Some Factors Affecting Performance in General Chemistry

by

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This document is dedicated to my husband Srinivasan and my children Rajiv and Ranjana without whose encouragement and support this endeavour would not have been possible.

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Chapter I

Introduction

Any study of the state of chemistry education must begin with a look at the whole of which chemistry is a part.

The ACS task force[1] reports that nationwide there has been a decrease in science and math achievement in the last fifteen years.

Between 1966-67 and 1980-81, the average score for intended majors in physical science on the verbal part of SAT declined from 515 to 438, and on the math part from 580 to 520.

Between 1980 and 1987 average SAT total scores remained stable even though the number of test-takers as a percent of high school graduates increased from 33% to 41%[2].

In the state of Virginia, for the year 1990, considering average figures, the Verbal SAT score was 424 and the Math SAT score was 476. In 1991, the Verbal SAT was 422 and the Math SAT was 474. Science achievement for 17 year olds in 1990 was found to be lower than in 1970.

Table I Average Science Proficiency Scores of 17 year olds : 1970-1990

1970	1973	1977	1982	1986	1990
305	296	290	283	289	290

Scale:

150: Knows everyday science facts.

200: Understands and applies simple scientific principles.

250: Uses scientific procedures and analyzes scientific data.

300: Understands and applies scientific principles.

350: Integrates scientific information and experimental evidence.

There are obviously many components responsible for the deterioration in performance level since 1970. The score of 1970 tells us that many of the gains of the post-Sputnik reform have been allowed to slip away and elementary and secondary school science education has been neglected[3]. This has a great bearing on how students perform at the college level. The purpose of this report is to give a general overview of some of the possible factors which may cause increasingly low student achievement in general chemistry at the college level. This is followed by a review of the general chemistry course at Virginia Tech. Even though there are many components which play a role in student achievement, this report will

attempt to show that student attendance as a measure of attitude and their unwillingness to learn is the one of the main obstacles to better student performance and will provide some suggestions which need to be investigated further to overcome these problems.

Chapter II

Overview Of Some Factors Affecting Student Performance.

"Broadly stated, entry-level courses should provide the foundation that enables all students to continue their education in science, math and engineering, both formally and informally[4]."

There has been a growing concern about student performance in the general chemistry course[5]. It has earned the reputation as being one of the most difficult first year college courses. Chemistry being a central science, is a required course for most science and engineering majors. So even though there are many thousands of students taking these courses, to many of them, it seems uninspiring, boring and irrelevant and there are not enough students who are sufficiently interested in the subject to major in it which can result in a shortage of qualified chemists[5].

The number of Bachelor's degrees in the natural sciences dropped from 7.9% of all undergraduate degrees in 1985 to 6.5% in 1990. The number of bachelor's degree graduates in chemistry from colleges and universities offering an ACS

approved program decreased 3% in the 1988-89 academic year, the smallest in four years[6], but this figure increased to 7.2% in the 91-92 academic year[7]. The total number of Bachelor's degrees awarded in 1990 was 1.05 million, 13% more than in 1980[8].

Table II Summary of Bachelor Degrees Offered in Chemistry : 1985-1992

Year	Number of Schools	Undergraduate Degrees
1985	579	9679
1986	580	9295
1987	582	8848
1988	584	8372
1989	593	8122
1990	599	7650
1991	599	7872
1992	601	8435

Another reason to promote an interest in chemistry is so that not only can science, engineering and medicine graduates understand its applications in their own field, but they should also be able to understand and discuss intelligently some of the major problems faced today with increasing pollution and diminishing resources[5]. To generate an interest in the subject, the main area of focus should be during high school and first year college chemistry[4].

Sherwood L. Boehlert, (Vice-chairman of the House Science Research & Technology Subcommittee) states[9] " Previous reports seem to have taught many people little more than how to talk about the educational crisis. Universities now talk about the need to encourage more students to pursue math and science, but they still run introductory courses conciously designed to discourage those students. Public officials now talk about the importance of education, but they oppose new programs and underfund existing ones. Parents now lament the quality of their schools, but they do not participate in school activities or discipline their children. Businesses now express disgust at the quality of their new hires, but they don't help improve the quality of schools in their communities. ...The point is clear: Problems are not solved simply by documenting them."

