1998 < http://www.triz-journal.com/archives/1998/08/c/index.htm> (Accessed on 2007 June 4)*

[6] *Figure 2 is adapted with modification from TRIZ Basic Course Material, Intel Corp.*

achieved but there is no machine. The function is often performed using existing resources. These resources abound in any system. Some are free resources like gravity, wind, fluidity, shape, etc. Others are part of the system itself like the container, propeller. Other resources can be thought of as harmful side effects like vibration, heat. Some resources appear to be non existent like a dead space (which can be used for temperature insulation or sound insulation).[4] TRIZ practitioners are adept in identifying these resources and in converting these into something that can solve the problem.

To illustrate, a TRIZ classical problem [8] involves this scenario: "A metal's resistance to a strong acid is usually tested by immersing a cube shaped metal in the acid at certain temperature and time. The metal sample is then tested towards its effects on acid immersion. Unfortunately, the acid also damages the walls of the acid container, thereby complicating the test results. There is a need to improve the testing process especially if one is doing thousands of tests with limited acid containers. A typical solution provided by non-TRIZ practitioners worldwide suggests a change of the container into an acid resistant container or to coat the container with a special material. This type of solution is answering the question of: "How can we improve the current situation or process?" In TRIZ approach, one should ask: "What is the ideal solution?"

"Ideality is achieved by performing the function with existing resources. The obvious resources in this system include the acid container, the metal alloy, and the strong acid. According to ideality, the container is a harmful effect and should not exist, so the focus is directed at the other resources like the metal alloy itself, or additional resources can be identified (geometric resources include size, shape, and volume of the metal alloy). The acid has resources too (fluidity, specific gravity, volume, etc.). The environment surrounding the specimen and acid contains resources such as gravity, temperature, humidity, etc" [8].

TRIZ practitioners are skillful in finding resources in the system that contains the problem and use these resources to solve the problem. In this case, gravity, the fluidity of the acid, and the shape of the metal alloy were combined to create a solution: change the shape of the metal sample, such that it becomes the container for the acid. The solution is elegant in a way that it utilizes the available resources, eliminates the harmful effect (contamination with the corroded container is eliminated) and maximizes the function (to test the resistance of the metal alloy with acid). This kind of thinking is very innovative and inventive.

"TRIZ emphasizes achieving ideality using a structured and repeatable method. The process is teachable and transferable. Whether one can solve the problem is not the issue. One must be able to produce inventive solutions (ideality) consistently. TRIZ provides the structured methodology for realizing that goal" [8].

Contradiction Principle. The barriers to achieving Ideal Final Result comes in the forms of contradictions – a situation in which an attempt to improve one parameter of a system leads to the worsening of another parameter. In normal thinking, we often consider contradictions as a stumbling block to creative ideas. In TRIZ, one needs to search for the contradictions because by removing these contradictions in a system, a good inventive idea is generated. In fact, a very reliable indicator by which to evaluate an idea is to see if the function is maximized and it removes the contradiction.

To illustrate, this problem shows how contradiction principles helps solve a long standing problem in industry [9]: "In producing pure copper sheets, the electrolytic process generates a small amount of electrolyte liquid that is deposited on the pores on the surface of the sheets. When the copper sheets are stored the electrolyte liquid evaporates, creating oxide spots on the surface which reduces the value of the copper and results in financial losses. The best way to solve the problem was to avoid creating the pores in the first place. But doing so requires lowering the electrolytic current, which in turn results in significant reduction in productivity. Instead, a company usually decides to reduce the financial losses by washing the sheets of copper prior to storage to remove the electrolyte from the pores. This was not only costly but inadequate, and attempts at improving the washing process continued for long time. In fact for over 15 years (with millions in losses) engineers and scientists from similar productions all over the world tried to solve this problem. They achieved very limited success, mostly by pursuing better ways to wash off the electrolyte."

The contradiction in this problem is that the electrolytic current must be low to avoid pores, and must be high to increase productivity. By applying the methods in TRIZ for dealing with physical contradictions, a solution can be generated in a fairly straightforward manner. "To do this, one should ask the following: Where (if trying to resolve a contradiction in space) or when (for resolving a contradiction in time) do we really need the current to be low to avoid pores? The answer is obvious: a low current is needed at the end of the process to prevent the pores, while during most of the process the current can be high to ensure a high level of productivity. Given the fact that the complete cycle takes 72 hours, it was revealed that reducing the current for the last 30 minutes only was enough to produce pore-free copper. It is astonishing to note that with TRIZ training, people who have worked with the problem for 15 years were able to find the answer in half an hour!" [9].

Altshuller's researches revealed that inventors through the ages had been employing a relatively small set of techniques to resolve contradictions, regardless of the field or application in which they worked. From that, Altshuller identified 40 Inventive Principles. This collection of inventive principle is the most widely known and used in TRIZ problem solving technique where each principle recommends a certain method for solving a particular problem. If the problem can be mapped to a generic problem, then anyone can directly access the most used principles (which are systematically organized into a matrix according to the type of contradictions) and generate ideas to solve the problem.

Other Foundational Elements of TRIZ. Limitations in space only allow this paper to present very brief descriptions of two TRIZ concepts above. The reader must be advised that this paper does not present a comprehensive and working knowledge of TRIZ. The discussions presented merely provide a simple glimpse at two foundational elements of the science of TRIZ[7].

TRIZ is a methodology utilizing numerous principles, tools, and other methods. To learn more about TRIZ, a non-exhaustive list of other elements of TRIZ is presented below. Each of these elements has a philosophical and applied base that is essential to gaining a complete understanding of TRIZ.

- **Technical and Physical Contradictions**, a technique that helps problem solvers spot contradictions in a system and identifies methods for resolution.
- **Contradiction Matrix**, a tool that directs inventors on the statistically appropriate inventive principle in resolving a contradiction based on contradicting technical parameters
- **40 Inventive Principles**, a collection of inventive principles where each principle recommends a certain method for solving a particular problem.
- **ARIZ** (Algorithm of Inventive Problem Solving), an integrated technique aimed at solving most difficult inventive problems that contain physical contradictions.
- **Su-Field Analysis** (Substance-Field Analysis) is a method of analysis where the problem is modeled as two substances (two objects) that interact through a field. It helps to view a problem in different perspective such that different sets of inventive solutions are suggested.

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[7] *The reader is warned against forming conclusions about TRIZ solely on the basis of this paper. The author strongly recommends the references listed on the last part of this paper for a more comprehensive and detailed discussion with case studies to see the full merits of TRIZ.*

- **76 Standard Inventive Solutions**, a problem solving technique in TRIZ showing a collection of inventive standards for problems that involves undesired interactions.
- **Laws and Trends of Technology Evolution**. This involves the study and analysis of general tends in technology evolution and how one can get inventive ideas by predicting the changes the product will experience in the future basing from a general trend making it easier for anybody to develop a strategic plan for new inventions.
- **Systems Thinking**, a TRIZ technique that helps one to expand the vision and helps extend analysis level by looking at the subsystem, system, and supersystem
- **Scientific and Physical Effects**. This part of TRIZ focuses on studying how to use the knowledge of natural sciences (physics, chemistry, geometry etc.) in the inventive process.

Integrating Triz in the Academe

Integrating TRIZ into the academic curriculum is an educational imperative that must be addressed with urgency to develop among our people innovative and inventive thinking. As with most technical topics, TRIZ can be self-taught, but formal training helps focus the mind. TRIZ has been incorporated in most Russian schools including elementary level [10] and picked-up recently by American [11], European and Japanese schools [12]. Due to its impressive ability to deliver innovative solutions to technical problems, engineering schools in the US are already beginning to embrace TRIZ. In the foreseeable future, TRIZ will be a required subject in engineering programs. The potential of TRIZ principles and tools in developing innovative and inventive thinking among Filipino students is very promising and it is time we integrate TRIZ in our curriculum.

Science Education. The potential application for TRIZ in the sciences is unlimited. TRIZ yields tremendous efficiencies in the sciences by systematically eliminating the majority of solution variants and providing completely new solutions paths for research. This promises to revolutionize the scientific method and accelerate scientific discoveries. TRIZ-educated students in physics, chemistry, biology, etc., will not only utilize their disciplinary knowledge, but also draw upon knowledge found in other disciplines.

The crucial task is to reach science instructors and educate them about TRIZ. This may prove to be difficult. Most science instruction is narrow in focus and scientific research is even narrower in focus. This is due to the belief that a high degree of specialization is required to advance each scientific sub-field. TRIZ has the potential to liberate both science instruction and scientific research by leveraging knowledge found across scientific disciplines and providing an entirely new methodology for solving problems.

Initial Focus on Pre-service Science Teachers. The integration of TRIZ in the Philippine academic setting is explored initially in the existing pre-service science education courses at Philippine Normal University - Manila (PNU). By incorporating these inventive principles to the pre-service science education curriculum, future teachers will be capable of propagating the skills and concepts to high school students via multiplier effect. Pre service science teachers are also the stage where their minds are more open to new ideas compared to in-service science teachers. They are far more accepting to new concepts, strategies and technologies because they are less disturbed by imposed boundaries, limitations and bureaucracies often experienced by teachers in the field.

The approach in teaching innovative and inventive thinking based on TRIZ is developed and applied to third year science education majors in chemistry (BSE Chemistry and BS Chemistry for Teachers -BSCT) and physics (BS Physics for Teachers -BSPT) at the PNU. The third year level of science education at PNU is characterized by majorship stage where students focus on the content study of major science as they prepare for the research stage, teaching techniques and off-campus practicum on the fourth and final year. Science education majors at PNU are major feeders of competent science teachers at the public and private secondary schools in the country. These future teachers will also be major players as research advisers in the high school level science investigative research like the Intel's International Science & Engineering Fair, DOST's SIBOL and the National Science Fair by the Association of Science Educators of the Philippines (ASEP). By introducing TRIZ to the pre-service science education curriculum, future teachers will be capable of propagating the creative concepts, inventive principles and innovative thinking skills to secondary students thereby developing a culture of science and invention among students. The next phases of this study will include a secondary level incorporation of TRIZ.

TRIZ Training. Introducing TRIZ to university syllabi (as well as in secondary level syllabi) however is not easy. Although creating a totally separate 3-unit credit course dedicated to TRIZ is ideal (can be an elective course but should be a mandatory subject in any engineering course), the reality in any academic syllabi is that curriculum are exceedingly overloaded and there's no more slots available to introduce and insert a challenging and comprehensive subject like TRIZ. Considering the limitations, the present study is opting on alternative modes of instructions.

In industry the best known method in teaching TRIZ to engineers requires 40 hours (1 week) of training for the basic level and followed by 40 hours for advanced level and another 160 hours (1 month) are allotted for more advanced level usually taught by internationally recognized TRIZ masters. In between the basic and advanced levels, engineers are required to solve a real problem in line with his work area or create a verifiable inventive idea emphasizing the use of TRIZ concepts and tools. Aside from the TRIZ study materials available outside the industry, in-house mentorship and virtual community of TRIZ users are available within the company to sustain the trainings and learnings of engineers.

In introducing TRIZ to the academe, an abridged training material is developed for this present study considering the level of students. A two day seminar workshop for basic TRIZ was conducted initially for 29 interested students (will be expanded in the future study). The timing of the seminar is scheduled two days prior the start of the semester. This is to create effective transformational learning to students since they are fresh from vacation eager to learn again and most importantly, they are not pre-occupied with the rigors of the formal academic requirements and pressures at the time of the training. The seminar is designed to be appealing to students so that it induces a "mental knot" in the learner stimulating them to a "higher level of consciousness" such that old way of thinking is broken and replaced with a significantly different approach thereby creating a desire to apply and use it.

In constructing a learning experience around TRIZ, the following key areas are emphasized during the two-day seminar workshop:

a) **Patents**: emphasizing that patents are one of the greatest sources of human creativity and how these were analyzed by TRIZ inventor to come up with inventive principles.
b) **Problem consciousness**: increasing the awareness that problems become problems only because we are naturally affected by "psychological inertia" limiting our ability to solve problems only on things we know and how TRIZ can help get around these mental barriers to come up with out-of-the-box ideas.
c) **Innovation awareness**: developing the understanding of inventive creativity levels and realizing the difference between an apparent solution and break through innovation and show how TRIZ can take students out of their thinking limitations thereby developing solutions which they thought could not have imagined.
d) **Case studies**: show good cases and examples of ideas generated by TRIZ and emphasize the power of TRIZ-based thinking in coming up with an elegant solution maximizing functionality while minimizing cost and harmful effects.

e) **TRIZ principles and tools**: introduce TRIZ theories in an appealing way to show that it works and that students can feel they can adopt it easily.

TRIZ training in industry is increasingly aided by computers, softwares and pay-per-view online sources. While these tools may improve significantly the productivity of engineers, it does not guarantee creation of totally novel ideas. Observations have shown that development of better designs, new products and innovative inventions within short time are equally possible without the use of computers. Considering the limitations in most academic settings, the incorporation of TRIZ in the academe utilizes computer-free learning and emphasizes concepts, although free websites are provided for students to explore and maximize the benefits of online invention idea generations.

The two-day TRIZ seminar workshop is sustained by modular tutorials, weekly readings on TRIZ concepts and analyses of case studies. In as much as TRIZ cannot be studied in any meaningful way unless it is applied to solving problems, a regular TRIZ problem challenge is designed and posted for students to practice their learning in solving real world problems in competitive fashion. Cash prizes and the chance to have their ideas be applied for patent are ultimate come-ons for the TRIZ Problem Challenge. A group-on-one follow-up is conducted regularly for the whole semester to guide students in creating more innovative solutions to a real world problem of their choice.

Student's Responses and Feedback. Prior the seminar-workshop, 100% of the student respondents (and college professors surveyed) haven't heard about TRIZ before, confirming the observation that most people are not aware of its existence. When asked whether they believed they are creative enough to be able to invent something that can change the world, 24.14% answered in the affirmative, 13.79% said NO, while most of them (62.07%) said they are not sure. This result is anticipated since the current thinking prior introduction to TRIZ is that creativity or innovativeness is related to genes or luck and most are not sure whether they have what it takes to be innovative. When the 7 respondents who believed they can invent something were asked, most of them said they can work hard given a chance to work on a problem indicating a trial-and-error way of thinking. All of these conceptions about creativity, innovativeness and inventiveness however were revolutionized after the TRIZ seminar (Figure 3). All of them realized that the principles and tools of TRIZ changed the way they perceived a problem and that by using it, everybody believed that it increases their ability to solve problems and given more exposure to it, most believed they can indeed innovate or invent something.

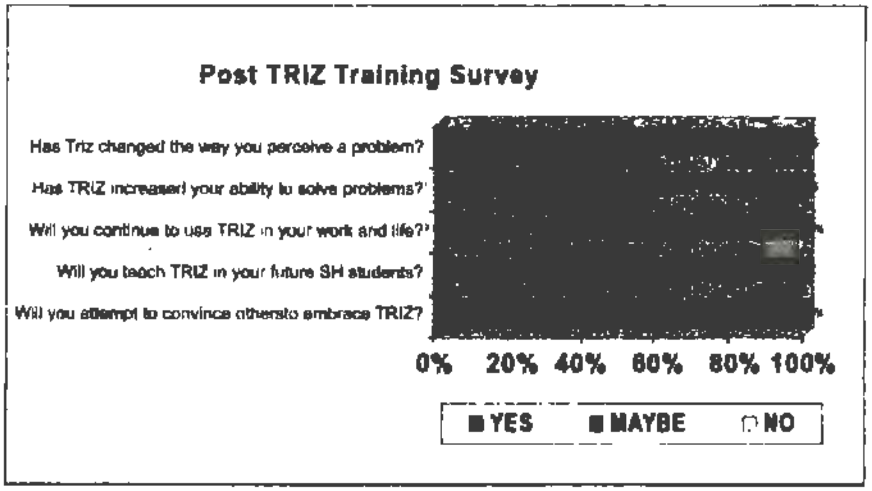

Figure 3: Post TRIZ training survey on science education students at PNU

The following are some of the comments given by the student respondents about TRIZ:

> *"With TRIZ it enlightened me that there are elegant solutions to all the problems we encounter and it provides us with strategies and organized way in analyzing the problem."*

> *"I used to see problems as a hindrance to achieving something but because of TRIZ I now see problems as a challenge - a chance to create something new to innovate and improve the way this world lives"*

> *"Using TRIZ methods as a guide to solve a problem, I can easily get a solution in a more innovative and inventive way. It helps me to think logically and see things in a deeper perspective."*

> *"Back then, I was used to solve problems without first analyzing its components thus I was consuming a lot of time thinking of a solution. Now, it's far more convenient to analyze every bit of components so as to use the right inventive principle. TRIZ has given me some techniques that I could use to help me hasten up my thinking capability in solving problems."*

> *"TRIZ made me think beyond my wildest imagination and I think that I can use these principles for life to make a difference for my country."*

When students were asked whether they will share the TRIZ concepts to friends and colleagues and teach it to future students, everybody was upbeat and answered optimistically. Below are some of their comments:

> *"I would truly want to share the concept of TRIZ to my students for this would help them in their studies and in their everyday life"*

> *"It is a big help for students especially in science so that they can start thinking innovative solutions to problems."*

> *"I will definitely share TRIZ, for who knows if one of my students would be the next great inventor."*

> *"TRIZ should be the best thing to be introduced to others knowing the importance and benefits one can get."*

> *"I want to share TRIZ because it would give many people the chance to exhaust their thoughts and the chance to widen their perspective in solving problems that they may encounter in life."*

> *"In teaching TRIZ, I will allot a session or two to introduce the basics of TRIZ and as application of lessons in chemistry, I will give a problem in real life situation and using TRIZ, they should provide solutions. I will also use TRIZ in advising investigatory projects for HS science fair. I will even incorporate TRIZ challenge problems in my authentic assessment tool and even recommend it with my co teachers."*

Team TRIZ Projects. Although third year students are not doing research subjects yet, TRIZ is helping them identify an interesting problem to work on. They were asked to give a generic real world problem that they would like to solve. Using the "ideality concept", "functional analysis tool" and "substance-field modeling", students are guided to dissect the problem into a functional problem such that inventive ideas can be generated using the TRIZ tools like the "contradiction principles and matrix", "trends in technology evolution", "scientific effects", etc. The following group projects are being worked on by some of the students:

Table 1: Sample inventive ideas generated by the students using TRIZ methodology[8]

General Problem	Functional Problem/ Contradiction/Trend	Inventive Principle/ technique used	Inventive ideas
Uncontrolled household pests	Increase of household cockroaches causes hygienic problems at home. If commercial anti pest sprays are used then the cockroaches will decrease but the spray effectivity will decrease after time.	Preliminary anti action Periodic action Nested Doll	1) Encapsulate the anti cockroach active ingredient such that it releases slowly over time. 2) Use the "nested doll" principle such that layers of layers of anti-cockroach active ingredients are hidden on a surface to where they are most attracted.
High % of biofuel blends cannot be used for old engines	If 20% biofuel blends is used, then the total fuel cost and consumption will decrease but the biofuel is incompatible with old engines due to filter issues.	Composite material	1) Design a composite material for the old engine filters such that the biofuel blend does not clog. 2) Use the concept of "increasing pressure then suddenly dropping the pressure" around the filter such that engine filters will be cleaned periodically.
Design of floor polishers is highly dependent on man	If floor polishers are to be ideal, it should be free from human dependency	Trends of technological evolution	1) Design a floor polisher similar to toy cars where it will bounce back once it hits a wall and put enough weight on the bottom so that it always returns to an upright position.

