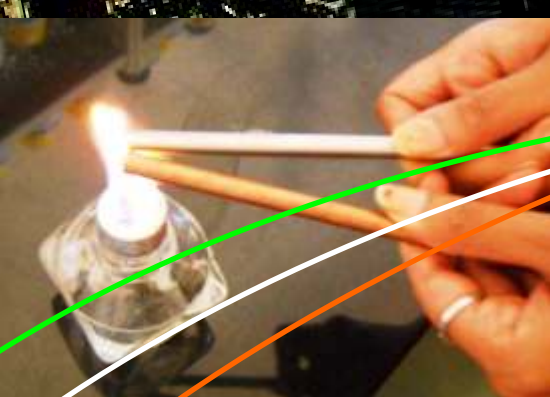
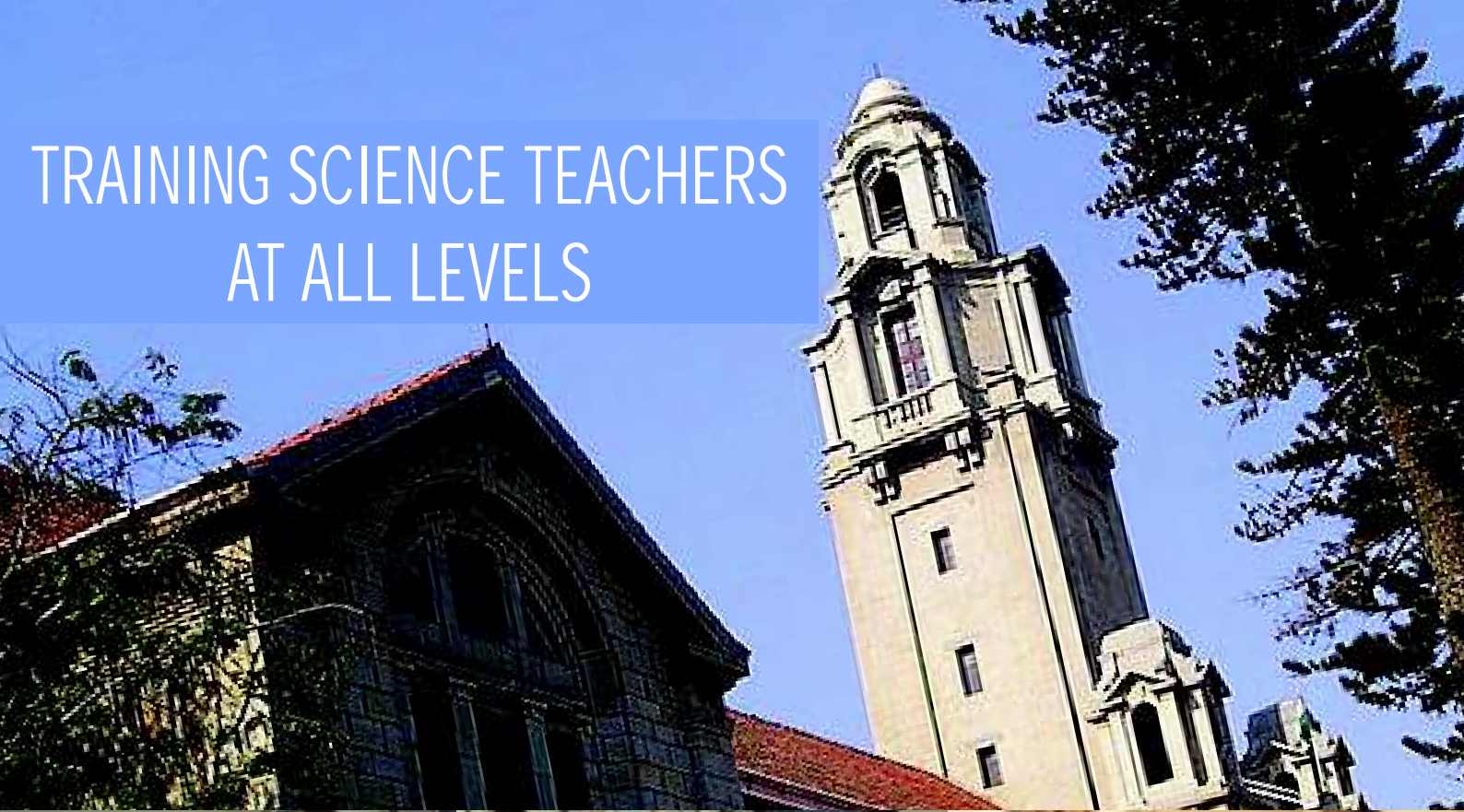


TRAINING SCIENCE TEACHERS AT ALL LEVELS



CENTRE OF EXCELLENCE IN SCIENCE AND
MATHEMATICS EDUCATION
Indian Institute of Science Kudapura Campus
Under - Pandit Madan Mohan Malaviya National
Mission on Teachers and Training
(PMMNMTT), MHRD, Govt. of India