This chapter deals with some of the obvious problems in high schools and colleges today. Some of these, given time,money and determination, can be solved. Therefore in addition to the problems documented, authors suggestions for

further investigation, termed 'Wishlists', are placed in subsections following the appropriate categories.

I. High School Chemistry

Hirsch[10] aptly notes, " The top educational priority for Virginia and for the nation is to lift all of our high school graduates to a competitive international standard. Not all of Virginia's high-school graduates will go to college. Yet all Virginians can and must achieve the competence just mentioned by the 12th grade if they are to secure good jobs for themselves and create a high performing economy for the state and the nation".

Science[1] and Math education starts early in the elementary schools. For grades K-3, seventeen minutes a day are devoted to science and for grades 4-6, twenty-eight minutes a day are devoted to science. And even though there is a positive attitude towards science at this stage, it is found that there is a steady decline of interest in the higher grades.

In spite of the variety of courses offered in any subject based on ability, (eg. AP courses, consumer science, etc.) nationwide there has been a steady decrease in the amount of science completed by the students during their high school years[1].

In 1981, the median number of years of courses completed in grades 7-12 by the college-bound group was 4.2 years of English, 3.7 years of Social Sciences, 3.5 years of Mathematics, 1.3 years of Biological sciences and 1.6 years of Physical sciences. This situation has led to fewer students graduating from colleges with a science degree.

On average, a high school graduate in 1987 earned a larger number of total course units than a high school graduate in 1982. But, of the total course units earned in 1987, on average, about 7 in 10 were academic units, 2 in 10 were vocational units, and 1 in 10 were personal use units. Overall, high school graduates earned a smaller percentage in academic units than did graduates in 1982[2].

High school is the period when students receive their first exposure to chemistry in the classroom as well as the laboratory. These first impressions about the subject play a very important role as to how the discipline is viewed, whether they have an aptitude for it and even whether they view it as a probable career choice. Therefore, it is very important to generate an interest in chemistry at the high school level so that students will be encouraged to study it further in college.

A. Some Problems for immediate consideration.

The ACS task force states some of the major problems facing todays high schools. They report[1], "At too many schools, teachers are not

sufficiently qualified enough to teach science at the high school level. Few chemistry teachers have real subject matter competence in the discipline and those who do are increasingly wooed away to other professional employment". Fortunately, this situation is now improving. For instance in the state of Virginia, since 1992, all teachers of chemistry need to have a B.A or B.S in **chemistry** plus a valid license to teach. Moreover, "There are problems of facilities and finances in schools. Science teachers have a greater need than others for special kinds of facilities and equipment, to teach as well as to demonstrate the subject matter. Seldom are these forthcoming in the quantity and quality needed"[1].

Chemistry is a constantly growing field with new developments every day. It is important for the students to be exposed to what is currently new in the field. Unfortunately[1] there is very little help given to teachers who want to maintain or improve their proficiency of instruction in chemistry.

Students[11] learn what they see, but high schools, due to limited finances, do not have chemistry laboratories where students can see and understand for themselves the basic principles governing chemistry. Waste disposal is a major problem. Teacher demonstrations are also restricted due to limited supplies. Chemistry is taught in a passive mode where the teacher lectures and the student takes notes. This situation is not conducive to generating interest in the subject[12]. In fact, all of these problems

contribute to the students not comprehending the subject matter properly and labelling the discipline as abstract and difficult.

The one place where these problems are not evident are at the 'gifted schools' who with the help of the best teachers and sophisticated facilities are able to greatly generate student interest and imagination. Unfortunately this system is meant for a privleged few who are lucky to get in[11].