[8]*The ideas listed are potentially patentable ideas generated by the students. As a protection from possible copycats, the disclosure of these concepts here is a defensive publication which can be used as evidence of originality during patent litigation.*

During the exercise of idea generation for their team projects, students were encouraged to generate as much inventive ideas as possible, regardless of how silly and outrageous it may seem. A lot of concepts were easily generated with the aid of TRIZ tools and most are high level innovations. These concepts were trimmed down in terms of which are doable considering the time, the budget and the resources. TRIZ indeed was able to tap the innate creative ability that already exists within the students.

Summary

In today's challenging world, the necessity of improving the problem solving.skill among Filipinos is very eminent. An efficient problem solving methodology that is reliable, repeatable and teachable is therefore sought. TRIZ a system of creative thinking and innovation meets the criteria. The principles in TRIZ have been shown to be effective in creating innovative ideas in the industry for decades. Evidence abounds that TRIZ methodology can be applied successfully by people of all ages.

The potential of TRIZ to make science become more interesting to students is very promising. Since students systematically discover solutions that involve applications of scientific knowledge, they begin to see immediate value in the sciences. In this crucial time where the interest of students in science education is of immediate concern, it is heartening to realize that TRIZ may prove to be an effective way to stimulate students' interest in the sciences, and create a culture of science and invention.

Conclusion

Although no attempts were made to measure the individual creative and inventive characteristics of the students before and after TRIZ exposure, (this may be done in the future) the subjective observations indicate that the initial attempt at introducing TRIZ to students is successful and can very well be extended to any group of students including secondary and elementary pupils. When faced with a problem, it can be observed that the students were able to think about the problem in new ways, able to look for resources and aim for ideality in each solutions generated. It was also evident through sample problems and TRIZ challenges that the levels of inventive solutions are higher and that the time involved in solving a problem decreased.

Recommendations

It is necessary to teach our students innovative and inventive thinking and to integrate TRIZ into the curriculum if we are serious as a nation to improve our people, making them ready for the challenges that lie in the future. TRIZ is an educational imperative that must be addressed with urgency and it deserves to hold its own place in the academic curriculum. Teaching science classes to students without giving them access to TRIZ is doing students a great disservice. TRIZ is an important ingredient to education if we need to raise the level of the national "Creativity Quotient" of the Filipino people.

TRIZ training to in-service Filipino teachers is a first step. The TRIZ training of pre-service science education majors should be strengthened and institutionalized. The development of materials suited for Filipino students must be intensified such that incorporation of TRIZ principles to any secondary science courses can become comprehensive and lively. Integration strategies of TRIZ concepts to other areas of the sciences and field of studies need to be developed. Teachers must strive to make creative ways of presenting TRIZ principles to younger students. Large scale TRIZ challenges should also be implemented to sustain the learning of the students.

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Suggested Readings

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Teaching High School Math Effectively

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Introduction

In a study conducted by McCann Erickson a few years back, it was revealed that the Filipino youth of today are found to be highly sociable and interactive. They look at schools as ideal venues for socializing and creating connections with other people. The rapid rise of infrastructure as well as the development of technology has contributed to the waning interest of students in traditional methods of educating. According to research, "most teachers teach the way they learn". Hence, how teachers were taught mathematics when they were students most likely affect the way they teach students today.

Nebres and Lee-Chua reported in their study:

Filipinos in general have never been noted for mathematical ability. International surveys (including the Trends in Mathematics and Science Study, TIMSS 2004) have placed the country near the bottom; and local studies similarly reflect such performance -- by students and teachers alike.

This study reveals that Filipino students are not yet globally competitive. Further in their study, they discussed national and local efforts to channel creative skills into mathematics and they considered "excellent master teachers" as one of the critical variables in successful high level problem solving.

Difficulties of Students

In some ways, Ateneo students are similar to the students from Lupang Pangako. They also find it difficult to retain skills learned in previous years such as performing operations on fractions and working with word problems. They also have difficulty focusing on very rigorous tasks such as proving concepts. They are easily bored by procedural discussions. They prefer applying the concepts without really understanding them, which explains why mistakes are committed when questions are posed differently from what they are used to. Tests that evaluate understanding of several concepts through synthesis questions also bring about poor results. Students can perform individual skills but find it challenging to address problems that need multiple-step solutions.

How does the Ateneo High School (AHS) Math Program address these weaknesses?

> *It is the goal of the Math Program to develop in the students their ability to think logically and critically by emphasizing the correct application of laws, properties and theorems, insisting on precision and accuracy and encouraging creative approaches in problem solving. The Program also hopes to equip the learners with the discipline and fundamental skills that will help them address problems they will encounter later on in the service of others.*

Throughout the years, several routines/practices have evolved among math teachers in the Ateneo High School. In an informal survey conducted among all the current fourth year students (420 total), we asked them what among these practices they find helpful in learning math. Based on the results, 85% of the students appreciate being given an idea as to what will happen next in terms of the subject matter. They ranked ***being given an overview of topics at the start of each term, stating objectives every period*** as well as ***assigning homework at the start of each session*** (rather than at the end) as very helpful in terms of learning the math concepts. This tells us that the students are also goal-oriented. They want to know what it is teachers want them to learn and how these lessons are interconnected. This is also the venue for teachers to let students realize the interconnections of math concepts in the different year-levels. How students perform combined operations in first year will affect how they solve equations in second year as well as fourth year. Their lessons on learning the formulas for special right triangles in geometry will affect how they learn trigonometric concepts in fourth year.

Eighty-three percent of the students also appreciate the practice of ***giving daily homework*** and having ***regular quizzes***. Contrary to common belief that students would rather not work outside school, this gives us the impression that students realize that mathematics is a skill subject and therefore requires practice outside of school hours. Math teachers have devoted several hours a week for ***study hall sessions*** that provide students with a venue to answer more exercises while a teacher is around for questions or clarifications. These sessions are open to all students but priority is given to those students recommended by their teachers based on performance in class. These practices/structures ensure that students are able to practice skills learned as often as possible.

Ninety-two percent of the students prefer the use of ***manipulatives, illustrations*** and ***visual aids*** to deliver lessons. Teachers are encouraged to use colored chalk to highlight important concepts as well maximize the use of the overhead and LCD projectors in class in order to pique the interest of students through the use of colors and figures. In order to address boredom that might occur during a 50minute period, teachers also make use of different materials such as *factor tiles, 3-D representation of special products*, *graphing board, graphing softwares/calculators, construction* tools and the like.

Ninety percent of the students also find ***having experiments or activities in class***, together with ***using examples that they can easily relate to*** as effective in helping them learn and appreciate the lesson. In the first year, the teacher conducts a variety of games. The use of illustration boards by each student helps the teacher monitor which students have understood the lesson and which ones still need extra exercises. In the second year, some of the examples of experiments done in class are: *Wrecktangles* as an introduction to linear equations and the *M&M Activity* as an introduction to statistics. During the discussion of word problems, teachers also keep in mind the *Think Philippines* thrust of the school when creating problems students can easily relate to and therefore understand better. In the third year, since the approach to geometry is inductive, students do *hands-on construction activities* to identify geometric concepts. In the fourth year, an experiment serves as a motivational activity for each function such as the *Raven & the Jug for linear functions*, *The Noodle Escapade* for graphs of trigonometric functions, etc. Teachers also incorporate the study of models for each type of function discussed in class. These activities also address the social need of students to build connections by working within small groups.

An interesting result of the survey was noted when students were asked as to the type of teacher that helps them learn math better. Ninety-seven percent of the students noted that they prefer the type of ***teacher who exhibit knowledge of the subject matter as well as the capacity to explain***

concepts clearly. Lowest ranked among the traits were the 'extreme' types: lenient and strict teachers. This gives us the impression that students do not consider strictness, or lack of strictness, as a contributor to effective teaching. Rather, an organized teacher who can easily be approached and has a sense of humor is perceived to be a more effective teacher. This data is supported by the result of the study done on first year students last year by De Guzman, which concluded that students preferred knowing teachers who focus on helping students learn content and equate success when students master the subject.

Conclusion

We live in a constantly evolving environment. Students adapt to this environment and so we encounter different types of learners every school year. It is important to continuously assess practices and techniques done by math teachers in order to be able to determine which is most effective in helping our present students learn mathematical concepts. Continuous teacher training is also essential in helping teachers cope with these changes. A lot of new developments are happening in the field of education and math teachers should be aware of these changes. Teachers should also be adept at the use of technology since this primary environment is where we find our students to be immersed in.

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Effective Technology Transfers in Academia

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Abstract

A successful technology transfer of scientific research results obtained in academia to a commercial product or service is a rare occurrence. It is even rarer for an institution in a developing region. At HKUST, I was fortunate to be a participant on two occasions, and maybe a third one. One relates to the so-called PRS in educational technology that provides immediate feedback and reinforcement for active learning in a large class. Another, in biotechnology, concerns the applications of human growth factors (*hEGF* and *bFGF*) produced by a proprietary bacteria excretion system (*BES*). The affordability and authenticity of this *hEGF* enabled, for the first time anywhere, the treatment of diabetic foot ulcers with 95% success and other hard-to-heal wounds like bedsores and Steven-Johnson Syndrome with equal effectiveness. The third relates to the new use of human resources --- enlist a group of already successful individuals to live together in fellowships in a resort environment and to actively assist in the educational, economic and social development of the host locality. A review of these developments may provide clues for increasing the occurrence of these and other similar desirable outcomes.

Introduction

Knowledge derived from research and development (R&D) drives healthy societal growth as is evidenced by the data on Gross Domestic Products (GDP). Most R&D is conducted in universities. Universities are ranked according to the quality of their research output, the major element of which consists of the publications of their faculty. The rank order then is based on a figure of merit that takes into account the number of publications and the so-called impact factors of these papers. The impact factors are discipline specific, and are determined by the leading academics of the respective disciplines. It is not surprising then that technology transfer of research result that fills a niche or is breakthrough in application is a rare occurrence because of the nature of the incentive just mentioned. Of course contract research with established industry is common in professional schools but it is directed mainly at processes, systems, or technologies already in place. Such contract research is also rare in a developing region for economic reasons.

Societal growth cannot depend on services alone. New products and goods, including tools for services, are essential and these require technology transfers from R&D. There is a recent unhealthy trend of the better students gravitating towards the business schools for their first degree. This trend could be made more balanced by not only accomplishing more successes with technology transfers in academia but also, when making personnel decision, by weighing equally the impact factors of technology transferred to the market place and those of academic publications.

Here we focus on the "new or broad impact" type of technology transfer. The fact that it occurs rarely does not mean that there are no common threads among successful cases. It is my hope that these common threads be identified from recounting my own experiences so that (1) the powers-that-be could incorporate these in their plans, budgets, and operations and (2) the chance of success for technology transfer in academic is increased.

PRS - An Educational Technology Transfer

Few would argue against *Socratic dialogue* as the best way to teach because the two-way communication provides immediate feedback and reinforcement to both the student and teacher. Feedback is important to students since learning requires inspiration, motivation, reinforcement or a combination of these and, in the classroom, it enables the learning to be supplemented by *peer instruction* among students and contingency teaching wherein the coverage is geared to responses from students. But *Socratic dialogue* is impractical for a large class and, so, a learning tool called the *Personal Response System (PRS)* was developed [1, 2, 3] to enable the essential aspects of *Socratic dialogue* in the classroom.

PRS enables each and every student to answer questions in private in a large class. It is based on the mature infrared technology similar to that of the remote controller for TV and, therefore, is relatively low-cost and reliable. Its features include (1) student transmitter handsets each tagged with a unique ID that permits individual ownership, (2) the handset having a 10-digit keypad plus two additional H/L modifier keys for indicating high or low confidence on the answer sent, and (3) the answer is accompanied by the ID. The signals are registered in a line-of-sight receiver connected to a PC. A larger area can be covered with several receivers connected in series ahead of the PC. The teacher poses a multiple-choice question by any convenient means. The students respond by pressing their answer on their handset within the pre-set time interval (a minute or two is usually sufficient for a class of 100). The successful reception of each signal is acknowledged by a flashing box in an array projected on the screen that shows the corresponding ID. At the end of the question interval, the individual responses are recorded in the PC and the tabulated results are displayed as a bar-graph for immediate feedback.

The experiences of diverse PRS users have been positive. For example, Draper and Brown of Glasgow [4] surveyed several disciplines and concluded that the use of the handsets was judged by both learners and teachers to benefit them. The three most important features reported by students were (a) getting feedback to learners about whether they understand the material presented, (b) it does get most students to think about the question and decide on an answer while alternatives do not, and (c) the anonymity is often important in achieving these benefits. Perhaps the best testimonial for the success of the technology transfer is the numerous PRS users listed on the Internet that span across disciplines, institutions, and continents.

Specific to *PRS*, the sequence was:

1. the need to engage all students for active learning in a large class was recognized;
2. the solution implemented was a learning tool based on a low-cost existing technology and developed by a team with one member having expertise in microelectronics;
3. a prototype was built to prove the practicability of the conception;
4. intellectual protection (IP) was filed;
5. the IP was licensed to an OEM (original equipment manufacturer);
6. the OEM proceeded with the production only when there was a guaranteed number of units ordered that covered the start-up cost (fortunately, the author had a teaching development grant that can be used for the purpose); and
7. the products were distributed mainly through word-by-mouth and the Internet.

Recently, an extension of the technology that would make it accessible even to the economically poorer areas was worked out and the IP protection filed [5].

GVN - A Biotechnology Transfer

With the 21st Century belonging to Biotech just as the 20th Century belonged to InfoTech, I was determined not to be left out. Thus, when Wan Keung Wong of Biochemistry at HKUST asked me to join the technology transfer efforts of the Bacteria Excretion System (BES) he developed in Escherichia coli and Bacillus subtilis, I did not hesitate to jump at the opportunity

In BES, the recombinant proteins are excreted into the medium and, thus, enabling purification that is simple and straight forward. Over 10 recombinant proteins of different origins, functions and sizes have been produced. The most notable of these is human epidermal growth factor (hEGF). The hEGF so produced has been tested to be pure, authentic, and toxin-free, and indistinguishable from one produced by our own body. Its cost effective production has enabled, for the first time anywhere, the treatment of diabetic foot ulcers with 95% success [6] using our hEGF. The successful treatments of other hard-to-heal wounds like those of bedsore and the Steven Johnson Syndrome have been equally dramatic [7].The large scale production of basic fibroblast growth factor (hbFGF) is now being developed. The combination of hEGF and hbFGF would provide a significantly more effective treatment of deeper wounds.

The successes with hEGF should have easily attracted licensees or investors particularly with a patent on hEGF filed [8], but that was not the case. After some period and many efforts, an injection of venture capital by the China Nansha Technology Enterprises Limited has provided impetus with the formation of a company called Gene-vinate Limited (GVN) [9]. GVN utilizes the results of biological research and development for the active promotion of skincare and healthcare technologies and products. Its activities include the production of human growth factors and the development, production, and marketing of cosmetic, skincare, and healthcare products with various combinations of hEGF and hbFGF as active ingredients. The first consumer product is now in the market.

Success had not come easy perhaps because the technology was "too new" for its time. The original partnership had to shoulder all expenses associated with the patent application and bFGF production development as no other party was willing to do so.

SHARPEN - A New Social Institution

In the undertakings discussed above, three stages can clearly be delineated.

1. A new marketable idea or concept that came serendipitously, through experience, a systematic study, or a combination of these. Exchanges of ideas with various experts would clearly be helpful in this context.

2. Demonstrate the practicality of the idea or concept. A working prototype is essential, and accessible and affordable resources, both human and material, are required.
3. Implement and market the product or service. A working capital is needed and a good network for this is almost essential.

A common denominator for all three is accessible expertise that is affordable. In academia, it is almost always necessary to go outside of the institution for such resources at some stage. A natural question is — why not have most, if not all, of the expertise in house? There is also the increase chance of generating a useful idea or finding a creative solution to problem when the working group consists of experts in various areas coming from different backgrounds. A new organization called the Society for the Housing and Advancement of Returned Professionals, Educators, and Networkers (SHARPEN) is being formed partly in response to this question.

There is a personal angle to SHARPEN [10] as well. Since it is not uncommon for successful people to purchase a housing unit in a resort here and there for vacation and/or retirement, why not do it together with people of similar inclinations in the same location so that one could continue to be active by helping the local community grow while enjoying a life of leisure and fellowships? Members could enjoy:

1. a well-equipped housing facility;
2. belonging to a unique organization;
3. doing teaching, technology transfers, starting new businesses and/ or incubating high-end industries;
4. belonging to a critical mass of experienced professionals to undertake inter-disciplinary, multi-disciplinary, and think-tank activities;
5. an opportunity to develop symbiotic relationship with the community;
6. an opportunity to have a profound positive impact on society that one could not achieved individually;
7. a natural setting to interact with young people; and
8. living and working in fellowship with a group of like-minded, stimulating people with different backgrounds.

The suggested qualifications of members are:

1. experienced teachers;
2. established professionals;
3. senior civil servants;
4. researchers with good track record in R&D;
5. experienced managers in large organizations; and
6. successful entrepreneurs.

The host locality could benefit from:

1. a pool of seasoned experts and professionals with international experiences and networks to assist with its developments;
2. in-house expertise on education, applied research and technology transfers (starting new project/program quicker);
3. continuous replenishment with new bloods;
4. a large capital injection because SHARPEN members purchase their own housing and pay living expenses;
5. added cultural and economic values and activities;
6. good chances of being bequeathed with wealth;
7. more likelihood of outside injections of capitals and development funds;
8. experts coming voluntarily that the locality could not attract nor afford to pay under other circumstances.

