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## PEDAGOGICAL: ACCOMPLISHMENTS AND GOALS

*My Philosophy of Life*  
*While there is a will there is a way*

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*Summary* — **Realizing that investment in human-resource development are the most efficient and highly effective ways of elevating standard of a society; philosophy, contents and pedagogical techniques in mathematics and related fields are devised to create a nation capable of putting forward arguments on the basis of numbers and phrasing intelligent and inquisitive questions to come closer to truth.**

**Philosophy** To cultivate habits of creative thinking and critical analysis, by providing highly-motivated students sufficient depth as well as adequate breadth of the core and the related subjects, so that they can make informed, independent decisions, under stressful situations. To integrate the various aspects of curriculum development (why to teach – philosophy; what to teach – contents; how to teach – pedagogical techniques) in such way that the student is educated to become a *manager* of resources of the universe (not a *thief*) and shall know relationship with Allah, self and environment. As part of my duties in the capacities of Dean, Faculty of Science and Caretaker Dean, Faculty of Engineering, steps were taken to introduce mathematical-thought processes in the physical, the biological and the engineering sciences so that these disciplines could put up with the challenges and the complexities of the Third Millennium. Social sciences were powered by mathematical approaches through mathematical art and societal mathematics.

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® Higher Education Commission, Govt. of Pakistan  
§ National Testing Service Pakistan  
# American Institute of Aeronautics and Astronautics  
‡ International Brain Research Organization  
‡ The Abdus Salam International Center for Theoretical Physics, Trieste, Italy

‡ The Early Talent Research Participation Program  
¶ Transparency International Pakistan  
\* Anthromathematics Group  
§ Department of Mathematics  
‡ National Growth and Developmental Standards for the Pakistani Children <http://ngds-ku.org>  
€ United States (of America)

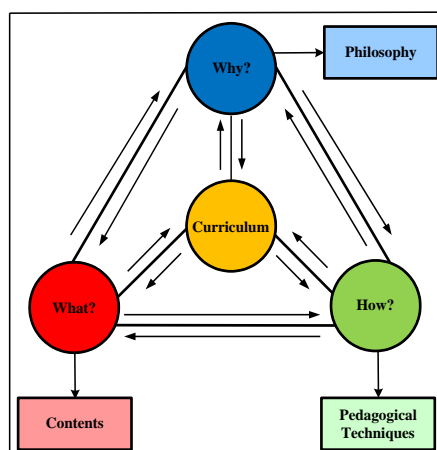
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**Philosophy, contents and pedagogical techniques —  
their relationship with curriculum development**

<http://www.ngds-ku.org/Papers/J39.pdf>

**Methodology** *What to learn* is the main factor in **training**. A trained person ‘knows’ the techniques, which can be repeated under standard situations. *How to learn* is the essence of **education**. An educated person ‘knows’, ‘can explain’ and ‘can apply’ the concepts and the techniques. Emphasis is placed on concept building (through debates, discussion sessions, activities) and technique developing (smart approaches to problem solving, problem broken down into ‘data’, ‘objective’, ‘solvability’, ‘strategy’, ‘setting up of problem’, ‘solution’ and ‘result to proper significant figures’). A motivational session (comprising of historical evolution, applications and relationship to the students’ own discipline, in particular, and the society, in general) is conducted before start of every course. Students’ level is determined in the beginning (through pretest, life-history essay and discussions). A system of continuous feedback (to set pace and depth) in addition to end-of-term confidential evaluation is established. Each course is divided into one-week duration units. The mode of instruction consists of pre-reading (before the start of unit) and pre-quiz; lectures accompanied by activity and followed by tutorial and discussion/problem-solving session; one-minute post lecture summary (by students and, afterwards, by the instructor), post-reading, assignment of homework problems and post-quiz (not all the described methods are applied in a single course).

