

## Chemical Engineering and Chemistry Experimentation as an Introduction to Engineering for K-12 Students

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### Abstract

The New Jersey Institute of Technology sponsors a wide range of outreach programs geared toward K-12 students in order to expose and interest them in science and engineering as a career. These programs have a chemical engineering and chemistry component which is a lecture/laboratory format that is directed to experiential learning and communication skills. Depending on the educational level of the program, the students either do experiments on a bench scale or on pilot plant size apparatus, all of which have been designed by the authors.

### Introduction

The Pre-College Center of New Jersey Institute of Technology has a broad range of outreach programs aimed at introducing K-12 students to science and engineering as a career choice. Among the various programs which have a chemical engineering and chemistry component are:

- (1) Chemical Industry for Minorities in Engineering (ChIME)  
(7th and 8th Grades)
- (2) Upward Bound (10th to 12th grades)
- (3) Females in Engineering: Methods, Motivation and Experience (FEMME)
  - (a) FEMME Continuum (6th & 7th grades)
  - (b) Senior FEMME (8th & 9th grades)

Each of the programs has a specific curriculum appropriate to the level of education of the participants.

The experimental chemical engineering laboratory portion of the course involves a “hands on” experience with equipment both bench scale and pilot plant scale. The pilot plant sized equipment is located the senior unit operations laboratory and consists of a piping arrangement for a fluid flow experiment that contains flow meters, various diameter piping and fittings. The laboratory also has a six inch diameter glass column packed to a height of six feet with 1/2 inch Raschig rings, a 6 inch diameter Plexiglas tower packed with 0.110 by 0.125 inch cylindrical plastic rings, and a cylindrical Plexiglas tank 5 inch in diameter and 6 feet in height with a quick opening valve for studying efflux time from a tank.

The acid neutralization and temperature measurement experiments are bench scale apparatus. The acid neutralization unit simply consists of a buret and beakers while the

temperature measurement experiment uses a hot plate a 600 ml beaker filled with 300 ml of water, a standard mercury in glass thermometer and a metallic dial thermometer. The students are divided into groups of two for the neutralization and temperature measurement experiments and groups of three for the pilot scale experiments. In the neutralization experiments each group is given four beakers filled with 25 ml of HCL solution, each of different normality and told to measure the amount of NaOH required to neutralize the solution. Methyl Red is used as the indicator.

In the temperature measurement experiment, the students fill a 600 ml beaker with 300 ml of water and place it on a hot plate. The students then take a mercury in glass thermometer subdivided in units of one degree Fahrenheit and a metallic dial thermometer containing unit divisions of 10 degrees in °F and °C. They then record temperature readings each minute until boiling is reached.

In the pilot plant size experiments, the students measure pressure drop in a straight pipe, each group doing a different diameter or shaped pipe, in a packed column with air flow only and counter current air-water flow or in a packed column until minimum air fluidization is achieved. In the draining of a cylindrical tank students fill the column to a given height, which is usually 52 inches, attach different lengths of similar diameter pipe and measure the efflux time at four inch intervals. For the calibration of a flow meter, students do the typical time-weight collection technique to calibrate in gpm an unknown capacity percent flow rotameter.

### ChIME

The chemical engineering and chemistry portion of the ChIME Program introduces the students to careers in chemical and environmental engineering through the use of video tapes, lectures on the theory and operation of equipment for measuring pressure drop in packed towers, circular conduits and fluidized beds, calibration of flow meters, draining time from cylindrical tanks, neutralization of stomach acid by “tums”, and temperature measurement by different type thermometers.

The bench scale experiments are followed by the students operating the pilot plant sized equipment, recording the data obtained and then proceeding with the data analysis. Then students with the assistance from the course instructors, are taught how to prepare a brief technical report and the audio visual materials for an oral presentation. These reports are the culmination of the chemical engineering portion of the course and this portion of the overall twenty (20) day program is done in five (5) days.

### FEMME

FEMME Continuum students only undertake the experiments on neutralization of acids of different strengths by titration and temperature measurement by mercury in glass and metallic dial thermometers. This program, which is a two (2) day effort, only involves data taking, analysis and graphical representation of the experimental results.

Senior FEMME participants undertake experiments in the senior chemical engineering laboratory on the pilot plant size equipment which encompass experiments on pressure drop

in packed towers, circular conduits and fluidized beds, calibration of rotameters and time for the draining of a cylindrical tank. Students in this program undertake two (2) of the listed experiments, take data, analyze it, write a report and make an oral presentation on one of the experiments they have studied.

### UPWARD BOUND

The Upward Bound program is an intensive six (6) week summer program which meets five (5) days a week for students residing or attending high schools in Newark, NJ. As in the other programs, chemical engineering is only a part of the program and is a lecture/laboratory integrated experience consisting of 3.5 hours per section, (25 students) one day per week. The lecture topics cover the theory of experimentation, statistics, unit dimensions, graphics, data collection and analysis, oral presentation and report writing. The course also has a homework assignment component. The laboratory experience consisted of experiments on the chemical engineering pilot plant size equipment listed previously. Students undertake experimentation, in groups of three in greater depth than any of the other programs and are expected to undertake more than one experiment. After the data reduction and analysis, a detailed technical report is prepared. Based on their laboratory experience and their written report, an oral presentation is made to their class and the program faculty.

In addition to the students undertaking the broad program which consists of studies in computer science, architecture, math, physics and chemical engineering they also do an independent research project. Students mentored by the authors undertook experimental studies in the area of fluid dynamics and heat transfer using equipment in the Fundamentals of Engineering Design (Freshman Laboratory).

The students review of the chemical engineering portion for all of the programs was unanimously excellent. They were particularly excited with the “hands on” laboratory experiments, but also found the communication efforts rewarding.

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### Biographies

DERAN HANESIAN served as chairman of the Dept. of Chem. Eng., Chem., and Env. Sci. from 1975-1988 and is Professor of Chem. Eng.. He came to NJIT in 1963. He received a bachelor of Chem. Eng. in 1952 and a Ph.D. in Chem. Eng. in 1961, both from Cornell Univ. Dr. Hanesian worked for DuPont from 1952-1957 and 1960-1963. He taught at the Algerian Petroleum Inst., Yerevan Poly. Inst., Armenia as a Fulbright Scholar, the Univ. of Edinburgh, Scotland, and Rutgers, the State Univ. of NJ. He was the recipient of the Robert Van Houten award for Teaching Excellence in 1977 at NJIT, the ASEE, Midlantic AT&T Foundation Award for Excellence in Instruction in Eng. in 1986, the John Fluke Award, ASEE, 1994, the Outstanding

Tenured Faculty Award, NJIT, 1994, and the Distinguished Teaching Award, Middle Atlantic Section, ASEE in 1997. He is a Fellow and Emeritus Member of the American Institute of Chemical Engineers and a Fellow and Life Member of the American Society of Engineering Education.

ANGELO J. PERNA received his B.S. ChE degree from Clemson University in 1957 and his M.S. degree from there in 1962. He received his Ph.D. from the University of Connecticut in 1967. He worked as a production and development engineer with Union Carbide Nuclear Company in Oak Ridge, TN, and taught at VPI, and the University of Connecticut. He is currently Professor of Chemical Engineering, Chemistry and Environmental Engineering at New Jersey Institute of Technology. In 1997, he received the NJIT Alumni Award for Teaching Excellence. He is a Fellow in both the American Institute of Chemical Engineers and the American Society of Engineering Education.