Many students[13] due to pre-conceived notions about the level of difficulty of science also try to avoid the subject by choosing the vocational track. At present, many students[11] who choose the vocational track are not required to take chemistry or any of the other science courses. Instead all they study is one general watered down version of one subject which passes for science and hence these students graduate from high school without any good exposure to any science subject[15].

Rutherford[14] notes " Tracking will either have to be abandoned or the content of the various tracks radically changed. Vocational students - as future citizens and as entrants into a work force in which the best jobs increasingly require technological sophistication - need to acquire a strong foundation in science and mathematics, an understanding of how these relate to technology, and an awareness of the dual nature of the technology-society

relationship. College preparatory students - as future citizens and potential leaders in law, politics, business, education, and government service - need the same thing."

Therefore it is very important to expose a larger number of students to a general introductory chemistry course at the high school level. Many of those who choose the vocational track are also generally found to be minority and low income group children who have been disproportionately assigned to low ability tracking in elementary school from which they can never catch up[15]. Therefore a low-ability student from an upper class background finds it easier to go to college than a high-ability student from a lower class background. Due to the 'academic elite' system which exists in our society, a lot of educable students are missing out on a college education which is eventually a loss to the nation[15].

There are studies[16,17] to show that college chemistry professors are incorrect in their assumptions as to what topics are covered in high school. This is probably due to the fact that high school teachers do not agree on what topics to include in their syllabus. In a survey at over 140 high schools[16], each teacher was given a list of 50 lecture topics. Eighty percent agreed on forty-four percent of the topics; they could not agree on over half of them and there was no agreement as to which topics should be excluded.

Children[11,18] from other countries like Russia, France, Germany, Japan, India and China find U.S schools very easy. These kids have learned in the third or fourth grade what is being taught here in the seventh grade. This is probably due to the fact that these countries have established national curriculums and they have worked back from these goals to figure out what amount of subject matter should be completed by which grade. This country happens to be one of the few in the world without a **national high school curriculum**. After the furor created over setting a syllabus for family life and sex education, the authorities decided to limit their duties to prescribing textbooks and leave it to the individual teachers to decide what to teach from it[11].

Shankar aptly observes[18] "With a national curriculum, everybody knows what is required. If there also are clear and visible stakes-getting into university or apprenticeship program-the pressure is on to make sure youngsters meet the standards. Without national standards and a national curriculum there are no such pressures. That is why students in other countries work hard and do so well-and why students in our "easy" and undemanding schools do not. Knowing that should lead us to act".

Many teachers[11] feel that another major yet overlooked problem in a normal day in high school is the number of hours students (especially seniors) miss in a day due to extra-curricular activities. In any given week,

active students can miss anywhere from one-two class sessions a day, which is 20-40% of instructional time. This situation makes it very difficult for the teacher to do any constructive teaching and the student loses out on a lot of material. Since all sciences basically build on previously taught material, this situation will eventually cause the student to perform badly and lose interest in the material as he/she can't keep up.

Wish List

The following are some short and long term solutions which need further investigation.

1. In order to overcome the segregation problem which results in an uneven distribution of students exposure to science, it is necessary to eliminate the concept of tracking which means getting rid of the gifted schools and changing the structure of the vocational track.

2. Schools for gifted education such as governors schools receive most of their funding from private sources (private communication). If this system were to be eliminated with all gifted students streamlined with everybody else, the following would be the advantages.

    a. All the students get the benefit of the most skilled teachers who otherwise end up at the gifted schools.

b. This streamlining process will raise the standards in our public schools with more of the educated and wealthier parents getting involved.

c. The schools will benefit from the private sector funding which normally goes to the gifted schools in purchasing costly equipment and setting up decent laboratories.

d. The higher ability students can be recruited as peer tutors which will be beneficial all around.

3. It is also very important to raise the standards of the vocational track system and get rid of the derogatory stigma attached to it as this usually results in teachers teaching 'down' to these students. Vocational students also can find it easier to go on to college in case they change their mind. Moreover this will be the first step in establishing a national curriculum.