Potential members are all over the world. For SHARPEN/China, there are the Chinese intellectuals and scholars who left Asia in the 50's to 60's because of political turmoil. Their Chinese roots and upbringings would beckon them to return "home". For SHARPEN/Philippines, there are the many Filipino intellectuals and professionals all over the world who left for economic reasons. Returning home could be attractive particularly if they feel that they are useful and wanted. It may just be the impetus that would enable the establishment of a world-class university that, in turn, would make Philippines a regional center for higher education. Two other points to note are: (1) non-retirees are not excluded provided they are willing to be a resident for an extended period each year, for example, three months; and (2) the summer for Northerners is the beginning of the academic year in the Philippines.

Quo Vadis?

In discussing PRS and GVN above, the three stages leading to success all require expertise. One invariably needs to go outside the institution to obtain some of these. It is reasonable to expect an increase chance of success with technology transfer if all or nearly all resources are available in house. In academia, there is also the need to give the appropriate incentive of weighing the merits of technology transfers as no less than those of publications in refereed journals. SHARPEN is suggested to be an alternative solution for in-house resources. In a sense, SHARPEN could be considered a technology transfer in itself if and when it becomes operational. Already mentioned is the increase chance of generating a useful idea or finding a creative solution to problem when the working group is composed of experts in various areas coming from different backgrounds.

More successful examples would also serve to encourage others. Other technology transfers that I have been involved with include: (i) the HKUST College of Lifelong Learning that relied heavily on the Internet to deliver instructions which at that time was considered novel, (ii) Creative Forex Limited [9] with Amador Muriel as co-founder for trading foreign currencies based on his new "Molecular Theory of Turbulence", and (iii) Bio-Click Technologies Limited [9] that have the know-how for the BES productions of the three Cellulases (Endo-cellulase. Exo-cellulase, and Cellobiase) needed to convert cellulose into glucose for applications in biofuel and waste recyling. The first two do not quite fit the "new or broad impact" type, while the third has a huge threshold for Stage-2 development which would require signifciant time, effort and resource to surmount. It is nevertheless interesting to note that item (ii) could help SHARPEN grow their reserve funds for projects.

The bottom line for successful technology transfer is having a group of creative, educated, and experienced people working together with a common goal. What is new with SHARPEN is to explicitly sought out those individuals who are already financially self-sufficient, who cherish the joys of fellowships, and who willingly and actively work together to find ways to enhance the educational, economic, and social developments of the host locality or institution.

Finally, a successful science and technology park like those found in Boston and San Francisco is anchored on one prominent R&D-oriented university or two. The least arduous route to achieve a similarly successful park is to first have a group of professionals in-house with various talents and experiences to help nourish a R&D-oriented university along, and SHARPEN is such a group.

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Public Understanding of the Social Sciences

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In August 2005, the TV channel BBC asked its overseas viewers to vote for the "Greatest Briton". In that poll, Sir Isaac Newton, who contributed much to the world's understanding of gravity and planetary motion, was voted the greatest. If a poll on the "Greatest Filipino" were done in the Philippines, who would she or he be? Would a scientist, natural or social, be voted the greatest Filipino? Or would the greatest Filipino turn out to be an actor, a politician, a singer, or a boxer? The answer to this question can be taken as an indicator of the existence of a culture of science in the Philippines.

To be scientific, a person must be able to assess whether or not a personal experience responds to questions of validity and replicability. Personal experiences have to be theorized and be set in a broader paradigm. To be scientific, a person must be able to distinguish between the transcendental (e.g., spirituality, religion) and the mundane (e.g., physical survival), between specialist knowledge and lay knowledge. How many Filipinos are able to make these distinctions?

An examination of the development of a scientific culture in the Philippines would primarily concern itself with the meanings and practices of everyday life of both the scientists and the society which they emerge from. The daily activities and the social relationships being created by scientists, technologists, and users of scientific knowledge and artifacts can be the means of understanding the society which generates such culture and practice. In turn, the knowledge of a society can be the means of understanding its scientific and technological enterprise. Both explorations allow a fuller understanding of imperatives for the culture of science and technology to be present not only in laboratories, universities, scientific reports, journal articles, books, but more importantly in everyday life.

Thus, the project of building a culture of science in the Philippines requires an understanding of the public understanding of the sciences, as well as science's understanding of its public. In this presentation, I will focus on the former, in particular on the public understanding of the social sciences. What is the public understanding of the social sciences that would, for example, allow them to vote for a social scientist as the greatest Filipino. Or not? How is this public understanding constructed? If this public understanding were to be reconstructed, in what directions?

Understanding the Public's Understanding of the Social Sciences

One way of looking at the development of scientific culture in a society is to examine whether or not it has become a "knowledge society". One of the earlier versions of the notion of knowledge society is Daniel Bell's (1973) idea of a society wherein knowledge is an important element of production along with capital and labor. In a knowledge society, new technologies and knowledge workers such as scientists, technologists, and other experts are essential. According to Bell, changes in the society's social structure - comprised of the economy, technology and occupational system are manifested in the following:

- Shift from a goods-producing economy to a service economy;
- Pre-eminence of the professional technical class in the occupational distribution;
- Centrality of theoretical knowledge as source of innovation and policy formation for the society;
- Future orientation in the control of technology and technological assessment; and
- Creation of intellectual technology to aid decision making.

Development work as a public

Let us look at the central manifestation of a knowledge society: centrality of scientific knowledge as source of innovation and policy formation and decision making well into the future. Towards this end, there are many insights that one can learn from the social sciences. Burawoy (2005) cites W. E. B. Du Bois (1903) The Souls of Black Folk, Gunnar Myrdal (1994) An American Dilemma, David Riesman (1950) The Lonely Crowd, and Robert Bellah et al. (1985) Habits of the Heart as some of the books written by sociologists which are read beyond the academy and have stimulated public discussion about the nature of U.S. society. In the Philippines, the works of sociologists and anthropologists such as Frank Lynch and Mary Racelis, which have contributed to the understanding of Philippine society and culture in the 1960s, the works of Walden Bello, which help people to understand the debacle of globalization and development, and those of John Carroll, which show how sociology can be used as a tool to help the poor and the marginalized, could be some of the works being read by a wider public albeit by a specific public. Social scientists who write in the opinion pages of national newspapers where they comment on matters of public importance likewise introduce the frameworks and methods of the social sciences to the public. A few examples: Randy David (sociologist), Alex Magno (political scientist), Michael Tan (anthropologist), and John Carroll (sociologist). Quite recently, psychologist and educationist Patricia Licuanan wrote an article in a national paper, explaining that students learn better when the mother tongue is used in the instruction. She was responding to a government order which mandated, among others, the teaching of English as a second language in Grade 1 and the use of English as the medium of instructions for English, Science, and Math starting Grade 3

What insights can be learned from the work of social scientists?

Let us take as an example the work of sociologist Emma Porio which enables us to understand further an idea introduced by de Soto (2000): that some poor individuals and groups take it for granted that they do not have capital to benefit from capitalism in a more systematic way. De Soto argues that the inability of the poor to produce capital is the major hindrance to the widespread enjoyment of the benefits of capitalism. He points out, however, that most of the poor in Asia, Africa, the Middle East, and Latin America do have assets and capabilities to make a success of capitalism. But since these assets are not adequately documented (i.e., houses built on land whose ownership rights are questionable, businesses that are not incorporated), they cannot be converted into capital (i.e., collateral for a loan, equity against an investment). One of the solutions that De Soto is suggesting is to give the poor access to formal property. Formal property includes a system of ownership rights (e.g., titling and recording assets), as well as a system of thought that allows people to work on their assets for the purpose of generating capital. He argued that through formalization of their properties, the poor can be part of a representation process where documents are the visible signs of a process that links all assets to the rest of the capitalist economy.

While the formalization agenda undoubtedly solves a number of problems with regard to the poor's access to capital, Porio and Crisol (2004) show that there are limiting cases. Some development planners and workers who take on De Soto's ideas also take a number of realities for granted. The formalization agenda fails to differentiate between different kinds of poor people and their differentiated needs and interests. Porio and Crisol's analysis of experiences from the community mortgage program for urban poor residents in Metro Manila show that ownership does not work for everyone, and that there is a need for intermediate instruments for tenure. Since, as Porio and Crisol show, ownership works only for the "better of the poor", intermediate instruments for tenure, which include lease arrangements and governmental proclamation agreements, ensure that the "poorer of the poor" can afford less costly arrangements of tenure. This means that poverty programs have to be monitored on their ability to stratify different types of poor and to design appropriate programs for different types of poor individuals and communities. Putting one solution, ownership, towards urban poor's tenurial security does not consider that people have different capabilities and therefore have different responses. An approach to security of tenure that differentiates among different capabilities must provide a range of solutions that include not only ownership but also rental arrangements.

Many social scientists work in various capacities as consultants, experts, and researchers in international development projects. For example, a research project of the national oil company which aims at assessing the environmental, economic, political and social consequences of its energy development projects included in its project brief provisions for a sociologist, an economist, and a political scientist to work alongside engineers and natural scientists. A research team for the development of tourism plans and strategies for Metro Iloilo and Guimaras includes social scientists such as a sociologist, psychologist, and a heritage economist who work with tourism managers and specialists, marine specialists, architects, and urban planners. The sociologist's task is to ensure that women and communities in the area participate and benefit in tourism-related projects, while the psychologist's job is to design human resource development interventions for the communities.

The everyday life-world is the province of reality "which the wide-awake and normal adult simply takes-for-granted in the attitude of the common sense" (Schutz and Luckmann 1973). Meanings created by the interactions of individuals in society become typified into routines or patterns that become the social stock of knowledge, or the recipe or map which a member of a group or society uses to interpret the everyday life-world and to identify the set of practices and social actions required of in this everyday life-world. With the growing awareness of the role of social scientists in activities typically and traditionally understood to be the realm of engineers and natural scientists, does the general public routinely turn to social scientists for explanations of and plans of action for the social world?

Many social scientists complain about the flow architecture of research, advocacy, policy and action that limits the ways in which scholarly works might or have contributed in shaping development initiatives and policies. One anthropologist says:

> "They want to simplify. That's the bureaucracy. They say "everyone", but there are differences."
>
> GR, 30 June 2007.

Another insight into the role of the social sciences in the everyday life-world of Filipinos can be drawn from the Tasaday controversy (Pertierra 2003). Because the arguments over the facticity of the Tasaday were held in the media, a dispute that could have been resolved scientifically (by the anthropological community) suddenly became a political dispute (i.e. a view is either anti-Marcos or pro-Marcos). Non-scientists such as politicians and media personnel share the same space as scientists. Expertise and competence were not given the role to resolve a mainly scientific dispute.

Thus, one public of the social sciences, the development world, may understand the work of social scientists as part of the legitimating process, or worse, as dispensable, easily replaceable by a media personnel or a politician.

General public

> "Who is this person appearing on TV? She is supposed to be a sociologist. How come I can say what she is saying myself! If that is only what sociologists say, then someone who sees this co-called sociologist on TV would ask why he or she should let her or his child take up sociology in college."
>
> CSK, chemist and mother, conversation, 6 June 2007

Newscasts and talk shows have been one of the vehicles in which the general public comes to know about social scientists and their works. TV reporters and assistants of talk shows would call university departments and ask who among the faculty could be interviewed for this and that topic.

These reporters are actually taking the "short-cut". A library research would have informed them about the works of a particular social scientist that have a direct bearing on a particular topic. It however appears that the world has succumbed to what Gertrude Stein has earlier observed: Without pictures we do not exist. Thus, while TV reporters could have done the library research themselves or conduct in-depth key informant interviews, the main interest is on how to get the social scientists to appear on TV. Social scientists appearing on TV lend an air of legitimacy to a news or feature report whose storyline has long been decided independent of what the social scientist would say or not say. On TV, a 30-minute interview could appear as a one or two sentence-interview. Which sentences or ideas these would be, the social scientist has no control of. The primacy of legitimation over substantive content discourages certain forms of broadcast journalism to be investigative and broadcast journalists to be researchers. One does not have to wonder why we have a Center for Investigative Journalism when journalism should be first and foremost investigative!

The other reason for the general public's misconception of the work that social scientists do is that, more often than not, social scientists who appear on TV are propagating general social sciences. They are likely to comment on anything as a generalist. The more established social scientists who have developed expertise in specific fields are more likely to be preoccupied with teaching, research and writing, and consultancies, leaving them with no time to grant TV interviews and accept TV guesting invitations. Many of them have had the experience of being "used" by the media in previous interviews (e.g., an interview being "cut" to support a storyline for a news or feature report) and would now mechanically turn down requests for TV interviews and guestings. More often than not, established social scientists do turn down requests for TV interviews because topics could be too "general" and do not call to bear specialist knowledge. Examples: "Why do Filipino men urinate in public spaces?" Why are we fond of "tingi" (sachet marketing)?" "Why do starlets not wear underwear?" Why is bayanihan no longer being practiced these days"?

While the language of the social sciences could readily be used to explain these phenomena, the topics themselves risk trivializing the social sciences. While a good sociologist could explain urinating in public places to the nascent experience of urbanization of most Filipinos who would have grown up in the rural areas abundant with open spaces and to the lack of public structures in cities such as public toilets which would allow "urbane behavior", these insights run the risk of being reduced into a few words. Thus, the episode on TV might show the sociologist saying something that any Juan or Juana could also come up with!

During the 2006 national conference of sociologists, sociologist themselves complain about fellow sociologists – who unfortunately are not members of the professional association of sociologists – who trivialize sociology with their trite appearances on TV. Where lengthy expositions are reduced to second-long sound bites, Prof. Randy David, who uses the language of sociology to inform and explain social phenomena to the public gives this advice: Prepare one sentence that contains the essence of what you want to say and say nothing more than that. Through this way, the TV editors could not "cut" the sentence as it is the only one! While not to be taken literally, David's advice is an injunction for social scientists to prepare for any media interview. One should have at least one big idea for the interview. But until such a norm becomes widespread among social scientists, the general public's understanding of the social sciences is one wherein anyone with an opinion can be a social scientist.

Improving the public understanding of the social sciences

Burawoy's (2005) work on "public sociologies" provides some ideas for addressing the issue of improving the public understanding of the social sciences so that a culture of science might develop in the Philippines. Accordingly, Burawoy maps out the division of sociological labor among four types of knowledge: professional, critical, policy, and public, which should complement and not negate each other. Public sociology brings sociology into a conversation with publics, understood as people who are themselves involved in conversation. Policy sociology is sociology in the service of a goal defined by a client. It provides solutions to problems or to legitimate solutions that have already been reached. Professional sociology supplies true and tested methods, accumulated bodies of knowledge, orienting questions, and conceptual frameworks. Critical sociology examines the foundations, both the explicit and the implicit, both normative and descriptive, of the research programs of professional sociology. It ensures that the stability of sociological frameworks and practices is often subject to periodic rupture or revolutions by making professional sociology aware of its biases and by promoting new or alternative research foundations.

From Burawoy, we learn that like sociology, the social sciences can be categorized in terms of its audience and the type of knowledge it produces. Its audience can be academic or extra-academic and its knowledge instrumental or reflexive. For instance, professional social sciences are characterized by an academic audience and instrumental knowledge, while public social sciences has an extra-academic audience and relies on reflexive knowledge. Bautista (2004, as cited by Porio 2006) modifies the Burawoy model to take account of Philippines realities where social scientists who engage an extra-academic audience using instrumental knowledge are not merely engaged in "policy". In the Philippines, social scientists engage policy and participatory development and are action-oriented (please see Table 1).

Table 1. Typology of Philippine social sciences (adopted from Burawoy, 2004; Bautista, 2004; Porio 2006)

Audience / Knowledge	Academic	Extra-academic
Instrumental	Professional	Policy/participatory development/ action-oriented
Reflexive	Critical	Public

Imperatives for a culture of science

What social scientists should know and do:

1. Social scientists have to be aware of the different possibilities and responsibilities opened to them. Social scientists can and should occupy multiple locations. Sociologist Randy David, for example, simultaneously works in both professional, critical and public worlds. The works of his fellow sociologists, Cynthia Bautista and Emma Porio, are located within the professional and policy/participatory development, and action-oriented fields. Economist Cielito Habito works in policy, professional and public fields. Historian Ambeth Ocampo who teaches, writes a column, and heads the national institutions for history, cultural, and arts is a public, professional, and policy/action-oriented social scientist.

2. Professional competencies—being good in one's discipline—allow one to occupy multiple-locations or perform different roles as a social scientist. Public commentaries (e.g., TV appearances) should be limited to areas of one's expertise, usually established through one's researches, rather than expounding on topics of broad interest. The challenge is for young social scientists to specialize and for the established social scientists not to forego public and critical social sciences for the more lucrative world of policy/action-oriented consultancies.

3. Students are the first public of the social scientists. The challenge of the social sciences which takes people as its subject of inquiry is to engage in different publics in different ways. However, there is a view among social scientists who are working in the academe that their only task is to teach. The other view, no less faulty than the first, is that one's only task in the academe is to produce knowledge through research. A social scientist should depart from both views and instead see teaching, research (including research-based consultancies and publications), and outreach

(through membership and leadership in professional and action-oriented associations) as complementary processes. Categories such as "teaching university" and "research university" should only exist as a discourse as the practice combines both teaching and research

The multiplier effect of teaching cannot be underestimated as our students secure, through their own engagements, the place of social science frameworks, research methodologies, and methods in Philippine economic, political and social life.

What relevant actors can do for social scientists:

1. Universities and colleges should support original thinking among the social scientists that they employ by providing structures for research and extra-academic engagements and treating these activities as public goods. Often, social scientists remain in their professional worlds, but even within these worlds they are only able to do teaching, at the expense of research. There are many reasons why they are unable to perform more than one role. Those who are able to occupy more than one quadrant of the typologies of social sciences often come from the best universities in the Philippines where work conditions (e.g., workload) are relatively better than in other universities (please refer to Table 2). At Far Eastern University and Xavier University, full-time faculty members teach eight classes a semester. Faculty at the University of Santo Tomas and the Polytechnic University of the Philippines-Manila have to teach from six to seven classes a semester. Their counterparts at the Ateneo and UP teach four classes a semester, with UP faculty not being required to teach in the Summer.