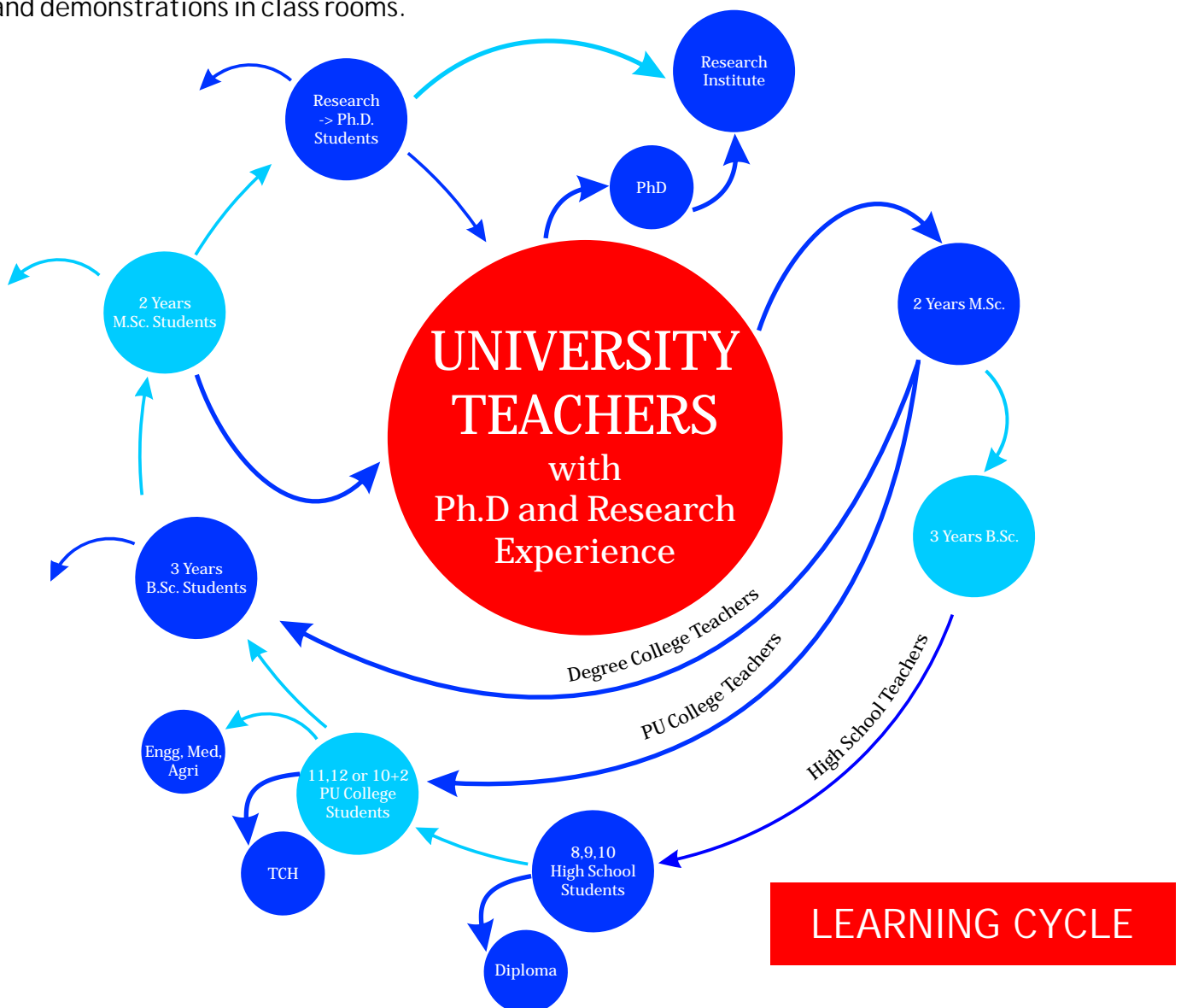
TALENT DEVELOPMENT CENTRE
Indian Institute of Science Kudapura Campus
Challakere, Chitradurga Dist. -577536, Karnataka

INTRODUCTION

Knowledge imparted to students by a teacher is proportional to Teacher's Knowledge. Therefore, if the teachers know the subjects well, they can disseminate the desired knowledge to the students. Each teacher teaches about 100 to 120 students per year in high schools, college and universities. Therefore upgrading the teachers knowledge has a huge multiplying effect. Realizing this, IISc has set up a Talent Development Centre on its new campus to train science teachers at all levels in the year 2011. Recognizing the effective method of teachers training program in TDC, a "Centre of Excellence in Science and Mathematics Education" at IISc Kudapura is instituted by the MHRD, Govt. of India under Pandit Madan Mohan Malaviya National Mission on Teachers and Training(PMMMMNTT).

India has moved from mass education to higher education. Prerequisite for higher education is quality teaching and learning at high school in 8, 9, 10 classes and Pre - University - 11 and 12 classes. Excitement to study science is created by science and maths teachers. Study of basic sciences - Physics, Chemistry, Mathematics and Biology are prerequisites to study Engineering, Medical, Agricultural Science and to higher education in science.

Science develops through experimental observation and verification. Curiosity is aroused during observation. Therefore science should be taught and learnt through experiments in laboratories and demonstrations in class rooms.



WHY

Science Teachers need training ?

In a **learning cycle** students climb up the ladder acquiring BSc, MSc and PhD degrees - become university teachers. At each stage many branch off to other courses and enter into other professions.