4. One of the most useful facilities which every school needs are computers. Both teachers and students can benefit from computerization in schools. The teachers can get reaquainted with the subject through computer tutorials which may also simulate all demonstrations. Computers are also a useful grading tool which can save teachers a lot of time in which to prepare their material. With proper computerization in schools, each student can proceed at

his/her own pace so long as they reach a minimum standard in the allotted time. The high ability students of course should be encouraged to explore the topic in more detail with added incentives being provided. This can be done using the 'SMART CARD' method adopted by Roanoke county high schools where all students with a GPA of 3.5 and above get a card where they get discounts at all kind of places from movies to fast food places, restaurants etc.

5. Students should have a chemistry laboratory at least once a week to experience for themselves the basic chemistry concepts. The use of microchemistry kits should cut down on costs for chemicals and waste disposal. The nearby colleges can perhaps help to design a workable solution to handle the waste disposal problem.

6. Student's should not be allowed to miss lecture for any school sponsored activity. Extra curricular activities should be held before/after school hours.

7. To generate student interest in the subject, more companies and businesses should be persuaded to hire student apprentices during the summer just so they can get a feel for the work involved. This real life experience will help in their choice of major as the decision will not rest on just how difficult they found the subject.

8. While being taught the basics, students should also be introduced to interdisciplinary fields such as bio-chemistry, food-technology, polymer science, textiles etc. so that they understand the vastness and diversity of the subject matter. Applications of chemistry may make the subject less abstract and more interesting.

9. Studies of science fiction may be introduced as part of the science curriculum to develop student interest and imagination. Examples of reading material for good scientific discussions would be along the lines of Micheal Crichton's recently successful "Jurassic Park",Isaac Asimov's "Flatland" and "The goose that layed the golden egg".

10. All teachers need to be educated with the set of craft skills that have to be mastered in order to do their work well, with appropriate compensation packages and reward systems to be used as incentives for better performance[19]. Moreover, school districts should support staff development programs for teachers of science to enhance their scientific knowledge and science teaching skills[20].

11. There should be improved networking among teachers in schools and universities to enhance instructional decision making[21].

II. Standards of Admission

U.S colleges are considered to be the best in the world13[22] while at the same time our secondary schools are considered to be inferior. America does have some of the best post-secondary institutions in the world, but this cannot be generalized to apply to all institutions. Students really don't need to know much to get into most of these colleges and there is no reasonable way to figure out how much they have learnt by the time they graduate[22].

This situation is probably due to the fact that there are colleges who are willing to take on students based on their ability to pay rather than on their academic achievements. John Keating, guidance director at Walt Whitman High School Maryland, states[23] " I thought some of these colleges would have folded, but they are surviving by taking anyone with a pulse in one hand and the bucks in the other".They[23] wrongly feel that after admitting them, they can hold them to a certain standard. They are not able to maintain standards and they cannot dismiss these students due to their much needed funds, and as long as students can get government loans and grants for their education, these colleges are not going to go out of business.

If colleges want to maintain their standards and to graduate students who are going to be productive in society, then they need to put pressure on these students and parents and raise the standard of admission[24]. Colleges do have influence over high school standards and student achievement and should demand more of the students. If these students realize early on that to get into college

they need good grades, they will perform at a higher level in high school. If they realize they can get by with less, then they won't work hard.

Shankar feels[22] that in lowering their standards, colleges have undermined the authority of public schools and parents to demand more of students.

IIII. **Wide range of student abilities**

Students enter college with widely different backgrounds and different levels of preparation. This makes it extremely difficult for the college professors to teach chemistry starting from a college level as most of these students are still learning material in college which should have been mastered in high school. One in three freshmen ends up needing remediation courses[24], professors are worrying about the effect of these marginal students on the rest of the class while administrators are worrying about increasing remediation costs.