In all combinations, the workload in the Philippine academe hinders original thinking and empirical grounding. In Australia, Germany, Malaysia, Singapore, and the USA, the teaching load of a faculty member ranges from three to four classes a year. This gives them time to do research, which regenerates the social scientist's public, critical, policy/ participatory development/action- oriented engagements as research, first and foremost, contributes to the teaching component of professional sociology. Moreover, grants for development of course guarantees that research insights are incorporated into teaching.

Table 2. Annual number of classes of a full-time faculty (selected universities)

University/college	Number of classes per faculty per year
Ateneo de Manila University	10
De La Salle University	12
Far Eastern University Polytechnic University of the	16 (plus summer)
Philippines-Manila University of the Philippines	14 (plus summer)
Diliman	8
University of Santo Tomas	12 (plus summer)
Xavier University	16

2. Professional associations of social scientists and national bodies of science and technology should play an integral role in public life. The establishment of AGHAM party list is one such initiative but scientists can still learn much more about political campaigning. Networks of social scientists (e.g., Philippine Social Science Council) and those found in universities and colleges should be better utilized.

Professional associations should begin to consider their role in contributing to public discourses through opinion columns in newspapers and in issuing public statements with regard to issues of public interest. The experience of two universities after coming up with public statements on the alleged cheating in the 2004 presidential elections that appear national newspapers is however instructive as to how this can be done. Since the nature of public statements is to speak on behalf of all the members of the association coming up with the statement, the process for issuing public statement should be marked by open dialogues.

Social scientists are losing out in the marketplace of ideas in part because of the lack of awareness of their roles vis-à-vis the four typologies of the social sciences and the absence of structures to support those with the vision to excel in more than one typology. If only for the goal of contributing to the development of a scientific culture, (a) social scientists ought to aspire to have a more serious public engagement through teaching, research, publications, and professional outreach, and (b) relevant actors such as university systems, government, business, and other research funding agencies ought to understand that they cannot and should not fully colonize original and creative thinking in the academe. Lyotard was given funds to conduct research on how to modernize the French university system. He ended up writing a canonical book on the condition of postmodernity, which was not useful with regard to the original intent of the funding. However, the work illustrates that pure research is good and hence is an argument for giving academics more money not merely for creating instrumental knowledge, but more importantly, reflexive knowledge.

Notes

[1] *The idea of "public sociology" is not without its critics, who argue that sociology is always public and that the term undermines the standing of sociology as an academic discipline. See, for example, Deflem (2004). The purpose of citing this term in this article is to highlight how the public might understand the social sciences.*

[2] *UP faculty receive honoraria if they teach in the summer. Ateneo de Manila University faculty have 30-unit workload, which typically includes a six unit or two-classes assignment in the Summer session.*

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An Interdisciplinary Working Life: Was It Worth Living?

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Very early in my working life came the realization that I am neither intellectually superior nor theoretically gifted. Being quite simple and rather ordinary, as a rural sociologist, I found my intellectual comfort zone in the precept that "Science must serve a human purpose". This has not made me a great sociologist, but at least, a different one, whose significant others are often beyond the discipline but always about everyday people. All these years my preoccupation has been with ordinary people and those whose science promises to make a difference in their lives.

Experience has shown that when research focuses on people's problems, interdisciplinary and participatory approaches to R&D become significant value-added to the process and the resulting product. This often means doing science from the ground up and then tapping into the most sophisticated tools and concepts of science to address the problem. In interdisciplinary and participatory R&D, people, places, purpose and particularities acquire greater clarity, specificity and interconnectedness. Every workshop with biophysical scientists becomes an occasion to look for the PEOPLE FACTOR, whether the subject is rice breeding, drought, natural resource management, trees, weeds, malaria, HIV-AIDS etc. There is always a human purpose behind each of these. For example, in breeding rice, the questions asked are usually: for what? for whom? for where? and for what purpose? These are all PEOPLE ISSUES which social scientists should seek answers to.

Science pursued as basic contributions to the body of knowledge of a particular discipline has well-defined pathways and channels of communication such as internationally refereed journals. Science pursued to address the problems of ordinary people still have ill-defined pathways and means of communication but when the research products fit into the complexities of real life, the impact on human well-being makes it all worthwhile. In a manner of speaking, "the proof of the pudding" is in farmers' fields and in consumer acceptance; in human development.

To nurture a science culture in our society and not just in science and technology institutions, it will go a long way if all departments of government including Congress will have a Research and Evaluation Unit in order to develop research-based policies and programs. The values of science like intellectual honesty, objectivity, excellence, verifiability, validity, innovativeness, systematic procedures and evidence-based conclusions are values which the rest of society could imbibe. These values are the antitheses of what predominate in our country today. In science, one does not cheat because truth will sooner or later come out. But scientists must also acquire interdisciplinary perspectives in order to better address the human purpose of science.

My Working-Life-Years

In my own small way, I have always believed that "ideas matter; individual matter, and they can make a difference." This characterized what I call my interdisciplinary WORKING-LIFE-YEARS which came in nine identifiable periods — the human side of which I will share with you.

The First Period is the 40 years I spent with U.P. I was promoted four times. The first promotion was mandatory; the second was probably merit; the third, was based on a recommendation I had written myself. It must have been a good one for that was the biggest salary increase I have ever had. The rank of University Professor was a call from Diliman, not an initiative from UPLB. The University played a passive role in my working life by never interfering with my FREEDOM TO BE and my FREEDOM TO DO. This probably made up for the P18,000 salary of University Professor when I retired.

The Second Period –Rice was, and continues to be my preoccupation for 43 years. I found in rice, an international public good where science best serves its human purpose. IRRI and PhilRice keep me reminded about what is important in science. PhilRice informed me that for more than 20 years as member of the Board of Trustees, I have survived four Presidents and ten Department Secretaries. Why they kept me for more than 20 years is interesting. Being a media-shy person, I am probably regarded as harmless.

The Third Period consists of 38 years with international agricultural research centers where I learned about crops, trees, genetic resources, potato, sweet potato and most of all, that agricultural research is really about people even when the science focuses on commodities, genes, soil, water, and nutrients.

The Fourth Period of 12 years found me in international health research where leading bio-medical scientists including Nobel Laureates behave like ordinary mortals fighting the virus, parasites and scourges of humanity like HIV-AIDS, malaria, TB; etc. Their health research programs are characterized by an ethic of CARING for those who need care most. Science is their tool but CARING is their driving force.

The Fifth Period is the Evaluation and Review Years which total 43 from 1963 to 2007. There have been more than 42 occasions to participate in the reviews of R&D programs either as member or team leader. All of these programs promise to benefit those who have less in life but between Promise and Performance is a great distance. In terms of potential influence on policy and program, these evaluation years have probably had more impact than publications but the latter are necessary to be invited to be a team member in the first place. International professional reputation is valued and so is probity. Furthermore, an evaluator has to learn to listen not only to what is being said but to what is not being said.

The Sixth Period consists of 11 years in the Board of Governors of IDRC (International Development Research Center of Canada). IDRC was not afraid to take risks in opening up new research platforms in developing countries. They were never afraid to go where it was difficult, even in the middle of the Sohel. They had an Information Sciences Division before Bill Gates became a household name. Frankly, it was from my IDRC years that I came into interdisciplinary thinking and learned the meaning of internationality in humanity. These have contributed very much to a culture of "research without borders". After all, there is a common humanity.

The Seventh Period is 24 years as Academician and National Scientist. Few people realize that while it is a recognition, it is also a lifetime responsibility to society. As a matter of fact, one does not retire from it. As my grandchildren keep reminding me, I cannot do anything stupid or undignified because it is unbecoming to do so.

The Eighth Period is two years with the Ford Foundation as Program Officer for a Provincial-Level Rural Development Grants Program. These were two years of spontaneous unannounced ground-truthing about rural development. These experiences remain unmatched by other field-level exposures. Despite all these incomparable lessons, I chose to return to the University. With an IDRC Senior Research Fellowship, with my heart in my head, the book Beyond Manila was produced. I will never again be able to write something like that in a deeply personal way.

The Ninth Period is the "Gendered'Years which were three intensive years plus much work on women issues before GENDER became fashionable.

Some women leaders call me a Reluctant Feminist but development programs for women are not always labeled GENDER or WOMEN. For example, CARD-MRI (Center for Agriculture and Rural Development – Mutually Reinforcing Institutions) has a membership of more than 300,000 women but this micro-finance institution does not carry a GENDER label although it produces a GENDER IMPACT.

I have served as Board member since 1998 and have never missed a meeting. Despite all these, I do not expect to be acknowledged as a FEMINIST among feminists.

The Secrets in my Working-Life-Years

I am not a Super-Woman.

There are many things I cannot do. I can't drive. I can't type. I can't cook. I can't swim. I can't do IT. I can't be an administrator. I am not an organizer. I never want to be an expatriate. This is the only country I have and will remain so despite its major and minor imperfections. In 1950, I was diagnosed positive for PTB in both lungs. For this, I owe U.P. a month of stay in the Infirmary as the only patient during the summer. Dr. Priscilla Tablan of the Quezon Institute worked me through endless Xrays, lab tests etc. in order to pass the physical and medical examination required to obtain the visa for graduate studies in the U.S. When she saw me upon my return, her considered remark was: "You've got poise".

"Sa totoo lang" (truth to tell), I am an untitled social scientist whose most appreciated reward is a hybrid gumamela named: HIBISCUS GELIA CASTILLO, an officially registered flower. But most of all, I am one of the Diamond Girls of UP, a lifelong group of friends. Our ranks are thinning but the loyalty and friendship remain.

At this stage in my life, I've probably, done all my foreign travel with 56 countries stamped on my passports.

The message from these innumerable trips, national and international is: "neither a shopper nor a tourist be. Do justice to what you were invited for and MAKE a DIFFERENCE. The invitation letters come."

The Years Ahead

I never get engaged in any project or program unless I can be passionate about it. The three great passions in my life now are: RICE, Participatory Research and Development, and MICRO-FINANCE. The first is one of anticipation, of waiting for more rice research results which have been promised but not yet delivered. The second is an intellectual and empirical challenge which requires not only proof of concept but proof by impact. The third is exciting work-in-progress on how women manage to improve their lives even with micro inputs invested with heart, mind, and social entrepreneurship.

What I am committed to is: more working years to the 216 already done. There have been more than 4 working-life-years for every year of my 53 chronological years as a working woman: How did I do it? I lived the years simultaneously.

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Development Initiatives and Trend-Setting in Higher Biology Education

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Introduction

The importance of the Biological Sciences has come to fore, e.g.: vaccines for AIDS, bird flu and others, early detection and prevention of cancer, increased yield in crop production, management of diseases, population control, bioremediation, biodiversity, environmental management, global warming, among others. This enumeration is endless since the information from the ever-diversified fields of the Biological Sciences impacts on our lives and in many ways, provide for solutions to many present-day problems. As such, Biology is the SCIENCE OF THE MILLENIUM!

Biology like other sciences has struggled in this part of the world, to rise as a potential factor to uplift the lives of the Filipinos. Why so? For starters, our deeply rooted religious culture appears to show at the onset, an apparent discordance between science and religion. Another reason is the perceived notion that science is purely for the intellectuals and the academics, somehow, they not being aware that in whatever tasks they pursue, they are applying science.

This paper shall present a general view of the status as well as the trends in the development initiatives in Higher Biology Education. It shall also provide information on the efforts of the Commission on Higher Education (CHED) for the last decade, relative to the improvement of the Biology discipline at the tertiary level.

Status and Trends

Based on the CHED Management Information System database, 150 of 1761 higher education institutions (HEIs) (8.5%) offer various Biology Programs. Of this number, 92 HEIs (61%) are private institutions, while

58 (39%) are SUCs. A total of around 252 Biology Programs are offered at different levels, i.e.: BS degrees offered in 144 HEIs, MS, in 26 HEIs, PhD, in 5 HEIs. Interestingly, not all HEIs offer a Bachelor of Science undergraduate program, but instead, a Bachelor of Arts and not all are titled as BS Biology (Table 1).

The data on the distribution of these HEIs by region and program level show that most institutions with the Biology degree offerings across levels are concentrated in the NCR. The Masters Program offerings are distributed in the NCR, Regions 7, 8, 10, and the Cordillera Autonomous Region, while, the Doctor of Philosophy Program offerings are in the NCR, Regions 8 and 10. It should be noted however, that this distribution data contain some discrepancies, e.g., those from the UP System, which are a consolidation of data from all its Constituent Universities (CUs). The seven CUs are located throughout the country.

Table 1. Biology Programs offered at different levels in Philippine higher education institutions.

Undergraduate Programs (16)	Masters Program (12)	Doctorate Programs (17)
AB Biology	MS in Biology	PhD in Biology
AB Major in Biology	MS Zoology	PhD in Botany
BS Biology	MS Botany	PhD in Entomology
Bachelor of Arts in Biology	MS Genetics	PhD in Genetics
Bachelor of Science in Biochemistry	Master of Science in Botany/Biology	PhD Microbiology
Bachelor of Science in	MS Entomology Botany	Doctor of Philosophy Biology
Bachelor of Science in Microbiology	Master of Science	PhD Molecular Biology and Biotechnology
Bachelor of Science in Zoology	Major in Entomology	
Bachelor of Science Biology (Preparatory Medicine)	MS in Entomology	
BS Biology (General)	MS Molecular Biology	
BS Molecular Biology and Biotechnology	MS Molecular Biology and Biotechnology	
BS in Applied Biology	MS Plant Genetic Resources	
BS in Aquatic Biology		
BS Major in Biology		
BS Human Biology		

Note: Similar names were grouped together

The available statistics on student enrolment reveal that Biology offerings receive greater popularity over other disciplinal offerings in the sciences. And, we know why. The 2004–2005 enrolment data alone gave the following figures: 16,860 for biology, 3,876 for chemistry, 1,287 for physics, 1,277 for marine science, and 226 for geology. The graduation rates per level, based on data collected from 1990 to 2005, point to a weak performance rating with a range of 14–42% for the BS degree, 2–22% for the MS degree, and 0–18% for the PhD degree. Thus, only 1 out of 5 freshmen in the BS Biology program earns the degree they originally enrolled in while, 1 out of 10 completes MS/PhD degrees. The attrition rate for the BS program is mainly attributed to withdrawal from the roll due to academic or financial difficulties and secondly, to shift or transfer to more preferred programs. The attrition rate for the MS and PhD programs is basically due to financial difficulties.

The faculty profile indicates a total of about 1,175 faculty members with the following statistics on their graduate degrees: 772 hold MS degrees or are enrolled in an MS program; of this number, 252 are reported to have their MS degrees in Biology and allied fields. A total of 114 hold PhD degrees or are enrolled in the PhD program; 42 of these have their PhD degrees in Biology or in closely related fields.

Development Initiatives

Since 1994, CHED has initiated the development of higher education through innovative programs and projects aimed at improving the Biology Program offerings, among others. The Centers of Excellence (COEs) project was among the recommendations of the Congressional Commission on Education (EDCOM) in 1991. It was a means of providing support to HEIs with a track record for exemplary performance with the aim of enabling these institutions to participate more actively in national development. The COEs were intended to be: (1) the means for the country to catch up with its ASEAN neighbors; (2) the resource hubs from which other schools may draw strength; and, (3) the core of Philippine graduate education and research. When CHED came to being in 1994, this project concept was applied. At that time, the project concept was still an intervening measure to support a select number of HEIs in specific fields, particularly needed in nation building. This concept was eventually tailored to fit the needs specific to the different fields. In science and mathematics, the support of the COEs was envisioned to be a follow up to the Engineering and Science Project (ESEP) of the Department of Science and Technology. The CHED Technical Panel for Science and Mathematics (TPSM) believed that more gains could be achieved through continued support to initial efforts, such as those derived from the ESEP-DOST. At the same time, the CHED TPSM was cognizant of the fact that some HEIs demonstrated a potential for contributing to nation building efforts. These, however, have not yet attained the expected minimum core competencies for their disciplinal offerings. Thus, CHED came up with the concept for the Centers of Development (CODs).

From 1998 to 2005, CHED supported 14 Centers, with 5 as Centers of Excellence distributed as follows: 3 in the NCR (Ateneo de Manila, De La Salle University, and University of the Philippines Diliman), 1 in Region 4 (UP Los Banos), and 1 in Region 12 (Mindanao State University-IIT). The remaining 9 were Centers of Development located as follows: 2 in the NCR (University of Santo Tomas and UP in Manila), 1 in the CAR (UP in Baguio), 1 in Region 3 (Central Luzon State University), 1 in Region 6 (UP in the Visayas), 2 in Region 7 (University of San Carlos and Silliman University), 1 in Region 10 (Central Mindanao University), and 1 in Region 11 (Ateneo de Davao University). These Centers, in particular, the 5 COEs, produced 49%, 72%, and 76% of the total graduates from all the CHED Centers combined, for the BS, MS, and PhD degrees in Biology, covering the period from 1998 to 2004. The percentage graduate output by CHED Centers as compared to the overall graduation for the same 6-year period came to: 26% for the BS, 64% for the MS, and, 80% for the PhD degrees. What this indicates is that the 14 CHED Centers, representing only 9% of the 150 HEIs that offer BS Biology, produced a quarter of the total graduates. Significantly, the information also indicates that the higher-level manpower (with post graduate degrees) was generated mostly by these Centers.

Another CHED project was the development of Policies and Standards (PS) for Academic Programs in the basic sciences and mathematics. These set minimum criteria for degree programs, providing for specifications, such as, administrator qualifications, teacher qualifications, facilities requirements, among others. The PS for each discipline were developed separately by a group, each constituting a total of 7 policy-recommending Technical Committees for Biology, Chemistry, Environmental Science, Geology, Marine Science, Mathematics, and Physics. The Technical Committees oversee the developmental and curricular needs of each specialized area. The Chairs of each of these Technical Committees sit as members of the TPSM.

The Minimum Policies and Standards (PS) for Bachelor of Science in Biology (BS Biology) is embodied in the CHED Memorandum Order (CMO) No. 24, Series 2005. This document contains a set of Rules and Guidelines "...For the purpose of rationalizing the undergraduate biology education in the country with the end view of keeping apace with the advances in science and the demands of globalization...." A series of orientations was conducted on the PS for the BS Biology program in several venues in Luzon, Visayas, and Mindanao from 2005–2006. This is because the CMO was to take effect in the first semester of the academic year 2005–2006. (Note that prior to the finalization of the document on the Minimum PS, CHED conducted a series of consultations and leveling off workshops in many parts of the country starting around 1996 until such period when the Technical Committee buckled down to draft the Minimum PS.) This 52-page document signed by the Honorable CHED Chairman, Dr. Carlito S. Puno, on 22 July 2005, ends with Article XX. Transitory Provision, stating that: HEIs with existing program in Bachelor of Science in Biology shall be given a 3-year grace period to comply with these policies and standards.