University teachers teach graduate students leading to MSc and PhD degrees. In turn, teachers with MSc degree teach BSc students. BSc degree holders teach high school students. Therefore if we train science teachers at High School, PU colleges, BSc Degree colleges and University teachers teaching MSc classes, the entire spectrum of science education is covered. It will make our science education system strong. It will be a new direction for science education. This can be a new strategy to improve science education in India.

Even though there are many training programs for science teachers, they are all devoid of laboratory program. Training programs are not at all rigorous. No evaluation of knowledge gained by the teachers after the training. No bench mark training program exists for teachers of any level in India.

Average intelligence of students in our country is quite high. Students are generally excited to study science. But, lack of correct knowledge of our science teachers, lack of experimental facilities in schools, college and universities and lack of experimental skill among the teachers have made our science learning / teaching rather poor. The teachers presently serving in high schools, colleges and universities are perhaps the biggest human resource in the world. Therefore, there is huge scope to improve science education in India by providing novel training to science teachers. Consequently, training science teachers at all level will bring huge benefits to young students and raise science education level at each stage.

Therefore Teachers must

- Have correct knowledge to teach the students.
- Realize that science is search of truth and should be taught with utmost honesty.
- Be clear on the basic concepts in the subjects they teach.
- Convey basic concepts/principles of science via experiments.
- Be able to do experiments themselves and show them to the students.
- Be excited first to excite the students.
- Upgrade their knowledge - a need to cope with advancement of science.
- Be exposed to scientists from Institutions of higher learning for inspiration and guidance.
- Inculcate habit of reading science articles, books and use internet.
- Support higher education system introduced from time to time.
- Be able to encourage students to take up science studies at +2 and at higher levels.

An ideal teacher should possess all of the above.



Residential Houses for Teachers



Teachers walking to the centre



Session in Progress at TDC



Dining Hall

What is IISc doing?

Create Training module at all levels

- Indian Institute of Science Bangalore completed 100 years.
- The Campus in Bangalore is too crowded.
- Acquired a second campus (1500 Acres) in Kudapura, Challakere, Chitradurga district.
- Karnataka Govt. leased unused and dilapidated sheep breeding farm to set up a Talent Development Centre to train science teachers at all levels.
- Developed model training program for High school and PU PG teachers.
- Developing model training program for Degree college teachers and University teachers.
- Create experimental facilities to train teachers at all levels.
- 10 days residential program for School and PU teachers.
- Three weeks residential training program for degree college and university teachers.
- 30% time for class room lectures/demonstration, 70% time devoted for experiments.
- Learning theory and concepts by doing experiments.
- Assignment / problem solving sessions in the centre and not in hostels.
- Experienced faculty and students of IISc and Universities teach and train.
- Test / exam before and after training to evaluate the effectiveness of the training



Teachers involved with the experiments

Infrastructure at TDC, IISc Kudapura:

- Residential facility for 130 teachers.
- Accommodation for 8 - 10 faculty members.
- Good and healthy food for 150 people in the mess.
- Internet facility both land line and WiFi.
- Multimedia lecture halls: 60 capacities.
- Uninterruptible power supply with UPS and generator backups.
- Laboratories equipped with experimental facilities for 60 Physics, 60 Chemistry and 60 Biology teachers.
- Lectures, tutorials and problem solving sessions for 60 mathematics teachers.
- Constant contact with IISc main campus for all support.
- Laboratories equipped to teach science for (a) High school teachers; (b) PU college PG teachers (c) College teachers (d) University teachers in Physics, Chemistry and Biology.
- Extensive computational facilities with computer and clusters.
- Mechanical work shop facility to fabricate instruments.
- Glass blowing facility to construct experiments.
- Electronics work shop to hook up simple experiments.
- Facility to design and develop novel experiments to explain theory

WHAT

is the problem with the present High School teaching system?

- Most Govt. and Govt. aided schools are single 8, 9, 10 classes with 100 to 120 students.
- 7 teachers: Science, Maths, English, Kannada, Hindi, Social and PET.
- One maths teacher with BSc PCM background - 18 periods of work load a week.
- One science teacher with BSc BZC background - 18 periods of work load a week.
- PCM teacher teaches mainly mathematics.
- Science teacher has to teach Physic, Chemistry and Biology.
- Science teacher deficient in physics and maths - not studied in BSc. But studied in PUC.
- Science teacher deficient in Chemistry because he is poor in physics and mathematics.
- PCM teacher, although can teach physics, has no time because of work load.
- Generations of students suffer because science teacher is not equipped to teach science including physics.
- Students with low science background from such teachers in 8, 9, 10 fail in +2 level.
- Teachers are not trained to demonstrate experiments to students either in class rooms or in laboratory.
- Little or no experimental demonstrations in the science classes.
- No experimental facilities in their schools.
- Not able to utilize Rashtreeya Madhyamika Shikshya Abhyan (RMSA) funds from MHRD, Govt. of India.
- Ultimate aim of excitement of learning science is killed at the root.

High School teaching system

HOW the Training program at TDC, IISc addressed these issues?