**Teaching of Mathematics** Mathematics is the unique discipline, which has the power of generalization and the power of application. Result in one dimension may be generalized to  $n$  dimensions. A mathematician develops the power to visualize abstract concepts. The distinction of mathematics to bring rigor to proofs and exactness to calculations makes it tool of the tools. The teaching of a concept in physical mathematics should include rigorous proof, physical interpretation and application. For example, proof using  $\epsilon_{ijk}$  notation of vanishing of curl of a gradient of potential should be followed by interpretation of curl as rotation at a point and gradient as the maximum rate of change between two equipotential surfaces. The student should be trained to link concepts in different scenarios, *e. g.*, fast freeze in structural biology and fertilizer production (similarity of processes) as well as electrical and gravitational potentials (similarity in mathematical expressions). The approach of a mathematician differs from the approach of a physicist — conservative forces are recognized by a mathematician as having no functional dependence on velocities or higher derivatives (such forces are functions solely of coördinates), whereas a physicist would consider work done around a closed path to be vanishing. A mathematical equation gives clues to the underlying physics, whereas physics guides form of the resulting mathematical equation (appearance of tensor in an equation suggests system anisotropy and vice versa)

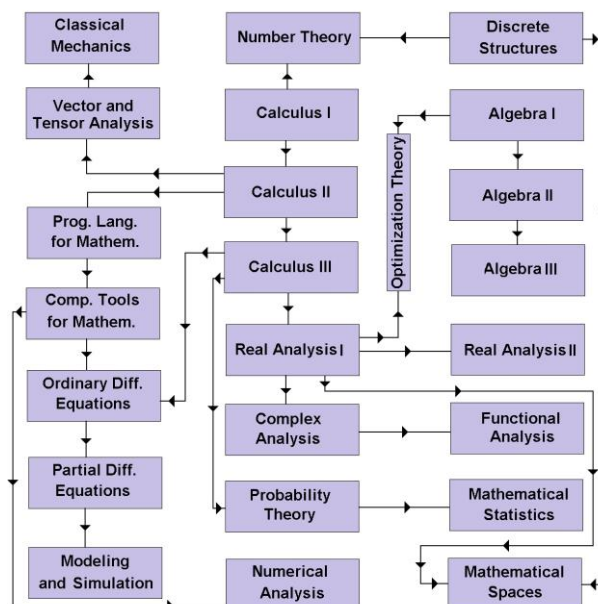
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**Precedence and influence graphs representing pre-requisites and co-requisites for BS (Mathematics) courses**

<http://www.ngds-ku.org/Papers/J39.pdf>

**Accomplishments** Undergraduate Students (sophomore level) of University of Karachi having no background in problem solving were trained in a four-month period to solve problems from the PhD qualifying examinations of the top US institutions. Freshman-level students (who did not study mathematics beyond grade 10) were taught linear interpolation and extrapolation while reading and interpreting NCHS growth charts. Physics was integrated with mathematics, special emphasis given to conservation laws, with implications and applications in different branches of science and engineering. As Member of Expert Panel (Mathematics), National Curriculum Council, Ministry of Education, Government of Pakistan, I reviewed outline for Classes I-XII Mathematics Curricula as well as developed and applied criteria for review of textbooks. This exercise has helped National Curriculum Review Committee (NCRC) for Mathematics, Higher Education Commission to interface BS curricula with pre-university curricula. I was selected as convener of NCRC and worked in this capacity during 2004-2012, which prepared 4-year BS, 2-year MS (MS to replace the existing MPhil Program) and 2-year PhD Programs in 2005 for possible implementation in Pakistani institutions. The committee reviewed undergraduate mathematics curricula taught in the national institutions for content and pedagogical techniques, striking a proper balance between pure and applied mathematics. These programs were revised again in 2008.

**BS Program** Salient features of this program may be summarized as:

*Prioritization of Courses* Must know (Foundation Courses)

Should know (Major Courses)

Nice to know (Electives)

*Depth and Breadth of Courses Syllabus* Given in terms of precedence graphs (flow charts) [depth: pre-requisites] and influence graphs [breadth: co-requisites], respectively

Course Supervisor is required to distribute syllabus breakdown into 14 units, each unit completed within a week.

*Pedagogical Techniques* Lecture sessions of each unit (normally, 2-3 lectures) are followed by a tutorial session (reinforcing the concepts taught through examples, alternate derivations and proofs) as well as a problem-solving session (teaching skills of problem formulation, qualitative analysis and finding solutions), each of these sessions conducted, separately, by the Associate Instructor at the end of lecture session of every unit. In addition, a review session should be arranged prior to each monthly test (hourly) and a comprehensive review before the final examination, both sessions conducted by the Course Supervisor.