The Minimum Policies and Standards are summarized below:

A. BS Biology Curriculum: The minimum range in total units per course category

	Number of units
General Education Courses	39
Non-biology Tool Courses	35
Core Courses	40
Science Electives	24
Free Electives	6
Undergraduate Thesis (or Special Problem)	6 (or 3)
TOTAL UNITS	150 or 147

B. The minimum units for each category

	Number of units
1. General Education Courses	39
Language and Humanities	21
Information Technology	3
Social Sciences	12
Life and Works of Rizal	3
Note: Natural Sciences (6 units) and Mathematics (6 units) requirements are fulfilled by General Biology I and II in the Core Courses, Mathematics, Chemistry and Physics in the Non-Biology Tool Courses	
2. Non-Biology Tool Courses	35
Chemistry: General, Inorganic, Organic Chemistry, Biochemistry	15

Physics: General Physics and Modern Physics	8
Mathematics: College Algebra, Trigonometry, Calculus, and Analytical Geometry, Statistics	12
Core Courses	**40**
General Biology I & II (5 units each)	10
Morpho-anatomy I & II (Plant & Animal)	3
Physiology I & II (Plant & Animal)	3
Systematic Biology (Plant or Animal)	3
Developmental Biology (Plant or Animal)	3
Genetics	3
Ecology	3
Microbiology	3
Cell and Molecular Biology	3
Note: Core courses, 3 units each, 2 lec, 1 lab	
4. Biology Electives	24
Suggested are: Entomology, Evolution, Freshwater Biology, Marine Biology, Molecular Biology and Biotechnology, Immunology, Histology, Theoretical Biology, etc.	
Note: Biotechnology is strongly suggested. Electives however, may concentrate on specific themes that the HEI may choose to offer.	
5. Free Electives	6
Science, Technology, and Society (3 units) or its equivalent is strongly suggested as a Free Elective	
6. Undergraduate Thesis or	6
Special Problem	3
HEIs may choose between an undergraduate thesis (6 units) and a special problem (3 units) to comply with this requirement	
Both thesis and special problem options INCLUDE a seminar course, which shall be offered in any of the last 2 semesters/ terms of the program	

CHED National Higher Education Research Agenda (Nhera)

Recognizing the important role of research in developing higher education in the nation, CHED undertook the National Higher Education Research Agenda (NHERA), which was operationalized in 1998. The Commission offers various forms of financial assistance through this program by offering block grants, grants-in-aid, commissioned researches, and professorial chairs.

Block grants are available competitively to private and public universities. The institutions receiving this form of assistance have to have a proven track record in research, at least 5% of the total faculty force have earned Ph.D. degrees, existing research facilities with updated computing equipment and updated collection of research journals or easy electronic access to these. Unlike block grants, grants-in-aid are extended to institutions that have lower capacities but show definitive potential in undertaking research. Commissioned researches, on the other hand, are given to individuals or institutions with track record in leadership in the scientific and academic communities and capabilities in these endeavors. In addition, professorial chairs are offered to prominent research faculty who are nominated by their own institutions. The type of researches funded through NHERA is aggregate by nature. The program encompasses all fields and allows an equal opportunity for pursuing developmental goals through research.

If an institution or its academic staff were awarded any of these research grants, counterpart assistance from the recipient universities would be required. The Commission obligates these institutions to allow reduction in teaching load or release time for the faculty researchers and full access to the institution's facilities and other incentives that the institution may provide.

Faculty Development Program

The Faculty Development Program (FDP) is under the CHED flagship project, the Higher Education Development Project (HEDP), which started in 2004. The HEDP is a mechanism to implement some of the sectoral reforms suggested in the 1998 Philippine Education Sector Study of the World Bank and the 2000 Presidential Commission on Education Reform (PCER). The FDP, as a subcomponent of the HEDP, is envisioned to improve the quality of teaching by upgrading the qualifications of the faculty currently teaching in the HEIs. For Biology, there are 13 institutions offering the Masters Program and these are spread from north to south of the Philippines.

Selection of CHED COEs/CODs for Biology

The selection followed the general guidelines and procedures formulated by the TPSM with focus on 4 general criteria:

- Instructional Quality: Faculty, Curriculum, Administration, Facilities, and

Students
- Research and Publications: Personnel, Facilities and Equipment, Publications, other scientific activities
- Extensions and Linkages
- Institutional Qualifications: Mission, Vision, Institutional Policies, Strategies and Principles, Support from Higher Administration.

Direction-Setting

The first selected institutions as the CHED Centers of Excellence and Centers of Development in Biology in1998 were given a 3-year support to improve the level of instruction, research, and extension, based on the needs these institutions reflected in their proposals submitted to CHED for funding, in accordance with the development concept of the COE/COD Program. In 2006, a new set of HEIs was selected as CHED COEs and CODs in Biology.

The newly awarded CHED COEs and CODs in Science and Mathematics are to perform functions in conjunction with National Priorities. These identified COE/COD Institutions must play a bigger role in Manpower Development, Research and Development, Linkages and Extension Services. They must develop into world-class S&T Universities with the research culture in place, such that more referreed publications are generated and ISI publications would become the norm. This mandate comes with an equally challenging task, which is to popularize science as part of the consciousness of the Filipino people.

Conclusion

On our part, we begin with standardizing the BS Biology Curriculum. We consistently strive to instill, early on, a mind set with a research orientation, going beyond mere asking. We continue to self-assess in the light of developments and advances in biology. We participate in programs on (1) the development of a scientific workforce, who shall remain doing their science in the country, (2) massive advocacy and promotional activities, (3) the improvement of educational institutions, and (4) the establishment of science-and-technology-based industries. We thus, benchmark ourselves based on performances and output. We continuously raise the bar!

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Educating the Youth on Veterinary Education Leading to Business

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Introduction

Educating the youth on veterinary education leading to business is an integrative approach to produce veterinary graduates as job givers rather than job seekers. Their strength lies on two important foundations: the science of veterinary medicine and entrepreneurship.

According to Cady (1961),"To educate (from "educare", to lead forth) never means to force into from the outside, but always means to draw out from within something already existing there." Thus, educating the youth means to bring forth ideas from the realm of concept to the world of manifestation.

Manuel and Cruzana (2002) states that, "Veterinary education is a component of the agriculture educational system wherein the science, art and philosophy of production, disease control, and health maintenance of livestock, poultry, companion and recreational animals, processing of meat, milk, and by-products, and safeguarding the health of wild mammals and birds, laboratory and aquatic animals, including public health, are undertaken, developed and promoted."

On the other hand, Topacio and Padilla (2002) stressed the involvement of veterinary professionals in their humanitarian role in the field of public health. Veterinary public health is a component of public health activities devoted to the application of professional veterinary skills, knowledge, and resources in the protection and improvement of human health. Veterinarians are involved in public health in the following areas: zoonoses, food animal production and hygiene, environmental protection and health, comparative medicine-biomedical research, disaster veterinary medicine and ethology and animal welfare.

These veterinary educators clearly defined the "animalitarian" as well as the humanitarian roles played by veterinarians in human society. Thus, a veterinarian is both an agriculturist and a medical man rolled into one.

From this wide field of scientific knowledge, someone who finds ideas, grabs the opportunities, takes the risks, converts or innovates concepts into the reality of products and services and sets aside comfort to establish a business, is a veterinary entrepreneur.

Veterinary Professionals and Entrepreneurs

In spite of the wide scope of knowledge that can be translated into real opportunity, few professionals including veterinarians take entrepreneurship as the road less traveled. Why newly-sworn in professionals choose to work for others instead of engaging in business may be because of the following reasons: lack of capital, high risk, lack of business exposure (both in theory and practice) and absence of opportunities.

"Entrepreneur" comes from the French word "entreprende", to undertake. Thus, an entrepreneur is a person who undertakes three important activities: organize, manage and assumes risks of a business. An entrepreneur is often defined as the owner of a small business who performs all or most of the business functions himself.

Studies revealed some of the qualities shared in common by entrepreneurs. Some of them are as follows (Ziberman, 2007; Copulsky and McNutty, 1974):

1. An entrepreneur makes thing happen. He is somebody who takes a concept and converts it into a reality: a product, policy or business.
2. An entrepreneur is a risk taker, but he is not a gambler in the true sense. He calculates risks and shows prudence when chances of success can be weighed.
3. An entrepreneur is a prime self-actualizer. He is motivated to achieve. He enjoys being a doer. He has a strong desire for achieving a job well done.
4. An entrepreneur has a lifestyle of hard work –the harder he works, the luckier he gets. Often, he sets aside comfort to establish an enterprise.
5. An entrepreneur makes his entrepreneurial quality apparent at various ages. Entrepreneurship is as likely to be found in the old as in the young. It does not diminish with age.
6. An entrepreneur is likely to come from a minority or deprived group and was probably challenged by life from an early age.

Most of the qualities of entrepreneurs are alive in most of us. However, research showed that some of the traits present among professionals separate them from becoming entrepreneurs. Professionals do not have the same goals as entrepreneurs. Some of these traits which differentiate them from entrepreneurs are (Copulsky and McNutty, 1974):

1. The professional is committed to his profession whereas an entrepreneur is forced to perform many functions as his ability and energy will allow.
2. The professional is committed to his own technology or skills whereas an entrepreneur is committed to the needs of the market.
3. The professional measures himself by his effort whereas an entrepreneur measures himself by the results he achieves in terms of profit.

Veterinary Education and Entrepreneurial Opportunities

After an uphill climb of being a professional, one is at the crossroad to find job to earn a living. Does a vet work for another in the service of veterinary medicine or engage in the business of veterinary medicine?

Unknown to most, a self-employed veterinarian has a big chance of becoming affluent, even in the most competitive and most powerful economy in the world. A 1995–1996 survey conducted in USA revealed that self-employed business owners and professionals dominate the list of American millionaires. The study also showed that veterinary services belong to the top 10 most profitable sole proprietorship businesses (Stanly and Danko, 1996). It is emphasized, however, that other than the right choice of profession, wealth is more often the result of a lifestyle of hard work, perseverance, planning and most of all self-discipline.

Locally, what business opportunities does veterinary education offer? Previously, it was mentioned that a veterinarian, is an agriculturist and medical man rolled into one. Having gone through veterinary education, some opportunities to enterprising professionals are found in Table 1.

Table 1. Business opportunities for veterinarians.

Veterinary Education	Business Opportunities in Different Sectors
I. Medical Aspect	**A. Service Sector**
	1. Veterinary hospitals and clinics
	2. Veterinary diagnostics
	3. Veterinary equipment and supplies
	4. Drug research and laboratory
	5. Zoo
	6. Aqua culture farm
	7. Wild park
	8. Geographic information system (GIS)
	9. Farms (livestock and poultry)

B. Manufacturing Sector

1. Pharmaceuticals/Biologics
2. Veterinary equipment and supplies
3. Diagnostic kits
4. Private abattoir
5. Poultry dressing plant
6. Stockyard
7. Pet foods

C. Marketing Sector

1. Veterinary equipment and supplies
2. Private abattoir
3. Veterinary drugs and biologics
4. Diagnostic kits
5. Pet shops and supplies

II. Agricultural Aspect

A. Service Sector

1. Manpower training
2. Technology transfer
3. Techno tourism/eco-tourism

B. Manufacturing Sector

1. Livestock and poultry farms
2. Gamefowl farm
3. Equine farm
4. Feed mill
5. Feed ingredient manufacturing
6. Farm equipment
7. Waste treatment plant and facilities
8. Sustainable energy (biofuel)
9. Meat shops

C. Marketing Sector

1. Farm and breeding animals
2. Farm equipment
3. Feed mill and equipment
4. Finished feeds
5. Feed ingredients
6. Meat shops

- Globally, animal agriculture makes important contribution to human well-being through the production of livestock and poultry. One of the most important needs of human is a dependable food supply. The Hudson Institute has estimated that the demand for farm products containing animal protein will double or triple in the next 40 to 50 years with the world population expected to about 9 billion in the next 20 to 30 years. Thus, there will be many opportunities for veterinarians in agribusiness (Gloyd, 1998 cited by Radostits, 2001).

Piggery Production as an Entrepreneurial Model

Pig production just like any production enterprise, must satisfy four business parameters to be profitable. These are Quantity, Quality, Time and Cost. These four factors must be balanced to sustain the life and growth of the business. Veterinary entrepreneurs identify, if not create, possible innovations or interventions so to bring about the best product at the least cost. Thus, veterinary entrepreneurs are also considered as innovators. Following one of the known economic theories by Joseph Schumpeter, the innovation theory states that innovators or entrepreneurs are important to economic development, for they can transform theory into reality.

Reducing cost. Increasing power cost and the ill effects of climate change are classical challenges being faced by the pig producers. These two factors coupled with the high cost of raw materials like corn, cassava, and wheat being diverted for biofuel production certainly affects cost of production. To a veterinary entrepreneur, this is an opportunity to be taken advantage of. Farm wastes can be converted to biogas and can be used to generate electricity. When applied, electricity from waste helps reduce power cost. Also, piggery waste if properly managed can also produce feeds and fertilizers.

Improving quantity. Farrowing rate, litter size and reduced mortality are functions of quantity. The desired farrowing rate is 80% (Galamgam et al., 2006), but is seldom achieved by piggery farms. For a veterinary entrepreneur, this is another opportunity. Adoption of a tried and tested AI technology using intrauterine-technique can provide a solution if adapted by veterinary practitioners. Intra-uterine AI using Absolute Technology can have impact above the industry target.

Improving quality and reducing time to market. Quality of hogs being produced can be improved using multi factorial approaches. This includes environmental health management, medication, and vaccination programs, nutrition and dietotherapy, and an appropriate breeding program, which all requires veterinary knowledge and animal husbandry skills. Quality enhancing program in hog production if properly mastered and maintained will reduce market time.

Suggestions and Recommendations

1. Veterinary schools should fortify courses with subjects that will help develop an entrepreneurial spirit. These institutions should take the lead in stilling values to graduates on the importance of entrepreneurship to the profession, industry and the country as a whole.

2. Veterinary professionals should develop deep understanding of the socio-economic realities, so as to help target opportunities with the end point of harnessing their veterinary knowledge in setting up a business.
3. Professional organizations in the veterinary field, should encourage, motivate, and recognize achievements of veterinarians in entrepreneurial field.
4. The government should create a business-friendly atmosphere to aspiring entrepreneurs. The government should ease some rules or minimize red tapes to make our country a haven for doing business not a worst place for running a business. Currently, World Bank ranks the Philippines number 126 out of 175 countries, almost at the near tail end of the worst places to do business (Philippine Export and News, 2007).
5. Financial institutions should follow examples of some banks making available funds and technical expertise in helping would be entrepreneurs through their various programs focused on SMEs (Dumlao, 2007).

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A Road Map for Science Education in Agriculture

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Among the many problems besetting our country today, the low quality of our education remains to he the foremost issue our government needs to address if we want to move forward towards a more progressive Philippines.

So what is ailing Philippine education?

Despite the fact that the basic literacy rate in the Philippines is very high and even closer to those of the developed countries than the developing ones, Philippine education has failed to live up to its potential for overall excellence. The general quality of education is very poor. In fact, the education outcome in the Philippines is quite low in comparison to the rest of East Asia, ranking last among 36 countries in student performance in mathematics and science tests. This dismal performance can be attributed to several factors. First, there is too little funding allotted to education. Each year, we hear the perennial problem of lack of classrooms, books, desks, chairs and even teachers, and until now, this has not been adequately addressed. The Philippines reportedly has the worst pupil-teacher rate in Asia at 45:1, even behind Laos (31:1) and Vietnam (30:1). Second, compounding these problems is the very low salaries of our teachers in comparison to our Asian counterparts. For instance, our teachers are receiving an annual salary of $1,241 while their Singaporean counterparts receive as much as $21, 280 and their Malaysian counterparts $5,800. This is why we are steadily losing our best teachers to United States and lately, even to China, where they are paid up to 10 times their salaries in the Philippines. Third, there is very low enrollment in S&T courses. Moreover, a lot of those who have graduated with degrees have not even acquired the necessary level of competence that their schooling is supposed to provide them with. Our graduates land in the wrong jobs and our trained researchers and technicians migrate abroad in search of greener pastures.

Let us analyze the issues by focusing on those surrounding agricultural education. Against the backdrop of national decline in enrolment in agriculture courses, we have the following challenges to confront with:

Declining support for tertiary education. UNESCO recommends 4% of the gross domestic product (GDP) for education. However, the percentage of the GDP the government has spent on education has actually decreased during the last five years, falling from 3.5% in 2000 to 2.4% in 2005. Similarly, the education sector's percentage share of the annual budget has dropped from 15.4% in 2000 to 12% in 2005.

Declining enrollment in agriculture and the poor image of agriculture. Most still have the perception that agriculture is a lowly profession because not much significant effort is done to promote both the field and the profession. So, when we talk about agriculture, what most people see in their minds is a picture of a poor farmer tilling the land from sun up to sun down with his carabao. We also have the culture and mindset that the brightest goes to medicine and the dumbest to agriculture.

High unemployment among our agriculture graduates. Yearly, we produce thousands of agriculture graduates who later turn out unemployed, or if they ever get a job, it is not related to agriculture but belonging to other disciplines.

Changing employment pattern. Most of our agriculture graduates land jobs in the call center industry as it is more financially rewarding.

VISION

Agricultural education has a vital role in meeting all these challenges. What we need is an agricultural system that will:

Address the needs of agricultural development within the Philippine context. Philippine agricultural education holds to its traditional methods of instruction. This method, while mirroring global trends in terms of course and curriculum, has a blatant downside: it is specifically tailored to the needs and demands of more developed countries like United States or Singapore. This should not be the case. Our Philippine agricultural education should be well-suited to the needs of the country while taking heed of the significant international developments and international forces that continue to shape the landscape of the overall educational system. What we need to produce are high-quality and innovative graduates with appropriate knowledge, skills, and attitudes that will meet the stakeholders needs. These relevant, employable, and innovative graduates will be the country's leaders of change.