- Invite 120 teachers: 60 (PCM) + 60 (BZC)
- Training for PCM (Mathematics) teachers - 8 days of Mathematics + 2 days of Physics.
- Training for BCZ (Science) teachers - one day maths + five days physics + two days chemistry + two days biology.
- Three hours lectures in the morning in the class room with demonstration.
- Seven to eight hours of laboratory experiments each day.
- Laboratory experiments involve observation, measurement and verification.
- Instructors are provided to help doing experiments.
- Direct entering the experimental observations in the lab book, no scope for fudging results.
- Completion of experiments monitored - approval by the instructor is compulsory.
- Over 30 physics experiments are done in physics.
- Over 30 experiments each in chemistry and biology for BZC teachers.
- Science teacher does over 90 experiments in 10 days.
- Maths teacher solves over 200 problems in 8 days.
- Assignments are written in the class rooms and not in hostel.
- Submission of assignments is compulsory.
- Two to three assignments are written in each subject by the science teachers.
- Questions associated with the theory to be answered at the end of each experiment.
- Disconnect between laboratory experiments and theory is bridged.
- Teachers are evaluated before and after the training.

Most of the topics in the 8, 9, 10 class science text books can be taught and learnt through experiments. New experiments are designed here in TDC to make the theory concepts simple. Experiments are also made simple to perform in a shorter time by choosing digital equipments and simplifying the method in each case. Experiments include measurements of density of solids, liquids, ideal gas law, photoelectric effect, optics and radiation, emission spectra, Fraunhofer lines, diodes, transistors, chemical estimation, water splitting, chemical reactions, preparation of gases, determination of Avogadro number, identification of microbes, growth



Prof. P. Balaram interacting with teachers



Dr. APJ Abdul Kalam
Motivating Teachers at TDC



Aufbau Principle



Spring Constant



Chemistry Experiments



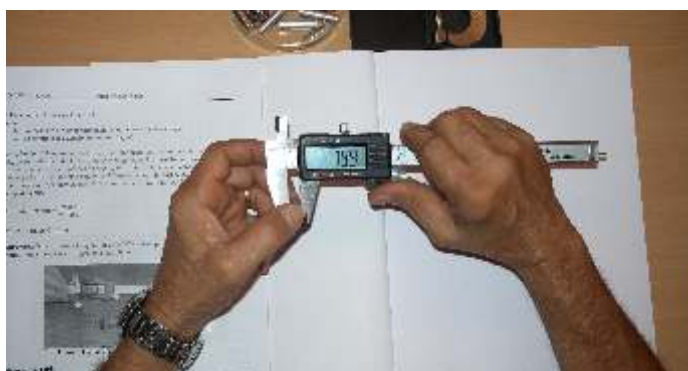
Prof. Chandradev's Demo



Telescope at TDC



Mr. Kumar Nayak's Visit



Digital vernier calipers

of bacteria and fungus in the lab, blood test, urine test, pregnancy test, HIV test and extensive use of microscopy in biology experiments.

Excitement of doing experiments was the key to make teachers interested in this training. For the high school teachers the experiments were new but within the book or syllabus. They have been teaching the theory behind the experiments but they have not done the experiments themselves. Therefore there was an instant appeal and excitement to carry out the experiments. The RMSA of MHRD has been giving money and now they say, they can implement the experiments in the schools.

We have shown to the teachers that they do not need elaborate laboratory to do the experiments. Class rooms and corridors are sufficient. Spirit lamp is sufficient.

Time required to do an experiment involving a concept is about 1 to 2 hours. The same concept in the lecture is covered at best in 10 min. Application of mind, direct observation of an effect and more time available to grasp the subject while doing experiment, deriving numbers from experimental data - all put together makes them learn the subjects more easily. Many of the concepts are also taught with demonstration experiments in the classroom during the lecture.

Not that the above methodology is newly discovered here in IISc. World over science is taught this way. But, in India, due to factors such as large number of students in classes, lack of space and laboratory facilities, lack of knowledge and skill among teachers, less conscious demand for quality education, attitude of making the students just pass, parents education level, lack of proper resources have made our science education uninteresting and less inspiring. This need to be reversed.

Problem solving sessions are arranged after they submit the assignments.

For maths teachers we follow "Lecture followed by assignment" routine. Initially, the teachers feel lost. Soon they start attempting to solve the assignment. In 2 days they get used to sit, think and solve problems in the class room in presence of fellow teachers and professor. An inherent pride and competition develops among the teachers to overcome inferiority complex. Discussion among the teachers, consultation with the tutors and the professor increase day by day. It is a sight to see the teachers sitting and solving the maths problems in the class room itself.

In the beginning of the course a test is given on what they are supposed to know. At the end another test gives us the impact of the training: Typical results are given on the individual teachers performance in the bar diagram for science as well as maths teachers.

Huge improvement in their performance is obvious. The teachers learn that they can work hard. Go back with confidence and high motivation to implement the experiments in their schools. Realize that study of science is a truthful venture.