Hirsch[10] states "Students who come to higher education have become an increasingly diverse group. They lack a common culture, and often a common set of skills on which a teacher can draw in presenting new materials. It is impossible to teach chemistry well to a group of students who have widely varied preparation for that subject, ranging from superb to totally inadequate. To accept the idea that remediation in basic skills should remain a college level task is to accept permanently a situation that we Virginians must insist upon getting fixed quickly". Hirsch's point is exemplified by the fact that in the summer of '93 at Virginia

Tech, the SAT scores of intended **Chemistry** majors ranged between 820 and 1490 (Glanville private communication).

Shankar[24] points out that the literacy tests that the NAEP (National Assessment of Educational Progress) gives to 21-24 year old college **'graduates'** show that less than one in five could meet the entrance requirements for colleges in other industrialized countries.

This[16,26] situation is probably due to the fact that the students have not learned the fundamentals of chemistry and the necessary problem solving skills in high school and cannot cope with the current general chemistry syllabus. To expect a meaningful study of chemistry at the college level we should consider Ausubel's definition[10] which says " The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly. "

Wish List

One way of ensuring that professors are teaching students of similar abilities is to set up 3 levels of chemistry, say CHEM I, CHEM II and CHEM III[27].

All students should take CHEM I in the fall of their first year unless they pass a proficiency test. This will be a revision of high school chemistry, basic math, quadratics, graphs, word problems, etc to improve problem solving and study skills. This level is probably

sufficient for the non-science majors who really do not have an aptitude for the subject.

CHEM II should be taken by all science majors (similar to General Chem at Virginia Tech) after which only the chemistry majors,biochemists and those on the pre-medical track take CHEM III which will be a more detailed version of CHEM II. Those who need to take CHEM III should have an option of passing out of CHEM II via a proficiency test.

By establishing these levels, we should be able to prepare our science majors better and maybe attract students who might otherwise never encounter the real chemistry or might encounter a watered down version of it.

Another major advantage to this system is that the course will not be too demanding to incoming freshmen who are adjusting to a whole new way of life. As many students are ill prepared for the usual first semester course in general chemistry, this will be a good starting point to reinforce and teach all the basic concepts they need to know before they attempt anything else.

Most of these students are eventually going to find jobs in industry. Industries report[28] that their new employees are not adequately prepared for their jobs in spite of their qualifications.

There seems[29] to be a mismatch between what industries expect and what they are taught in colleges.

There should be a better relationship between industry and academia for proper design of the advanced curriculum as the industrial demands for chemists can change ten times as rapidly as the educational system can respond[29,30].

IV. Role of class size

"The greatest challenge in teaching is to engage the student effectively in structuring and restructuring his or her own mental constructs[4]."

All universities, have been hard hit by the recession[31]. Tuition rates are higher; professors are scarcer; and classes are larger. The average cost of a four year college increased 7% in fall 1992 to a record $10,500. In spite of the tuition increase, introductory class sizes were raised and a smaller number of sections and courses were offered which resulted in fewer students graduating on time. The class size in most land-grant universities for an introductory course averages about 500 students and is perceived by many faculty to be one of the causes of low student achievement. On interviewing a sample of 25 freshmen from varying

backgrounds at Virginia-Tech, it was interesting to note that after the first week, all of them felt that there was no correlation between class size and their grade.

The concept of learning today is no longer the same as 20 years ago. Students are no longer comfortable **sitting** in a large auditorium listening to professors drone over the PA system all day. Learning today is synonymous with activity and teaching methods should change accordingly. Students should be given more responsibility in learning and trying to understand the material without the professor doing all the teaching[32].

Wish List

1. Students are found to absorb more information through group study. Therefore 25% of the grade could be based on group activities with each student being responsible for an activity within the group and teaching it to the others. With 10 students per group, there should be about 50 ongoing projects for the semester. They should be able to rely on their Teaching Assistants for individual/group help with the Teaching Assistant assigning a portion of the grade for participation and the professor grading the final report.