Develop leaders of our food and natural resources systems. These new leaders must have the social consciousness, values and ethics, and at the same time, must have entrepreneurial skills. They must have solid technical and scientific principles, with a holistic approach to problem-solving, should be life-long learners, and must have strong leadership and team building and communication skills.

STRATEGIES

What needs to be done?

We must build awareness among the youth by using a discovery-&-inquiry based method of teaching and by starting them young. In particular, we have to shift the emphasis of our undergraduate education from developing a professional to an entrepreneur. Very few professionals take on the entrepreneurial route. Agricultural schools should fortify courses with subjects that will help develop the entrepreneurial spirit. Relevant courses such as business administration, accounting, financial management and communication skills should be included in the agriculture curriculum. These courses should be part and parcel of the basic curriculum and not just exclusive to majors of the agricultural business degree. It is imperative that we educate our young people on agricultural education with a business focus so that our graduates would become job givers rather than simply job seekers. Relatedly, we must never lose sight of the importance of enhancing our RD & E programs in agriculture that will support the graduate education in agricultural science. There should be a strong government policy statement in support of science education and science technology with corresponding budgetary provisions.

ACTIONS

Education is a long-term play with no quick fixes. If we want to turn around our poorly performing education system, we need to look at system-wide and long-term solutions—not provisional answers—that can impact positively on all schools at reasonable costs.

The cornerstone of these is a three- point action plan. We have to push for reforms and reorient the thrust of our agricultural education through the following:

1. Advocate for the integration of agricultural science and

technology education in basic education.

We have to start our students young by using discovery-&-inquiry based teaching methods. We have to focus on building a strong base in primary education and transforming young children into inquisitive, thinking individuals with a passion for science and technology so that they will become intelligent, competent and productive adults who can contribute to a competitive economy.

2. **Partner with the industry and private sector in developing entrepreneurship in agricultural science education**

A very weak industry-academe linkage befalls our current system. We train people in theory and minute instances of application when in fact an emphasis on on-the-job training (an apprenticeship of sorts) would serve as the best environment for putting classroom knowledge into work. Classroom instruction can be substantiated by engaging visiting lecturers who are practitioners from the industries. Curricula can be customized to fit present and future skills and knowledge demands of the industries. In drawing up the specific subjects and activities to be required by today's college students (where more specialized training occurs), the industry sector should be consulted. This guarantees that graduates are equipped for employment and that industries have a pool of talented newcomers. The benefits of an industry-academe linkage outnumber its costs. On the part of industries, this lessens in-house trainings since companies can influence schools to incorporate relevant subjects into course curriculum. This automatically allows firms to divert some training expenses to other endeavors (capital build-up, etc.). Students, on the other hand, receive first-hand instruction from industry leaders and seasoned practitioners, something that textbooks cannot provide.

3. **Lobby for long-term, ample budgetary support by the national government to agricultural research and development programs.**

The common denominator in the educational problem is lack of funds. This is the foremost obstruction ailing our educational system. Without sufficient funds, we will not be able to give our students the best education that they deserve and this will only compound the deteriorating quality of our social and economic life. The World Bank encourages developing countries to spend at least 20% of their national budget on education. The Philippines could spend only 12%. The UNESCO's recommendation is a budget of at least 4% of our GDP and we are spending only 2.4%.

These three actions are, however, not silver bullets that will solve our problem of poor agricultural education. But they could otherwise unveil a silver lining if pursued. Still, the bottom line is that, we must have a strong and unwavering resolve to confront the issues.

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Road Map for Biology Education: Issues and Strategies

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Biology is science of life and includes plants, animals and microorganisms. The current recognized domains of life based on an evolutionary framework as proposed by Carl Woese are: Archae, Procaryae and Eukarya. However, not too many biology teachers are imparting this classification to their students. Biology education, therefore, must keep abreast with the numerous breakthroughs and advances in the life sciences. It is imperative that the basic, intermediate and advanced concepts in biology be correctly and effectively taught to elementary, high school and college students.

A road map is therefore crucial as a starting point towards the improvement of biology education. The issues and strategies discussed in this paper were garnered from a round-table discussion on biology education held in April, 2008 at the Traders Hotel. In this forum, leading science educators at the elementary, secondary and tertiary levels were gathered to assess the current state of biology education in our country, identify the present gaps, issues, and concerns, find out which priorities need to be addressed, and hopefully come up with a preliminary course of action. It was a common consensus by the participants that biology education in the elementary, secondary, and tertiary levels should be supportive and complementary with each other.

The main factors identified to be affecting biology education at all levels are the curriculum, teacher factor, learner factor, and the learning environment. In the ensuing discussion, the issues in each of the factors were briefly presented, followed by recommended strategies.

Biology Curriculum

The main issue in the curriculum is that there are too many topics that need to be covered in one session, leading to information overload. Teachers are forced to keep on parroting information to their students to be able to cope with their lesson plans, without determining whether or not their students understand the topics. Also, there are numerous misconceptions about some of the topics covered in the teaching materials (e.g., "Dark" reaction in photosynthesis).

The curriculum must, therefore, be reviewed and revised to make it more relevant and holistic. This should involve middle management, who will serve as implementors. The parents' and students' viewpoints must also be considered.

There should be a review of the scheduling of the subjects. Some topics that are not related should be deleted so that relevant discussions can be made. The whole biology teaching education program must be reviewed, and the curriculum for education majors standardized (e.g., B.S.E.E. / B.S.S.E major in General Science). The B.S. Mathematics and Science Teaching Program must also be considered.

Teacher Factor

Teachers are being asked to teach science subjects which are not their field of mastery. Some teachers lack inquiry-based training. Also, they are overloaded with teaching responsibilities and other duties as well. The teachers must undergo training and retooling in order to identify their innate intelligences and harness their talents and skills (e.g., peer mentoring). A teacher must also be a facilitator of learning who will consider the diverse leaning styles and multiple intelligences of the students.

Learner Factor

The learners cannot integrate what they have learned in school, causing fragmented learning. They also lack basic concepts in English and Math which are prerequisites for understanding biology. The students must not only be the learners, but the community as well, so that they will have ownership of the learning process. Participative learning must also be encouraged. There should also be English and Math drills to supplement their knowledge on the subject matter. Biological issues in the community should also be considered to generate interest among the students.

Learning Environment

The usual classroom set-up is a teacher-centered environment with minimal student participation. There is also a lack of audio-visual facilities that might aid in the learning process. Some of the classes are very large, limiting the learning outcome. Various kinds of environment must be used as contexts of learning, i.e., natural environment. The learning must be community-based. Classes should be smaller whenever possible. In case of large classes, appropriate teaching strategies must be devised (e.g., audio-visual materials).

Tertiary Level

Biology as a degree program

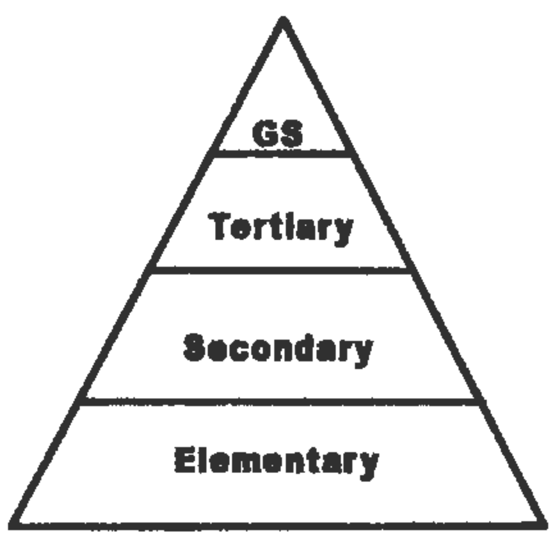
To alleviate the declining number of students taking Biology, the degree program itself must be restudied and reinvigorated. The introduction of novel courses such as bioinformatics and bioentrepreneurship will be of help. There should be some remedial or bridging classes, and discussions of ethical issues to enhance subject learning, even if there are some deficiencies in the tools in understanding specialized courses. There should be supplementary administrative support to be able to acquire additional facilities adequate for the learning process.

Biology as a subject

Integrative Biology must be considered to have a holistic approach in teaching the subject matter. The inquiry-based approach (investigative/ exploratory) must be used to sustain students' interest in the subject.

The Commission on Higher Education (CHED) made the following initiatives with the goal of improving biology education: (1) identifying CHED Centers of Excellence and Development, (2) standardizing the BS Biology Curriculum, (3) adopting common policies and standards for academic programs in biology, (4) creating a technical committee for biology that oversees implementation of policies and programs, and (5) having an adopt-a-school program among COEs to uplift the status of biology education in other institutions of higher education.

As a conclusion, a road map for biology education is portrayed in the figure below. The elementary level forms the base, and thus serves as



the conduit for a general overview of biology. As the student goes up the higher rungs of the pyramid, more and more details are learned; there is more focus on important topics and issues. But all these are towards the goal of understanding life's complexity as it affects the individual, the environment and society

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Roadmap for Developing a Culture of Science through Effective Basic Math and Science Education

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Culture of science has been defined in different ways. One definition says that people with a culture of science, including the young ones, are more exploring and not passive in getting information and ideas. Another says that these are people who have become not only qualitative but quantitative as well in describing and explaining things and are more creative and innovative. They are a problem-solving people. A country has imbibed a culture of science when decisions of institutions including government are based on evidence and science, and when science has become a way of life for its people.

Towards building a culture of science in the country, our division has focused on the basic math and sciences for the elementary and high school since these are the foundation of higher science and technology education. Even students who eventually major in other fields should have a strong foundation and appreciation of basic science and mathematics and should have been exposed to the analytical and critical thinking involved in such subjects. The CMPSD held four pre-Annual Scientific Meeting (ASM) round table discussions (RTDs) on mathematics and science initiatives, mentoring, science careers and strategies in science and math education and held a technical session during the 2007 NAST ASM.

We hereby summarize the challenges and strategies and possible solutions to the strengthening of basic math and sciences in the country towards building a culture of science.

Increasing Competency and Science Content

It was a recurring observation that many teachers are not majors of the courses they teach, for example, a biology teacher teaching physics or chemistry and vice versa. Competency in the subject matter is weak or worse, lacking. Among the suggested solutions are:

(1) Increasing the science content in the pre-service. During one of the round table discussions, a representative from the Commission on Higher Education said that the science content of education curriculum is going to be increased. This has to be to be confirmed.
(2) Inservice training should be further promoted for those who are already teaching.
(3) There are also many students who take up BS in various science fields (Math/Biology/Physics/Chemistry who can be encouraged to teach in high school and, thus, education courses should be made available to them.

According to the report on the TEEP (Third Elementary Education Project), significant improvement in math in the National Achievement Test was attributed to the Math Teachers' Lesson Guide series which was prepared by DepEd and Ateneo and printed/distributed by TEEP). We hope we can replicate this success with teachers' lesson guides for chemistry, biology and physics. We have thus linked up with colleagues in chemistry, physics and biology to see if similar lesson guides can be prepared for their disciplines for high school teachers. According to Prof. A. Cuyegkeng of Ateneo, a chemistry guide has already been prepared. This should be reviewed again if needed and efforts be made to distribute this guide to chemistry teachers with the appropriate accompanying training on its use as has been done with the math lesson guide.

On Pedagogy—from Vertical to Inquiry- and Discovery-based Method

Presently, the common method of teaching is the vertical type, concepts and facts handed directly from teacher to student. It is recommended that inquiry- and discovery-based method of teaching be adopted in the country and this should start from primary and nursery schools. Scientific evidence shows that this inquiry- and discovery-based method of teaching stimulates creativeness and innovativeness.

In December 2003, the InterAcademy Panel (IAP), a global network of the world's science academies (www.interacademies.net), issued a statement on science education for the youth which was signed by 68 academies of science, including the NAST. The IAP statement recommended to all national leaders the adoption of teaching based on inquiry-based pedagogy, with a major role assigned to students to ask questions, to develop hypotheses relating to the initial questions, and when possible to conduct experimentation using simple instruments. Further

IAP recommended that acquisition of knowledge by children should be horizontal which connects them with nature, both inert and living, directly and involves their senses and intelligence. Children who undergo inquiry- and discovery-based learning have been shown to be open to, enjoy and appreciate science. They perform better academically. They communicate better and are more creative.

Creativeness and Innovativeness

Development of creativeness and innovativeness among our students was cited as major challenge. As discussed earlier, the use of an inquiry-based and discovery-based teaching method will help develop creativeness and innovativeness among children. We know how well Chinese students perform in mathematics and the sciences. However, to further develop and strengthen creativeness and innovativeness among the young Chinese students, China has adopted the French programme called La Main á la Pâte (LAMAP), a "hands on" science education program. Vietnam, Cambodia and Malaysia have also adopted this programme.

In the Philippines, some schools have adopted various models of the "hands on" and inquiry-based teaching method but their adoption needs to be widened and, preferably, institutionalized. Drs. CC Bernido and MC Bernido have developed the Dynamic Learning Program in the Central Visayan Institute Foundation which consists of five pedagogical maxims: (i) learning by doing, (ii) sound fundamentals, (iii) mastery not vanity, (iv) adaptability, and (v) honesty. "Learning by doing" maxim for their math and science subjects in high school means lectures are given only 20 to 30% of the time while the rest is devoted to pre-designed activities.

One of our technical session speakers, Dr. J. Camacho recognized that the Philippine culture of complaining is reflective of the lack of proper training in problem solving. He discussed TRIZ (Theory of Inventive Problem Solving), a powerful methodology for improving thinking processes that promotes improved problem solving skills producing systematic innovation and creating novel inventions. Dr. Camacho is involved in promoting the integration of TRIZ in the academic setting.

Professor Nelson Cue, retired Professor of Physics at the University of Hongkong shared his experiences in successfully transferring technology to industry. He discussed the commercialization of PRS (Personal Response System) which enables students to think about the question and react immediately and allows the teacher to evaluate whether students have understood the material presented. Prof. Cue has also been involved in the commercialization of biotechnology products of recombinant human growth factors for therapeutic purposes. In his undertakings, he presented three stages which were clearly delineated:

1. "A new marketable idea or concept that came serendipitously, through experience, a systematic study, or a combination of these. Exchanges of ideas with various experts would clearly be helpful in this context.
2. Demonstrate the practicality of the idea or concept. A working prototype is essential, and accessible and affordable resources, both human and material, are required.
3. Implement and market the product or service. A working capital is needed and a good network for this is almost essential." (Cue, 2009)

He added that the bottom line for successful technology transfer is to have "a group of creative, educated, and experienced people working together with a common goal."

It cannot be overemphasized that creativeness and innovativeness are a major foundation of discoveries and inventions.

Financial Support to Education; Building Stronger Institutions

Lack of budget, inadequate facilities, lack of textbooks and the like were often cited as problems in the delivery of quality science education and education, in general.

DepEd Secretary Jesus Lapus announced an increase in the budget for the DepEd from PhP 120 billion for 2007 to 150 B for 2008. The new budget represents 2.7% of GDP, still less than the 4% recommended by UNESCO. Moreover, challenges for timely, cost effective and efficient management of resources, and less corruption, face government and especially the DepEd.

The Department of Science and Technology has ongoing projects on teacher training. The DOST Science Education Institute (SEI) developed the certificate and diploma programs in science and mathematics education offered in 16 Regional Science Teaching Centers where teachers can take the program for two summers and the certificate or diploma is granted by the university in which the program is lodged in that particular region. SEI also undertook a training project especially for the training of Mindanao teachers in collaboration with five universities in the area. Further, SEI has programs on faculty development at the master's and doctorate levels.

We acknowledge the enormous contributions from private sector and NGOs in the building of schoolrooms, teacher training, support to students (scholarships, books and reading materials, food and school supplies aids etc), and many other forms of assistance.

Mentoring and the Promotion of Science Careers and Science

The Division realized that to strengthen S & T in the country, we need to promote science careers among our youth, to mentor them well in their research, and to promote science in general to the general public. These concerns were discussed during the pre-ASM round table discussions as well as by some of our speakers during the ASM itself.

Prof. Dina Ocampo characterized a successful mentoring as follows (Ocampo, 2009): "(1) it should be reciprocal. It is not just one person doing all the talking. (2) It should be creative. It is a thinking process; the two minds must meet. (3) Both mentor and mentee should be connected to a vision. In education, when I mentor, I always think of how to make the teaching good, what will make the learning by the children more fun, more meaningful. (4) The mentoring should be informed by disciplinal understanding. (5) It should be guided by professional and ethical practice. (6) Mentoring should be transformative: the mentor should become a better mentor and the mentee should grow and develop depending on their goals and arrangement. In a transformative relationship, both parties change."

Bright Lining in the Horizon---the Initiatives

In his analysis, Father Nebres concluded that improvement of science and math education in the context of Philippine schools should address the following:(1) "Creating the absorptive capacity of schools and clusters of schools to take in and implement significant reform and improvement (attending to the macro problems); and (2) Targeted and focused interventions to address priority needs (academic and non-academic) (attending to the micro-problems). This means meeting the schools where they are, setting next level targets with them, and moving them to the next level." He cited examples of relative success stories like the TEEP which tackled macro problems (absorptive capacity in the school and community) and micro problems (teacher training, textbooks, lesson guides etc.).

We acknowledge the initiatives of various organizations and agencies, private and public, in various activities towards the improvement of science and mathematics education in the country.

- TEEP(Third Elementary Education Project)
- Project SSPEEd (Sectoral Support for Public Elementary Education) (2001-04)
- ACED (Ateneo Center for Educational Development) (2004-) work in Payatas
- Synergeia Foundation--- Project Josie (Bulacan)
- Synergeia in Lipa City---with Mayor Vilma Santos Recto
- BEAM (Basic Education Assistance for Mindanao) Australia (2002-04; 2004-08)

- EQuALLS Education Quality and Access for Learning and Livelihood Skills) in Mindanao USAID
- DOST
- DepEd

In his keynote speech during this meeting, Ateneo President Fr. Bienvenido F. Nebres said "... The culture of the natural sciences and mathematics is not to bewail or just describe a problem, but to solve them." He emphasized the need "to engage Philippine culture and move it into a problem-solving mode, away from a blaming or complaining mode."

The importance of giving attention to the social environment of our schools if we aim to improve and develop our schools and educational system has been emphasized. This means involving the whole school community – principal, teachers, parents and local government (barangay) officials.

Fr. Nebres added:

The challenge for us then is to ask how we can make progress for the majority of our students.