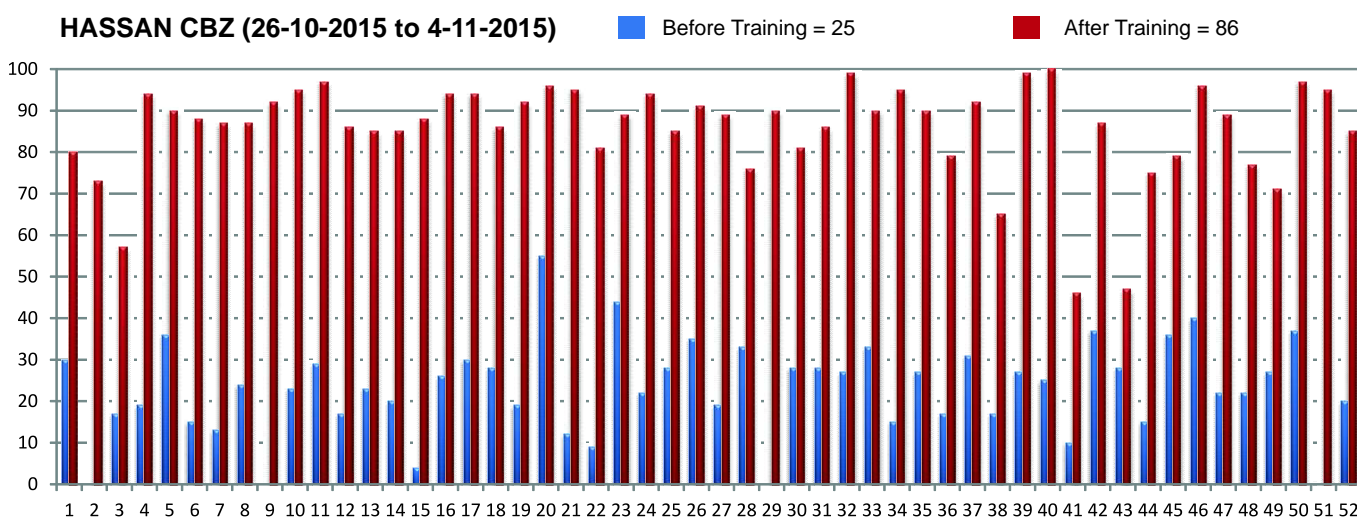
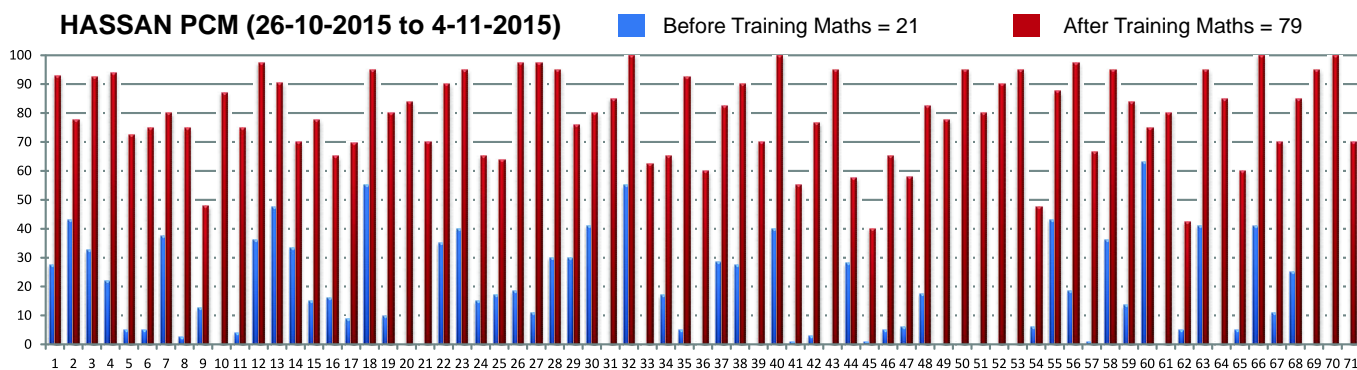


Charles Law



Professor T. V. Ramakrishnan observing experiment

Typical result of high school science teachers test before (blue bar) and after (red bar) training



PU College Teachers Training Program in TDC IISc, Kudapura

MHRD, Govt. of India is aiming at uniform standard of education in science for 10 + 2 students. Common 10 +2 CBSE syllabus with NCERT text books is considered a good starting point. Karnataka Govt. accepted this and requested IISc to train the teachers so that they can cope with the advanced CBSE syllabus for 11 and 12 classes. JNV Navodaya Samithi, MHRD also requested TDC to train their teachers periodically. IISc at Kudapura has developed a model training program for PU UG teachers

- 10 days residential training program for PU PG teachers.
- Three hours lectures in the morning.
- Lectures are on the basic concepts covering the entire 11 and 12 books.
- Demonstration experiments in the class rooms.
- 7 to 8 hours laboratory experiments to augment theory.
- Experiments involve measurements employing an instrument.
- Problems and assignments to be solved at the end of each experiment.
- Problem solving - assignment session to apply the concepts.
- Assignment - writing in the class and not in hostel rooms.
- Faculty members and instructors are available throughout the course period.
- Submission of assignments is compulsory.
- Assignments are corrected and returned immediately.
- Tests before and after the training.

Experiments done by the teachers here are not limited to those prescribed for the students in PU syllabus. Experiments are designed to make the teachers understand the theory in each subject. Determination of Planck's constant, Rydberg constant, acceleration due to gravity g , Avogadro number N , angle of minimum deviation, transistor characteristics, diodes, Zener diodes, gas law, absolute zero temperature, optics, spectroscopy, resistivity, earth's magnetic field, sound velocity, density of solid, liquids, soluble and non - soluble salts in water, R vs T are some among the 55 experiments they do in Physics.