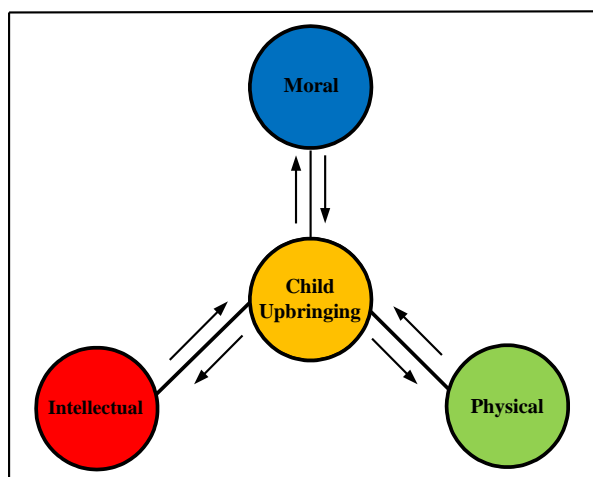
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**The curriculum should give equal emphasis to moral, intellectual and physical upbringing of a child**

<http://www.ngds-ku.org/Papers/J39.pdf>

<i>Continuous-Evaluation Report</i>	Course Supervisor (Instructor) is required to prepare a progress report after each hourly mentioning tentative grade (cumulative grade based on all hourlies, quizzes, problem sets and assignments taken to date) and attendance record (pilot tested at IBA and SZABIST). It may, also, include qualitative description of student's weaknesses and areas needing special attention. This report is discussed with the student as well as student's parents, if unsatisfactory.
<b>MS/PhD Program Entrance Requirements</b>	Important features of these programs are listed below: <b>For MS:</b> BS (Mathematics) or equivalent; GRE (General); written test; personal interview <b>For PhD:</b> MS in Mathematics or equivalent; GRE (General) and GRE (Mathematics); personal interview
<i>Masters Examinations [PhD-Qualifying Examinations]</i>	Masters' Examinations (written + oral) must be passed before starting thesis research; any student, who fails to qualify these examinations in 2 attempts, or by the end of first year of study, is asked to withdraw from the program. Masters' Examinations are to be offered by the department 4 times during an academic year. Written examination may consist of selected questions from PhD-Qualifying Examination, testing the student in core areas. Oral examination, testing the student in the area of specialization, is scheduled only after the student passes the written examination. During the oral examination the student is, also, required to describe the proposed research work. Committees formed by Board of Advanced Studies and Research conduct these examinations. In order to help prepare the student for these examinations, the department shall offer non-credit courses Masters-Examination (PhD-Qualifying-Examination) Preparation during the first and the second semesters of graduate studies.
<i>Pedagogical Techniques</i>	Lecture sessions of each unit (normally, 2-3 lectures) are followed by a problem-discussion session (reinforcing the concepts taught through examples, alternate derivations and proofs, innovative solutions to the problems), conducted by the Associate Instructor. In addition, a review session should be arranged prior to each monthly test and a comprehensive review before the final examination, both sessions conducted by the Course Supervisor.
<i>Undergraduate Teaching</i>	Student acts as Associate Instructor (Teaching Assistant) in a BS course. This is an opportunity for a student to gain teaching experience at the university level. Each course taught by the student earns a practical-experience credit and is graded according to at least two of the following evaluation criteria: <ul style="list-style-type: none"> <li>a) Feedback from students</li> <li>b) Lecture-/Tutorial-/Problem-solving-session observation by senior teachers</li> <li>c) Videotaped lecture-/tutorial-/problem-solving-session evaluation by experts</li> </ul>

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**Honors** Rated as best teacher in undergraduate and graduate courses taught at Hamdard Institute of Information Technology (1999) and SZABIST (2001); highest rating by experienced college teachers in the Six-Day-In-Service-Training Course conducted by HEC (2004); Chief Guest and Keynote Speaker in the Sindh Educational Conference (2009); Keynote Speaker in the First, the Second and the Third Karachi University Educational Conferences (2013-2016); taught PhD course, 'Higher Education in Pakistan' in Department of Education during 2014. Nominee of Academic Council for Board of Faculty of Education, University of Karachi (2014-2016), Convener, NCRC (Mathematics), HEC (2004-2012), Convener, Subject Committee (Mathematics), NTS (2009-2012) and Convener, Sub-Committee (Academics), the Education Committee, Transparency International Pakistan (2011-2014).