Reiteration of Recommendations

We reiterate our recommendations on the sustained implementation of concrete measures that can be undertaken to strengthen basic science and mathematics towards building a culture of science:

1. A strong government policy is needed for sustained support to science and technology and larger and substantial budgetary provisions for the development of science and technology.
2. The inquiry- and discovery-based science education should be institutionalized and be utilized in all schools of the country. This kind of science education is already implemented to some extent but only in a small number of schools in the country. In this regard, this inquiry- and discovery-based science education program should be developed in collaboration between the Department of Education, the Department of Science and Technology, the science community and the NAST. Centers for the training of school teachers in the inquiry- and discovery-based method of teaching science should be established. Centers and organizations that nurture talent in science and mathematics should likewise be supported.
3. A policy is needed from industry and private sector that rewards the technology career path similar to the career path in marketing and finance. We also need greater support for the development

of science and engineering in the universities from industry and private sector. Stronger academe-industry-government interactions and linkages should be pushed for the more efficient and effective development and transfer of technologies needed by industry and the general public.

4. From schools and universities, we need policies and measures that will strengthen mathematics and science education. We need to benchmark with our neighboring countries and set goals in terms of achievement in mathematics and science at school and university level.
5. We ask our present leaders in science and mathematics to invest time and effort in mentoring and developing a younger generation of scientists and in building with them stronger institutions mathematics, science and technology.

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The Importance of Accreditation of Engineering Programs to the Global Practice of the Profession

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An aspect of globalization is the free movement of professionals and of services across national boundaries. In the worldwide community of engineers, greater mobility is being sought through the internationalization of engineering education and the mutual recognition of professional qualifications.

"*Substantially equivalent engineering degree programs*" is the phrase often used to characterize engineering education systems adhering to common standards. Graduates coming from substantially equivalent programs in different countries are assumed to have basically the same competencies and can therefore enter into the practice of the profession across countries more easily.

The **Washington Accord of 1989** is one such effort to internationalize engineering education. The signatories to this Accord agree that an engineering degree program accredited by one member country is substantially equivalent to an engineering degree program in the same field accredited by another member country. As a consequence, graduates of nationally-accredited engineering programs are exempted from the educational requirements for practicing in any of the other signatory countries.

The International Professional Engineer (IntPE) Register accepts individual members exclusively from countries which are members of the Washington Accord. More specifically a prospective member must have graduated from a program that has been accredited under the terms of the Washington Accord. This makes it important and urgent for the Philippines thus to become a member of the Washington Accord.

This panel discussion aims to clarify the Philippines' present situation and the steps necessary to move towards membership in the Washington Accord.

Accreditation

Enrico C. Nera, ASEAN Eng., APEC Eng.
President, Philippine Technological Council
Chairman, Governing Board, ASEAN Federation of Engineering Organizations

Accreditation is a process by which a facility's services and operations are examined by a third-party accrediting agency to determine if applicable standards are met. Should the facility meet the accrediting agency's standards, the facility receives accredited status from the accrediting agency.

Aims addressed by Accreditation

- Security and protection of profession
- Mobility and transparency -- international recognition
- Reduces cost by increasing efficiency
- Compatibility
- Stability
- Stimulates improvement and Quality Assurance schemes

Global Impact of Accreditation

- Global Professional Mobility
- Mutual Recognition Agreements
- Assistance in the Development of Accreditation Process and Systems
- Substantial Equivalency Evaluations

Issues in the Philippines

- Present Accreditation systems
    - o Institution based accreditation
    - o Self accreditation by associations of HE
    - o Fragmented/sectoral
- 12 different engineering laws
- 12 different engineering professional organizations
- Program based certification by CHED-TPETA

Recommendations

The accreditation body should consist of 4 sectors namely government, HEIs, POs and industries.

The Washington Accord (WA)

Conrado Navalta
Director, Continuous Quality Improvement Office, MIT

- WA was signed in 1989
- An agreement between the bodies responsible for accrediting professional engineering degree programs in each of the signatory countries
- It recognizes the substantial equivalency of programs accredited by those bodies
- It recommends that graduates of accredited programs in any of thesignatory countries be recognized by the other countries as having
- met the academic requirements for entry to the practice of engineering

Scope

- Covers professional engineering undergraduate degrees
- Does not cover engineering technology and postgraduate-level programs
- Does not cover professional engineering designations such as Chartered Engineer
- Only qualifications awarded after the signatory nation became part of the Accord are considered

Admission Requirements

- An application for provisional membership supported by nominations from two of the existing signatories
- A positive vote by at least two-thirds of the existing signatories
- A prescribed period of provisional status (normally 2 years) during which the accreditation criteria and processes established by the applicant, and the manner in which those procedures and criteria are implemented, will be subject to comprehensive examination by a review team
- Unanimous approval of the existing signatories for transition from provisional status to signatory status

General Characteristics

Important Notes:

- The signatories to the WA shall be authorities, agencies or institutions which are representative of the engineering profession and which have statutory powers or recognized professional authority for accrediting programs designed to satisfy the academic requirements for admissions to the profession within a defined jurisdiction (e.g., country, economy, geographic region). Any such authority, agency or institution must be independent of the academic institutions delivering accredited programs within their jurisdiction.

ISSUES and CONCERNS

What is the responsible agency responsible for the signatories to the WA? PTC is not accrediting agency and has no track record.
PAASCU and PACUCOA must be independent of the academic institutions delivering accredited programs within their jurisdiction.

AASCU Accreditation of Engineering Programs

Concepcion Pijano
Executive Director, PAASCU

Philippine Accrediting Association of Schools, Colleges and Universities (PAASCU) is an accrediting agency for private sector since 1957.

Higher Education Programs Accredited by PAASCU

- Chemical Engineering
- Civil Engineering
- Computer Engineering
- Electrical Engineering
- Electronics and Communications Engineering
- Industrial Engineering
- Mechanical Engineering

Institutions with Accredited Engineering Programs

- 24 Higher Education Institutions
- 76 programs
    - 12 – Level I accredited programs
    - 42 – Level II accredited programs
    - 22 – Level III accredited programs

May 18, 2007 – PAASCU Board creates a Committee to work on its application for the Washington Accord
July 4, 2007 – The Committee meets for the 1st time and decides to recommend the following to the PAASCU Board in its August 3, 2007 meeting

1. Creation of a Commission on Engineering Education (CEE) within

PAASCU, similar to the Commission on Medical Education.
2. Creation of a Board of Advisers that would work in tandem with the CEE. Three eminent industry practitioners who are experts in the various fields of engineering will be invited to serve as advisers.
3. Revision of the Survey Instrument for Accrediting the Engineering Programs

ISSUES and CONCERN

Joint Statement of the European Networks for the Accreditation of Chemistry-, Engineering-, Informatics- and Medical Study Programmes They commit themselves to apply for membership to the European Association for Quality Assurance in Higher Education (ENQA) and to apply for registration in the envisaged European Register for Quality Assurance Agencies. This will affect the plan of the Philippines for a membership in Washington Accord.

Infusing Outcomes-Based Assessment to Current PACUCOA ACCREDITATION PROCESSES

Philippine Association of Colleges and Universities Commission on Accreditation (PACUCOA) is an accrediting agency for a private sector. It was incorporated in 1988. PACUCOA was approached by PACU to consider the inclusion of program outcome assessment in the engineering instrument so that the Philippines through n accrediting body will qualify for membership to the Washington ACCORD.

The proposed accreditation process, involves three major components:

Part I- shall require an engineering program to undergo a self survey or self evaluation. This component consists of specific provisions on policies, guidelines and practices.

An enhanced instrument that includes components of a program outcomes assessment that comply with CHED-CMO shall be used. The format follows the current engineering instrument. The sections on purposes and objectives, instruction and community development, and organization and administration have been revised to follow a uniform framework that conforms to a cycle of continuous improvement (i.e. plan do, check and act).

Part II- shall require the institution to provide qualitative and quantitative description of the program's various educational processes. This component shall immediately follow part I. This component describes

the process that show how the institutional and program objectives are achieved and evaluated.
Part III-requires the accrediting team to assess the program using a rubrics-based performance measure. This shall be comparable to ABET's level of implementation.

ISSUES and CONCERNS

Equivalency- process of program assessment and student learning outcomes assessment are substantially equivalent to those practiced by member economies of Washington Accord.

Transportability- Standardization of language and terminology so that meaning and intent are commonly understood by constituencies and stakeholders.

Reliability, validity and credibility of the assessment process: Acceptance of assessment strategies and practices across the accrediting community.

Evidence of student learning outcomes:A coherent way to explain the approach to the matter of evidence of student learning outcomes to outside constituencies or stakeholders.

Framework: A common conceptual framework that allows the various accrediting agencies to understand the key distinctions and similarities among approaches/practices.

FEED Accreditation of Engineering Programs

Prof. Edgardo G. Atanacio
College of Engineering
University of the Philippines Diliman

FEED Accreditation

- Outcomes-based: the focus is on what is learned rather on what is taught
- Intended to be consistent with the requirements of the Washington Accord
- Accreditation systems used as basis:
    - o ABET (formerly known as the Accreditation Board for Engineering and Technology, USA)
    - o Engineers Australia (EA)
    - o Japan Accreditation Board for Engineering Education (JABEE)
- Self-assessment, evaluation
- Evaluator pool from industry and academe
- Evaluation based on five accreditation criteria

Criterion 1: Students

- Admission and transfers
- Advising
- Performance evaluation and monitoring
- Student support

Criterion 2: Academic Program

- Program educational objectives
- Program outcomes and assessment
- Curriculum
- Professional component

Criterion 3: Academic Environment

- Faculty
- Support staff
- Facilities and physical resources
- Institutional support and financial resources
- Academic leadership and educational culture

Criterion 4: Systems and Processes

- Feedback and inputs to continuous improvement processes
- Approach to educational design and review
- Approach to assessment and performance evaluation
- Dissemination of educational philosophy
- Approval processes for program development and amendment

Criterion 5: Specific Program Criteria (SPC

- Chemical Engineering
- Civil Engineering
- Electrical Engineering
- Electronics and Communications Engineering
- Industrial Engineering
- Mechanical Engineering
- Metallurgical Engineering

ISSUES and CONCERN

Limited evaluator pool in the Philippines especially in Engineering program. More engineers from the manufacturing industries must be trained to be an evaluator.

CONCLUSION AND GENERAL RECOMMENDATIONS

The Philippines needs to develop an accreditation system that satisfies the requirements of the Washington accord. This system must be independent of the schools, industry-led and outcomes-based.

The present accreditation instruments presently used by the accreditation bodies need drastic change. Also there must be significant reorganization of the entire system.

The following immediate action is therefore recommended:

Creation of a Working Group consists of the following agencies/ institutions

- PTC
- PAASCU
- PACUCOA
- FEED
- AACUP
- \+ Gurus (Dr. Lazaro, Dr. Cruz and Dr. Follosco)

Expected Output of Working Group

- Organize a unified body to accredit engineering programs in the Philippines consistent with the Washington Accord
- Thresh out differences in the accreditation concept, process and status
- Come up with a unified accreditation system consistent with Washington Accord
- Identify/tap sources of funding

Convenor: Engineering Sciences and Technology Division, NAST

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Health Sciences Roadmap Towards Building a Culture of Science

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Introduction

The Health Sciences Division, in keeping the theme: "A Progressive Philippines Anchored on Science: Building a Culture of Science in the Philippines", chose key topics and expert speakers as follows:

1) Curriculum of the Medical School by Dr. Ramon Arcadio, Chancellor, UP Manila, 2) Evidence-Based Medicine by Dr. Domingo Bongala from the Philippine College of Surgeons, and 3) The Curious Phenomenon of Doctors Going into Nursing by Acd. Jaime C. Montoya, Executive Director of the Philippine Council for Health Research and Development. For the third topic, I had to pinch in for Acd. Montoya who had to attend to something very urgent elsewhere.

On the Curriculum of the Medical School

Dr. Ramon Arcadio, Professor and Chancellor of UP Manila, discussed the Trends and Actual Experiments on the Curriculum of UP Medical School. He first reviewed the trend in the world, but later focused on what have been tried in the Philippines, especially the UP experience. He noted that the present curriculum is a combination of the regular curriculum which is mainly discipline-based basic sciences–anatomy, physiology, pharmacology, and clinical medicine, and an introduction into the different specialties. At UP, they introduced the Integrated Liberal Arts Medicine Program (INTARMED), which is a shorter seven-year program. The regular program consists of nine years — four years of pre-Med, four years of Med proper and then one year more of internship totalling seven years. The INTARMED Program consists of Liberal Arts subjects in the first two years, followed by clinical clerkship that is community-based, then clinical clerkship that is hospital-based, and culminates in an integrated internship. The students obtain the MD degree in seven years, two years shorter than the regular curriculum.

From the experiences gathered from the implementation of these medical curricular programs, Chancellor Arcadio recommended for the Philippine medical school system: "Medical schools should shift to a more innovative and science-based curriculum to be monitored by CHED and the Association of Philippine Medical Colleges. And medical schools should adopt a community-oriented curriculum."

I would like to mention that the first community-based medical education program was introduced by one of our National Scientists, Dr. Paulo Campos, many years ago, through the comprehensive community health program in Bay, Laguna. This is now the trend— to go back to this community orientation.

It was further recommended that the basic medical curriculum should not be legislated, thus, the enumeration of subjects in the Revised Medical Act of 1959 should be removed. A shift to science-based curriculum should be accompanied by reforms in licensure examination, that is, for example, questions should be based on core competencies, not on the subjects. Exceptional colleges of medicine may be allowed to implement a shorter seven-year curriculum.

Evidence-based Medicine

Dr. Domingo Bongala, a member of the Philippine College of Surgeons and presented what is now a buzzword in medicine, evidence-based medicine. He gave as an example, the revised published guidelines on antimicrobial prophylaxis for different surgical procedures which were based on good clinical evidence. In this case, the guidelines involved actual randomized clinical trials on the use of antimicrobials for prophylaxis, that is giving antibiotics or antimicrobials before surgery to prevent and minimize infection as a complication of the surgical procedure. Based on the clinical trials specific recommendations on what antimicrobials or antibiotics are to be given before surgery. Dr. Bongala recommended that this evidence-based approach should be used for the adoption of all guidelines for diagnosis and medical treatment of common medical conditions. Evidence is better than using limited personal experience or 'gut feel'. Evidence particularly Randomized Controlled Clinical Trial is the gold standard.

The Phenomenon of Doctors' Shifting to Nursing

We are all aware of the phenomenon of doctors shifting to nursing to be able to go abroad and work abroad as nurses. I will now discuss this interesting phenomenon of many doctors wanting to be nurses. In our time, we liked nurses and some of us courted nurses and married nurses but we never shifted to nursing as a career. Today, we observe this curious phenomenon of many doctors going abroad and shifting to nursing as a profession.

Firstly, let us review some statistical data from the government agencies in 2003. The Philhealth accredited MDs in government number 21,000. In 2004, there was a decrease in this number of PhilHealth accredited MDs which would support the shifting to nursing of government medical doctors. In 2002, DOH reported that there were 3021 MDs and 4720 nurses in government service. The ratio of government MD to population in the Philippines was 1 to 26000. This is very far from the WHO recommendation of 1 doctor to 600 population. The ideal MD to patient ratio in the hospitals and perhaps in modern rich countries is 1 to 8. The ideal nurse-patient ratio is 1 to 4. The Philippine ratio is very much below this. This problem is nationwide.

In 2002, there were 9,453 nurses who took the Professional Regulation Commission (PRC) Examination for Nurses. This number jumped in 2003 to 15,000. On the other hand, the number of medical doctors who took the PRC Exam for Doctors was below 4,000. In government hospitals, a large proportion (20 to 40%) of the total number of medical staff in provincial hospitals was reported to be taking up nursing according to the association of provincial hospital directors in the Philippines. This shows that this phenomenon is occurring all throughout the regions of the country and many of these were reported by different medical societies in a survey made in August 2004.

In Misamis Occidental, the percentage of physicians enrolled in nursing was 20% and in General Santos and adjacent towns, it was a very high 78%. Overall, 8% of medical doctors were enrolled in nursing, 5% have graduated as nurses, and 2% of these have migrated abroad.

Why would government physicians want to leave and go abroad to be employed as nurses? In the Philippines, their salary range from PhP20,000 to 24,000 per month, and retirement benefits are minimal; they render difficult underpaid work and they have no secure career path for professional advancement. If they go abroad as nurse, they would get PhP216,000 per month, a two-year guaranteed contract and they can bring their family too. This is a very attractive offer available in many countries like the United States and the United Kingdom. Love of medicine and service to the nation are not sufficient to overcome the economic hardship resulting from low salaries of government physicians and limited career advancement opportunities for physicians.

To Create the Health Care Workforce of the Future

I will now summarize what we can do to create the health care workforce of the future. At the international level, macroeconomic policies that have impact on the national health workforce should be studied and favourable policy interventions can be designed at various levels and with various time frames.

At the national level, we can establish registries and network that effectively strengthen national human resource information system, establish mechanisms to allow for dialogue and cooperation among the different professions like medical, nursing, and allied professionals in health care. Chart and assume full control of our roadmap for the future medical practice in the Philippines and allot adequate time focused on resources on the future directions adapting to the needed change in strategic planning, membership, profiling, and advocacy.

We have to acquire a level of competency, clout, and control over the politics of health care not only where and when it hurts but also when and where it matters. Promote and safeguard the welfare of medical residents and fellows; ensure that they are not exploited; conduct a training orientation and curriculum in medical schools and residency training institutions. Redirect focus on public health and service to the country. Analyze current relative salary and human resource supply trends. Press legislation to improve the economic status and welfare of health workers; look beyond pay and to make health care sector more attractive to the citizens. Consider broader incentive packages that address living conditions. Develop long-term plan for achieving proper plate mixes of skills and geographical distribution Collaborate with other sectors and non-governmental organizations, etc.

To quote a guru in management "the only way to predict a future is to create it."

Thank you.

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Building a Science Culture: Some Premises in Mapping the Contours of the Road Ahead

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This presentation is by no means a roadmap with a clear-cut layout of the road ahead and the street network of which it is a part. Neither is it a map drawn from welldefined, compass-based directions and agreements on how the distance traveled at whatever point the Philippines is on the map will be measured. That we are only drawing roadmaps now says much about our condition. Some of our neighbors drew such maps many decades ago, explaining in part why they have achieved what they did. The experience of Vietnam at the height of the war is particularly instructive.