Over 50 experiments in Biology including DNA fingerprinting and over 50 experiments in Chemistry are carried out in 10 days. The experiments are more advanced than for the high school teachers. These experiments cover the entire subjects they need to know for teaching PU students. Most teachers have not performed most of these experiments in their BSc or MSc. The experimental program conducted in TDC is new for the teachers who are promoted from High School to PU colleges.



Pu Commissioner Rashmi Visit



Solid To Gas



Laser diffraction

Each of the experiments done by the participants is examined and approved by the laboratory instructors and faculty members. Approval is a must. They need to write the observations in the lab manual and the report then and there and take the signature showing the results. If the results are not satisfactory, they need to repeat the experiments.

Well-designed rigorous courses in physics, Chemistry, Mathematics and Biology have been developed with the help of experienced Faculty of IISc and from some of the Universities of Karnataka. Over 90 % of syllabus is covered in 10 days. Emphasis here is to teach what they do not know and what they need to know. Connectivity between the lectures, laboratory experiments is maintained. The teacher's interest and excitement is kept up till the last day. They learn the subjects with complete involvement are continuously monitored. Motivation to study becomes contagious and also competitive among the teachers due to unique residential atmosphere created in TDC.

Degree College and University Teachers Training Program

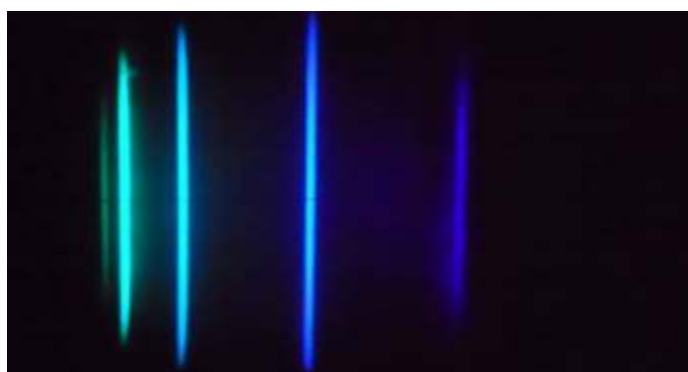
UGC refresher courses at academic staff colleges are arranged to enrich knowledge of College and University teachers but these programs are devoid of experiments. We extend the idea of "learn mathematics by solving problems and learn theory by doing experiments" to college and university teachers in all the four basic (PCMB) disciplines. In order to have parity with the UGC courses, we have kept the duration of the program to three weeks with emphasis on:

- Cover full three years topics for BSc teachers-based on the UGC guidelines.
- Cover core topics for MSc teachers based on UGC guidelines.
- Follow lecture- problem solving sessions - Lecture for mathematics programs.
- Three hours lectures in the morning followed by experiments till evening.
- Experiments should cover almost all the theory lectures.
- Assignments (one each day) based both on the theory lectures and experiments.
- Arrange lecture/experiments to bridge the disconnect between theory-Expt.
- Orientation towards research by extended laboratory experiments.
- Emphasis on honesty of presentation of experimental results.
- Carry out small projects which may yield new results.
- Cover deficiency in mathematics and electronics for science teachers.
- Exposure to literature, research and review articles- how to read literature?
- Seminar/presentation by the teachers on the projects they do.
- Train what the College and University teachers do not know and what they need to know within the syllabus.
- Emphasis on developing experimental skills.

Some of the experiments/ study aspects include mathematics for chemists, plotting the functions using Origin or Matlab, electronics for chemists, vacuum techniques, specially designed experiments in thermodynamics, electrochemistry, solid state and materials chemistry, quantum chemistry with an emphasis to use Density Functional Theory (DFT) to determine electronic structure of atoms, molecules, solids, recording and analysis of IR, UV, NMR, Mass spectra, determination of structure by x-ray diffraction, project oriented preparation and properties of materials, organic chemistry, all these within the syllabus and not outside the syllabus. Extensive experiments in physics include - solid state spectroscopy, structures of solids, electrical and magnetic properties of solids, and quantum physics with



Heat Conduction



Mercury Emission



Conductivity - electrolytes

DFT method to obtain properties, specially designed experiments in optics, classical mechanics, statistical physics, lasers, semiconductor physics and electronics. Biology program include electrophoresis for separation of proteins, DNA and RNA, Blotting (Western/Southern/Northern blotting) for Protein/Nucleic acid Detection, Geldoc system for Documentation of protein/DNA profiles, PCR, bioluminescence and fluorescent antibody technique/ immune-histochemistry using Fluorescent Microscope, experiments on Cells, various methods for culturing organisms, fungi many more normal facilities for biology experiments.

Tests & Results

Test 1:

First day Morning (On what they are supposed to know).
Direct and objective questions to test the knowledge and no multiple choice answers.

Test 2:

10th day morning (after the training).
Questions similar to test1 but a bit more difficult; different questions.

Tests became essential to make the program effective. In fact evaluation after the training is a test for the faculty who trained them. All the lab manuals, assignments, test papers and evaluated answer papers are returned to the trainees. The system is fully transparent and open.

Test Results:

Marks obtained by individual teachers before and after training are in the bar diagrams. Average / marks scored before the training is in blue and in red after the training. Huge improvement in their performance is obvious.