**Goals** Mathematics curricula need to be developed taking into account the breadth (reinforcing and building on the concepts and the techniques taught in other allied branches, say, physics, without duplicating) and the depth (preparing content-outline chart, containing the level, the concept, the activity/the experiment to reinforce this concept, the reference and the philosophy behind teaching this concept). Foundation courses in mathematics should train students in the following disciplines:

- |             |              |                  |
|-------------|--------------|------------------|
| a) Analysis | c) Geometry  | e) Number Theory |
| b) Algebra  | d) Mechanics | f) Topology      |

In addition, the students should be taught methods of mathematical physics, statistical techniques, probability theory, measure theory, set theory and logic, modeling and simulation. The students should be able to see the bridge leading them from mathematics to technology passing through physics and engineering — From Mathematics to Technology: A Bridge through Physics and Engineering, invited lecture delivered during the *International Conference on Physics and the World of Today*, Department of Physics, University of Karachi, December 18-20, 2008; full text of paper: <http://www.ngds-ku.org/Papers/C70.pdf>

<b>Biology</b>	The metabolism of food
<b>Chemistry</b>	The process of food conversion resulting in gaining energy, sweating
<b>Engineering</b>	Need of level surface, checking if the weighing machine, itself, is level
<b>Health and Safety</b>	Rapid loss of weight signals physical problems, unutilized food results in fat deposit, contributing to obesity
<b>Mathematics</b>	Significance of serial measurements, plotting of graph, computation of slope, concept of time series, prediction of adult mass (weight), net-mass computation from gross mass (Kamal 2010a), optimal mass-for-height — net mass is defined as mass with zero clothing on, gross mass is the mass recorded in indoor clothes
<b>Physics</b>	Measurement techniques, reproducibility of measurers, exertion of equal weight on both feet
<b>Quranic Studies</b>	Maintaining optimal weight-for-height is encouraged in the Holy Quran (verse 29, chapter 17, <i>Surah Bani-Israel</i> or <i>Suratul-Asra</i> ) by stating that one should exercise discretion in spending, neither to spend too much like burning candles at both ends nor become stingy (Kamal and Jamil 2012)

**Pedagogical opportunities offered by measurement of mass (weight) in various disciplines — biology, chemistry, engineering, health and safety, mathematics, physics and Quranic studies**  
(hands-on experience in the measurement process to enrich experience)

[http://www.ngds-ku.org/ngds\\_folder/M02.pdf](http://www.ngds-ku.org/ngds_folder/M02.pdf)

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- Educational Conferences** *The Second Karachi University Educational Conference (Educational Challenges of the Pakistani Children in the Twenty-First Century)*  
Faculty of Education, University of Karachi, September 2, 2015  
(Keynote Speaker and Conference Co-Chair)  
*National Workshop on Teaching of Physics*  
Department of Physics, APWA Government College for Women, Karachi, December 26-28, 1987 (Member, Organizing Committee)
- Teachers' Trainings** *The NGDS Workshop Series: Improving the Quality of Mathematics Education in Pakistan (at the grass-root level)*  
Beacon Light Academy, 'O' Levels, Karachi, August 12-26, 2009 (Master Trainer)  
[http://www.ngds-ku.org/ngds\\_URL/subprojects.htm#NGDS\\_Workshops](http://www.ngds-ku.org/ngds_URL/subprojects.htm#NGDS_Workshops)  
*Six-Day-In-Service-Training Course (Mathematics for College Teachers)*  
HEC Regional Office, Karachi, August 16-21, 2004 (Course Coördinator)  
*Correction Strategies at the Intermediate Level*  
Commecs Educational Trust, Karachi, April 17, 2004 (resource person for the module)  
*FDP Intensive Workshop*  
Commecs Institute of Business and Emerging Sciences, Karachi, 1999  
(Subject Expert in Mathematics)  
*Science Teachers' Training*  
The International School, Clifton, Karachi, 1997 (Master Trainer)

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