In a collaborative project in 1999, Vietnamese colleagues from my generation, who themselves obtained doctoral degrees from England or Germany quietly but persistently rejected our proposal to bring into the team Vietnamese scholars with doctoral degrees from Europe or the US, who were recommended to us by respected European and American colleagues. We did not understand the resistance at first because the team they eventually constituted consisted of Western-trained Vietnamese social scientists. To get our project moving, we just resigned ourselves to the idea that our Vietnamese partners were simply more comfortable with those from their own networks.

Only when our relations warmed in the course of the project did our Vietnamese counterparts explain their initial stance towards the scholars in our list. Every year since Vietnam established relations with Russia, after the United States accordingly refused to support its nationalist war against the French, the 500 high school students from all backgrounds who excelled in the national examinations each year were sent either to Russia or the Eastern European nations for higher education. They were ordered to excel in the fields they were in---the natural and yes, even the social sciences. They were expected to learn the language of their schools within six months and, even tougher than this requirement, were not allowed to obtain grades lower than the highest grade in the university where they were assigned. Their collective task was to ensure that everyone in their cohort made the maximum grade. They could not possibly get lower marks when their countrymen were dying.

At the height of the Vietnam War, their nationalist leader, Ho Chi Minh, sent the best and the brightest Vietnamese out of harm's way and told them that they ought to see themselves as soldiers at war for Vietnam (our colleagues claimed their brothers did not die for communism during the war but for their nation). They had to aspire to be great scientists because their mission was to rebuild Vietnam when (not if) they win the war. These Russian-trained scholars went on to study in Europe (now they also study in the United States) for their postgraduate degrees. They returned to Vietnam to build the research institutes of their country. Against this backdrop, it was easy to see why our project partners refused to even consider our list of Western-educated Vietnamese who did not go through the route of the country's best. They admitted feeling superior to those from the same generation in our list who merely obtained doctoral degrees abroad but did not go through the "Russian hardship post".

Interestingly for these colleagues, the war they are fighting now is global competitiveness. Our project with the Vietnamese in 1999 aimed to assess a new mode of donor-supported research, a symmetric North-South model where the donor had no say in the choice of projects as opposed to the usual asymmetric university-based research capacity building program. The only requirements under the new mode were for the science community to formulate a research agenda relevant to the development of Vietnam and for this agenda to be developed in close collaboration with other stakeholders. There is no question that our Vietnamese colleagues appreciated this participatory, development-oriented mode of research capacity building. They, however, told us on the side that their personal adherence to a symmetric and participatory donor supported research capacity building would not stop them from accepting grants under a more traditional asymmetric mode of North-South research collaboration. All they cared about at this point of their history they said, is to upgrade their research capacity regardless of how it is to be done or what kind of relations they would have with the donors. They know, after all, what they want to get out of them and did not foresee the possibility of being vulnerable to Northern domination. As far as they were concerned, Vietnam has vowed to use science to propel it to win the global economic war and its leadership will use all the means to get there.

The Vietnamese are already winning! Their stance towards their country's development and their deep love of nation (that our colleagues claimed would make them fight any force that encroaches into their space, whether it is China, Russia, or the United States) accounts for the value of science and scientists in the minds of the country's general public. It also explains why at the height of the US-Vietnam war, they continued to translate the best scientific books and articles into Vietnamese. No wonder they are topping the Mathematics Olympiads. That the mission for scientists and professionals is clearly passed on to the younger generation is manifested in their performance in international scholarship competitions. In the Asian Scholarship Foundation' review of humanities and social science proposals from young Southeast Asian scholars of which we were a part, the Vietnamese applicants used to be within the ambit of affirmative action just a few years ago; now they are among the best applicants. This remarkable change resonates with the experience of Vietnamese students in our own Asian Institute of Management as told by an AIM professor to a colleague. As a group, they usually start out among the poor performing students but end up among the top, come graduation time.

Unlike Vietnam, we do not have a nationalist visionary like Ho Chi Minh to imbue us with the mission of building this country through science, and the culture that it thrives in. Our visionary, Jose Rizal, the Renaissance Malay who was himself a man of science, has extolled us to greatness, but succeeding generations of leaders have not impelled us to put our act together in the context of a modem era for the sake of our nation. Our impetus to do something about our situation has come from diffused sources. More often than not, it has worked through negative psychology---our dismal performance in math and science competitions and exams; our lack of development despite a misplaced sense of superiority over counterparts in our region (with very little English skills) whose countries have began to develop much faster than us; the economically precarious existence of scientists and the muting of their social criticism because of their status in the hierarchy of public values; the debasing of professional natural and social scientists who, as Czarina Saloma-Akpedonu (1) pointed out in her paper yesterday, are made to answer trivial questions like--" Why do Filipino men urinate in public spaces?" Why are we fond of "tingi" (sachet marketing)?" "Why do starlets not wear underwear?" Why is bayanihan no longer being practiced these days"?; or dire warnings about our future such as that expressed in the Inquirer editorial in 1999 which says:

> "as a nation then, are we forever consigned to backwardness and pre-modernism, bound to commit errors of judgment and short-sightedness because we have failed to develop a scientific attitude that can explain the world and all its vagaries?" (2)

The Vietnamese experience demonstrates the need for a strong resolve to draw for our country, a roadmap for building a science culture in general and science and mathematics education, in particular. More importantly, it highlights the need to focus on formulating and implementing concrete plans of action.

This presentation attempts to draw some of the premises and contours of a roadmap from several sources: the rich and nuanced discussion of various issues in the Social Science Technical Session yesterday, the keynote speech of Father Ben Nebres in this Annual Meeting (3); and the insights from successful projects that include the Bemidos' experiment in Bohol (4) and other ideas about building a science culture that have been repeated in several annual scientific meetings of the NAST.

Let us now move to a few premises that those tasked with drawing the roadmap can draw upon. In discussing the premises, we shall cite developments that augur well for drawing concrete curves and lines in our future roadmap. Indeed, there are other premises but our time is limited so we will just focus on what to us are the more salient ones. Since the relative absence of a science culture is a social problem, we draw on the insights of social scientists in general, social scientists in yesterday's Technical Session in particular, and natural scientists in this forum who have an intuitive understanding of culture as a human condition and appreciate the need to bring "people" into scientific practice.

Premise 1: Science Culture is reflected in a mode of thinking and being that focuses all solving problems

Many of the vagaries we experience are a function of our lack of knowledge of the structures that bring them about. A scientific attitude, as sociologist Raul Pertierra would put it, is likely to result only if the world is perceived in certain ways (e.g. as unambiguous realities that unfold with some regularity and predictability) (2)

A scientific attitude draws from a much broader culture which is still evolving for us. What does it mean to build a science culture?

Drawing from the presentations in yesterday's Technical Session (social science) and Father Nebres' speech (3), a science culture prevails when people are able to

- assess whether or not a personal experience responds to questions of validity and replicabililty (1);
- distinguish the transcendental from the mundane; specialist knowledge from lay knowledge; opinion from fact; fiction from reality (1);

- because they have developed critical thinking (6);
- Keep their minds open to other ideas and, more importantly, pay attention to what others say (6);
- abide by the basic principles that underlie the scientific enterprise-intellectual honesty, sense of excellence, innovativeness, evidence-based conclusions, verifiability (7);
- come together to devise solutions in the form of abstract theoretical formulations and, equally, if not more important for a developing nation, solutions to concrete problems (3)

While analyzing problems towards their solutions is part of the culture of science, many of us think linearly: we think the more applied fields are inferior to the pure and theoretical disciplines, unmindful at times of the potential and actual contributions of practice or application to the development of theory. Dr. Gelia Castillo's inspiring reflections on her work and engagements highlighted a life dedicated to science in the service of ordinary people. Without undermining the importance of "pure" or "theoretical science", her plea is for more interdisciplinary (or multidisciplinary, transdisciplinary) research focused on solving concrete problems of concrete people, e.g. agricultural productivity, health concerns, or even connectivity.

In the 1990s, a team of scientists led by M. Gibbons codified this mode of knowledge production and called it Mode II in contrast to Mode I which we are familiar with. The following describes each mode of research (7):

> Mode I: is university-based with standards of research and evaluation determined by disciplinal concerns and hierarchies; In an ideal depiction of this mode, problems are set and knowledge produced in a context governed largely by the academic interests of specific communities. These communities are organized disciplinally and. lodged in artificially delineated academic departments. Within these homogenous disciplinal communities, knowledge is produced along dominant theoretical and methodological paradigms. Quality is determined through a peer review process, an effective form of cognitive and social control, reinforcing a discipline's definition of what problems and techniques are deemed important to work on. Finally, disciplines are organized hierarchically, with the basic disciplines presumed to develop or discover the theories to he adopted by the more applied fields. In the ideal typification of this mode of knowledge production, research utilization is not of primary interest to an academic. Understandably, within this framework, the user is relegated to the end of a knowledge production process, which researchers often have no compulsion to see through. For, theirs is the singular task of producing theories and concepts and evolving methodologies.

Mode 2: is demand-driven, multidisciplinary and less hierarchical This alternative mode of knowledge production is said to characterize the evolution of research areas at the frontier of science and technology such as computers, materials, biomedical and environmental sciences, fields that essentially produced demand driven knowledge lying in the interstices of academic disciplines. In the social sciences, development studies, which cannot be encompassed by any discipline lends itself more easily to the alternative mode. This mode consists of cognitive and social practices carried out in the context of application to a concrete problem. The practices transcend the theoretical and methodological positions of collaborating research partners from different branches of knowledge and disciplines, are organizationally less hierarchical, and tend to be more transient. In the course of understanding a problem, researchers go back and forth between the 'fundamental and the applied, the theoretical and the practical... the curiosity oriented and mission-oriented research'. Being locally driven and constituted, the alternative mode of knowledge production is sensitive to local contexts, committed to the involvement of users not only in the dissemination of findings but also in the definition of the problems and the setting of research priorities. It recognizes the existence of multiple knowledge sites and views the scientific practices lodged in universities as one of many sites that are brought together in the search of solutions to particular problems. Finally, quality is assessed not only in terms of technical merit but also the usefulness or relevance of the knowledge produced. As a consequence, the emergent research practices are more socially accountable and reflexive (Figure 1).

Figure 1:

Modes of Knowledge Production

MODE 1

- Research determined by academic interests
- Disciplinal and university-based
- Hierarchical organization following the hierarchy in disciplines
- Quality determined by technical merit through peer review
- Research utilization desirable but not necessary

MODE 2

- Research determined by the need to solve concrete problem/s
- Multidisciplinary; recognizes multiple sites of knowledge production
- Less hierarchical and transient
- Quality determined by technical merit and relevance
- Research utilization is of primary importance

Premise 2: If a problem-solving science culture in the science community will be the focus of our efforts in the next ten years, it is important to note that building a culture of science outside our epistemic community is neither a sequential nor a once-and-for-all event. While a roadmap should connect all the strategies, the process can proceed on various fronts. If the roadmap is clear, the momentum of intended and unintended changes will hopefully move in the direction we wish to take.

Dr Castillo's plea (6) for interdisciplinary approach can be translated into a plea for us to look at our lack of a science culture as a major social problem to solve. As far as developing our roadmap is concerned, we (natural scientists, social scientists, educators) would need-to move into the second mode of knowledge production to thresh the major issues at various levels—basic science education, science education at the tertiary level, science education of the public. All fronts have to be covered.

It is a plea for social scientists, in particular, to be grounded in their disciplines yet to open their minds to developments outside their disciplines. It is a plea for more of us to move easily from one quadrant of Burawoy' s practices of the social sciences that Saloma-Akpedonu (1) cited in her paper yesterday to another but to pay special attention to both policy social science/participatory research/action research. Just to give you an idea of Burawoy's quadrants:

Using sociology as a focal point (although the focus may be broadened to the social sciences), Burawoy posits that the practices of professionals in the discipline can be categorized in terms of audience and the type of knowledge produced. The audience may be academic or extra-academic and, knowledge, instrumental or reflexive. As expounded in Saloma-Akpedonu's paper (1),

> "public social science brings it into a conversation with publics, understood as people who are themselves involved in conversation. Policy social science is in the service of a goal defined by a client. It provides solutions to problems or to legitimate solutions that have already been reached. Professional social science supplies true and tested methods, accumulated bodies of knowledge, orienting questions, and conceptual frameworks. Critical social science examines the foundations - both the explicit and the implicit, both normative and descriptive - of the research programs of professional sociology. It ensures that the stability of sociological frameworks and practices is often subject to periodic rupture or revolutions by making professiona social sciences aware of its biases and by promoting new or alternativ

research foundations" (Figure 2).

The Technical discussion yesterday focused on the public's understanding of social science and how this can be enhanced---through responsible use of the media and more particularly, through effective teaching. Focusing largely on higher education, the discussion touched on the usual structural constraints we have decried about as educators in higher education (the budget for education in general and science education in particular, the low salaries of scientists, the heavy teaching load that constrain research). Surely, these constraints have to be addressed as part of the roadmap.

Audience / Knowledge	ACADEMIC	EXTRA-ACADEMIC
Instrumental	Professional	Policy/Participatory Development/ Action-Oriented
Reflexive	Critical	Public

Figure 2. Typology of sociologies. (modified table of Buramoy, from Bautista, 2004 (8).

Premise 3: At the level of basic science education, there is a wide array of effective interventions to consolidate and learn from as we lay the groundwork for a science culture

In his keynote address, Father Nebres mentioned several bright lights in the dark firmament of basic science education. Let me quickly resonate with his thoughts on the lessons from big programs in education reform. The Third Elementary education Project, which Father Nebres cited in his keynote speech, succeeded remarkably in improving the education landscape of 23 poor provinces (9). Pupils from TEBP schools performed extraordinarily well. Even their weakest schools, the multigrade schools in remote areas, performed better than their counterparts in other parts of the country. The project affected about 1.7 million elementary public school children in all the schools (about 8260) in the 23 Social reform Agenda provinces which were deemed to be the poorest during the Ramos administration and which leads us to'say it is the biggest social laboratory

DepEd has ever created. It

- **transformed the mindsets** of those who actively participated in the reform experiment;
- **proved the immense wisdom of trusting school heads and teachers,** who possess the best information on what goes on in their schools, with the responsibility of turning them around;
- **awakened and mobilized parents, communities, and local officials** to invest time, energy and resources in the fulfillment of their schools' mission for the future of their children; and
- **produced leaders at all levels of the organization and across functions with the capacity to manage change, providing them a positive, nurturing and liberating environment that allowed for mistakes while innovations bloomed.** By the time TEEP closed, these leaders had proven capacity to plan, organize, and direct components/units with the necessary zeal and flexibility of mind to carry out a gradualist but nevertheless radical approach to education reform;

All told, TEEP was a Low Cost-Reform amounting to only P 806 Per Pupil Per Year Over 8.5 Years. It is also heartening, from the presentations in the 7-8 July 2007 Karunungan Festival, that the TEEP schools are sustaining their efforts despite the end of the project in 2006.

To put educators in poor public schools in a position to begin exploring various methods of teaching mathematics and science and experimenting with them, presupposes that they appreciate change. We would argue for the necessity of large-scale interventions to lay the groundwork, for science and mathematics education of the learner centered, activity-based, science oriented variety espoused by the Bernidos (at the school level), BEAM (at the division-and province levels) or our academicians and scientists. In fact, we are tempted to say, the interventions need not aim for the ideal. Even just stirring the air can do wonders. As Father Nebres remarked in his presentation at the 7-8 July Karunungan Festival, imposing new ideas on teachers, no matter how great, would result in their adopting the ideas initially (for compliance's sake) but returning to their old ways of doing things unless they themselves, as engaged participants in the reform process, see the need for adopting the idea. If there is any lesson from the TEEP experiment, it is that teachers, who because of decentralization, have enjoyed the freedom to experiment in the classroom and discuss their experiences with other teachers in a setting where change is in the air, would have such strong craving for new ideas that they themselves will demand exposure to new ways of doing things.

Abstracting from the TEEP experience, such interventions may be effective if the following features are found:

- it is on a scale that can make a dent
- it is decentralized and school-based (as such opening what Father Nebres calls "open spaces for innovation"
- its starts from where the schools (teachers, principals) are rather than where they ought to be (which was related to an issue raised in the Technical Session yesterday, the need for scientists from imperial Manila to be sensitive to the situation in Mindanao, particularly Muslim Mindanao)
- it gives ample opportunities for these actors to learn hy doing and to open their minds to other ways of doing things;
- the best way to develop capacity is to be immersed in the activities that would build it up ... "'learning on the run", "dirtying one's hands", "solving problems" and "reflecting on processes" are the best way for reform programs to move forward.

In conclusion, allow us to reiterate our statements in a paper presented in the OYS Conference two days ago:

"In the recently concluded Karunungan Conference, Father Nebres and other speakers stressed the need to shift to a problem solving mode, particularly in science and math teaching, that would enhance the learning of important ideas, concepts, and theories in the classroom. This dictum, however, holds as well for the bigger social laboratory of education reform. While existing theories may enlighten the change process, such theories ought to "roll down" through the terrain that has to be transformed, and, if need be, be radically revised. This view presupposes that social transformation cannot be imposed from the outside; the whole point of reform is to enable actors on the ground to participate in the changes that govern their lives.

In light of this perspective, keen interest in the development of a science culture cannot be generated from above by scientists working in elite institutions of higher learning. Nor can it grow out of our conference resolutions, no matter how eloquently expressed. The need for science and the integration of its culture into everyday life must be realized and felt by those who directly shape the mindset of children, especially the majority studying in our public schools. The role of reformist interventions is to cultivate the soil so that more effective theories and pedagogies of learning science and mathematics can be planted and grow. If the soil is tilled, scientists may not even have to tell educators on the ground to adopt new strategies. Teachers and principals will walk the extra mile to look for new theories and methods once the ground is cultivated and they are all fired up. Under these circumstances, the role of scientists like us is to link or expose these educators to teaching practices that are not only desirable, but that work, unless of course the educators, through their own initiative, have found the necessary links even before we reach them".

As for higher education, the people in this audience have written so much on how to improve the state of science teaching and learning. We have barely touched the surface.

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Endnotes:

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(9) The discussion of TEEP draws from Bautista, Cynthia "Schools of the People": Philosophy of Education for the 21st Century. Paper read in the first plenary session of Karunungan Festival. UNESCO and Ateneo de Manila University, 7-8 July 2007 and Bautista, Cynthia. The Evolution of a Science Culture: Insights from Transformative Education on the Ground. Paper read at the Second National Convention of the Outstanding Young Scientists Inc. on Setting New Trends in Teaching Science Education, Manila Hotel, 10 July 2007.

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