Potential of most teachers to learn and perform better is indeed huge and proved time and again. By a combination of focused lectures, assignment writing, solving problems in the class and outside, doing experiments and grasping the theory behind the experiments all add to their ability to understand the subject. Generally, a problem on an experiment (which they have done) is answered by most in the tests. Inducing the teachers to learn theory concepts by doing experiments indeed works. Therefore if the experiments lead the science teaching in the schools and PU colleges, students certainly gain enormously.



Experiments in progress



Experiments in progress



Test in Progress

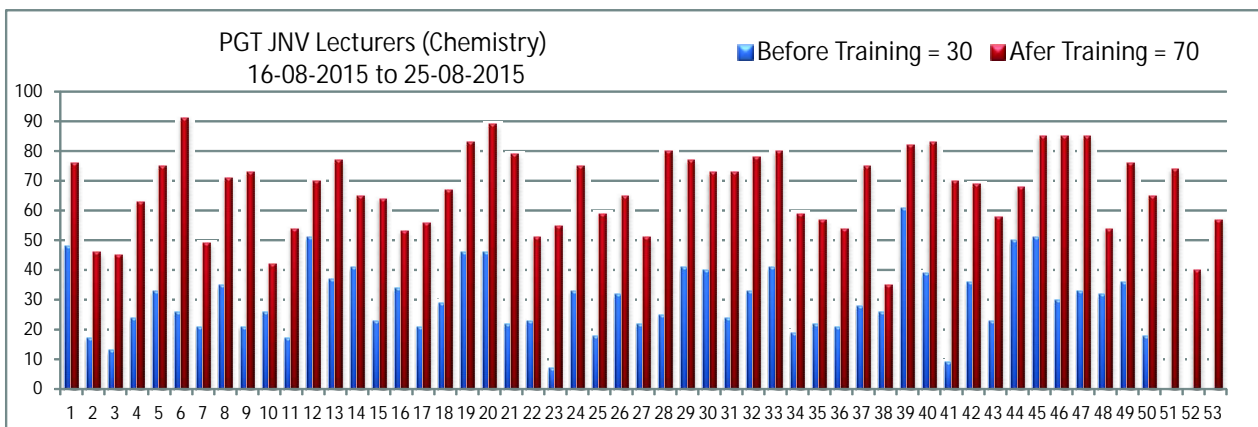
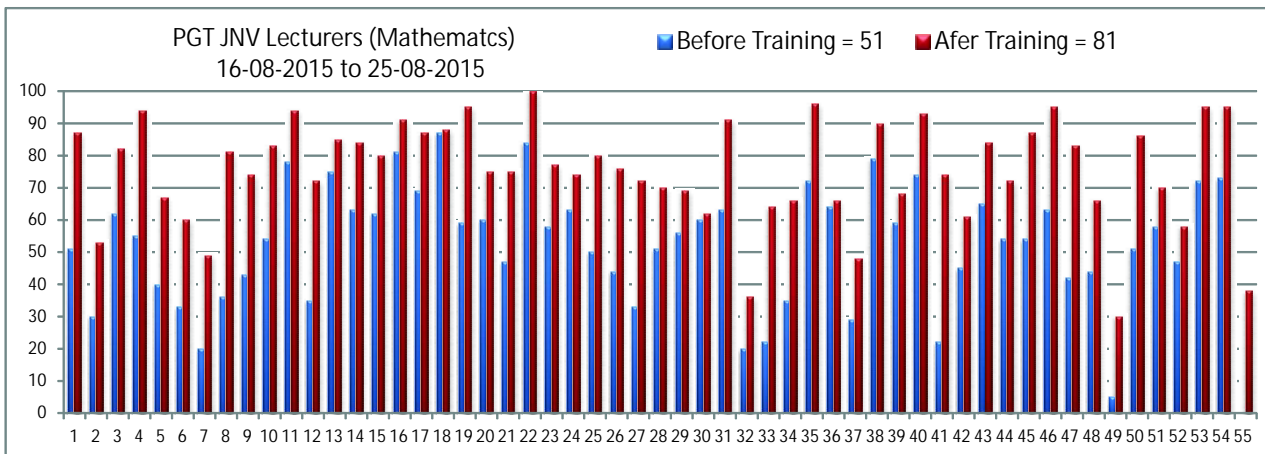
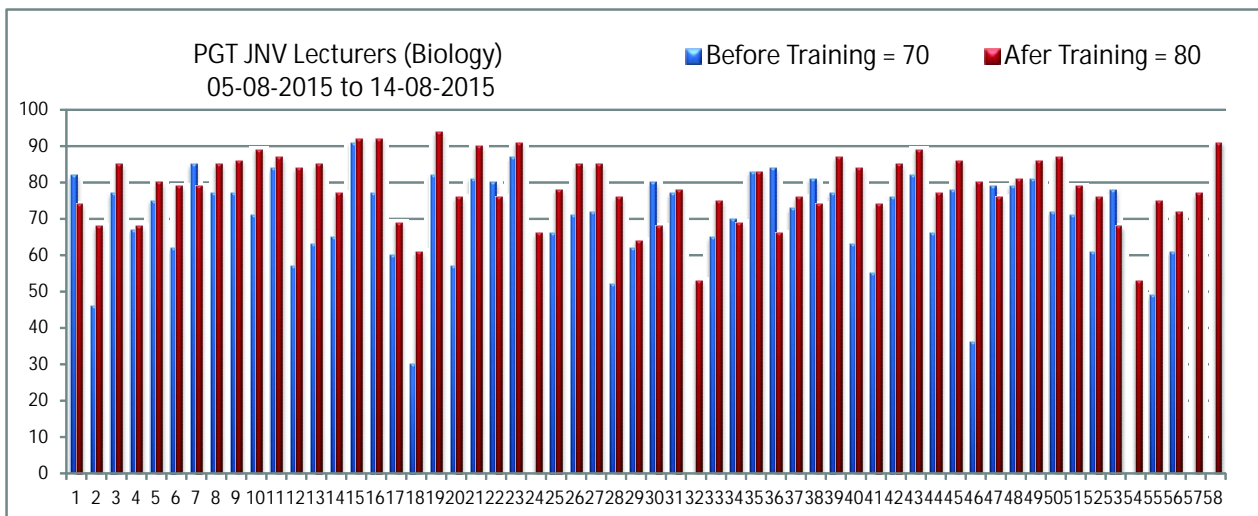
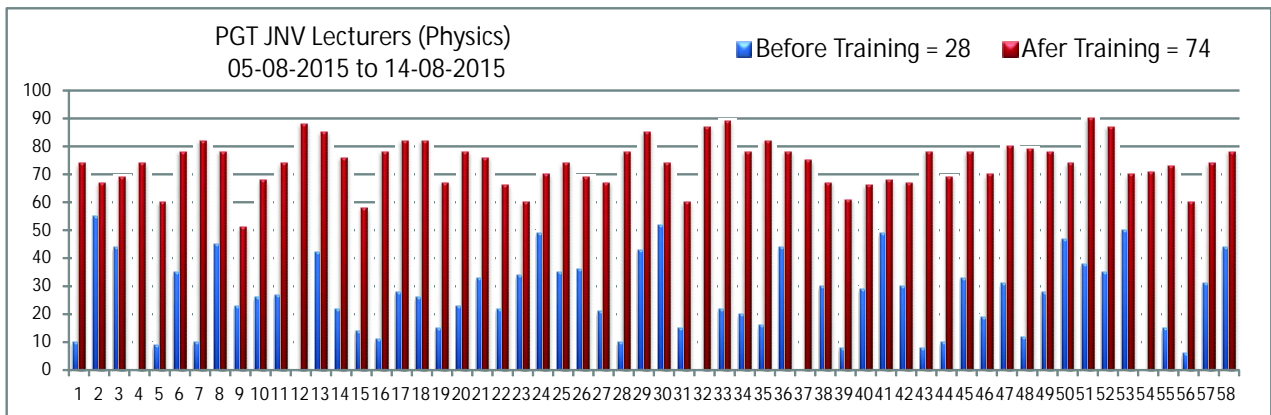


Heat convection



Test in Progress

Test Results



Some Observations

- The teachers in general are talented.
- They work hard (8 am to 8 pm for 10 days) to improve their knowledge.
- Highly motivated after the interaction with faculty of IISc and Universities.
- They pick up experimental skills faster than theory.
- Training in TDC inculcates discipline, hard work and truthfulness.
- They want to equip laboratories and want to do experiments for their students.
- Teachers feel committed to teach and train students with confidence.
- It is possible to train teachers to make the science education system strong.

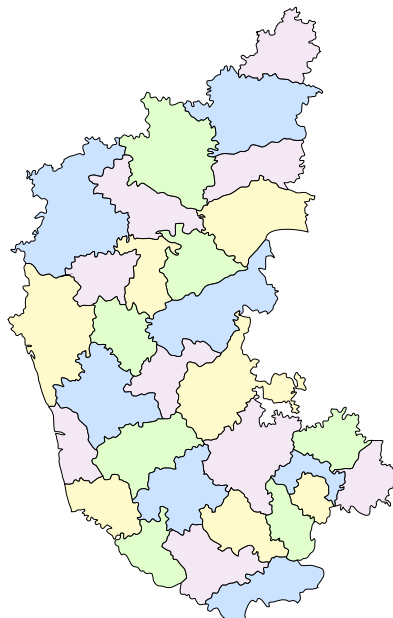
Feed back:

The teachers are unanimous in their feedback. Over 8000 teachers who have been trained so far expressed that this is a unique training program, first and only of its kind and essential for their profession, a must for every teacher. They expressed that only IISc and IIT's can give such good training. The training program is unique because of excellent laboratory experiments they can do in physics, chemistry, biology and solve maths problems.

The teachers are unanimous that all the science and mathematics teachers need this training and the Government should support it.



562 - JNV PG Lecturers
trained in India



5093 - High School teachers
trained in Karnataka

2332 - PU College lecturers
trained in Karnataka



18 - High School teachers
trained from Bihar



TALENT DEVELOPMENT CENTRE
INDIAN INSTITUTE OF SCIENCE KUDAPURA
CHALLAKERE, CHITRADURGA DIST. KARNATAKA 577536

Professor M. S. Hegde
Convener, TDC, IISc- Kudapura Campus
email: mshegde@sscu.iisc.ernet.in / mshegde@tdc.iisc.ernet.in
Tel: 9448191880

Contact us:

Professor B.N. Raghunandan
Chairman CEC
email : raghu@aero.iisc.ernet.in
Tel: 080-22933031