2. Experiments and demonstrations should be used regularly to teach the students about chemical reactions as it is logistically difficult and more expensive for the students to do it themselves in

the laboratory. On the other hand it would help the student if he/she could simulate the demonstrations on a computer and rerun the experiment altering the different variables.

3. Computers are a good way to supply and test the knowledge of the material in the textbook as well as to carry all 'koofer' files with the answers provided in detail. 'Koofers' are files carrying questions from previous examinations. As the 'koofers' are very popular with students, they will probably learn to put the computers to good use.

4. Because it is difficult to reduce the class size to more manageable figures due to budget constraints, the next best thing would be to set aside a certain time for every student to attend supplemental instruction classes with not more than 15-20 students where the basis would be working out problems and revising test material with extra credit being given to attending students. The Graduate Research Assistants or Teaching Assistants could be recruited to commit 1-3 hours a week for these sessions, the incentive being either extra pay or a tuition reduction.

5. It would also be beneficial to record the class lectures and to make copies available in the classroom for additional reinforcement (and for absentees).

The usefulness[22] of audio-tapes was proven in a study done at University of Maryland at College Park where fifty percent of the students earned D,F or W grades in chemistry. Some students were given refresher course tapes which reinforced basic concepts and calculations in chemistry. Sixtyfour percent of those who chose to listen to at least one tape got a final grade of A,B or C, while only fortyfive percent of non-users received at least a C grade.

Just providing these facilities is not going to get the desired results. The student should feel that it works for him/her. One possibility is making sure that a good portion of the test material is from the computer work stations, audio-cassettes and supplemental instruction sessions.

V. **Student attendance and attitudes and faculty morale**

"An institution that encourages, supports and rewards creativity in undergraduate teaching in much the same way it encourages, supports and rewards creativity in research fosters the synergism of teaching and research."

Not too many generations ago college education was meant only for a privileged group of people[34]. This situation is no longer true. The value and

necessity of a college education has been drummed into students by their parents who have seen their contemporaries reap the benefits of a college education. Today's students come from all walks of life and all income groups. Thus they are forced into a life as democratic as American life itself.

An anonymous professor in Michigan State explained it well when he said[34] " the students of this generation have had to absorb more knowledge, file it away in order, recall it quickly on command and apply it in a variety of situations never conceived by previous generations."

The faculty whose only job was to teach a handful of respectful students has been replaced by a harassed business-oriented professional who has all too often lost the confidence of his students due to his inaccessibility[34]. The very large classes pose a burden on everyone with the professors appearing bored,disinterested and indifferent to the students and vice-versa. Complaints about levels of teacher proficiency are seen in all schools big and small. Students are also overwhelmed by the sheer amount of material they have to learn and so they try to memorize whatever facts, theories and equations which they feel are necessary to pass the course[35]. The result is that in the bigger schools, students tend to miss classes as they feel they are not getting anything out of class anyway and they can always copy notes from someone else.Those who do attend have not read the material and have no interest in learning it. They will not ask or answer

questions. This pattern seems to exist in all classes in every department irrespective of the class size[34].

Paul Bruss, Prof. of English at Eastern Michigan University, sees professors around the country "throwing in the towel and marking time; they feel that they are babysitting a large bunch of kids who don't have the background or motivation to perform well in college. It is tough to walk in the classroom day after day and feel the resentment from half the class that is so woefully unprepared, they don't have any idea what is going on."

According to Harlan Miller[35], professor of philosophy at Virginia Tech, the following contribute to student unhappiness:

a) Increasing tuition,

b) collapsing job markets,

c) faculty indifference,

d) family/economic pressures,

e) conditioned unwillingness to accept responsibility and

f) very large classes.

He feels that of these to a certain extent c) and mainly e) seem to be most possible explanations.

Most faculty members[36] do empathize with psychological issues that occupy many of their students especially in their freshman year and are found to be effective mentors and role models in most cases. But it cannot be denied that in

every department there are indifferent faculty. Universities are fighting for talent in a shrinking labor market. They are not able to pay enough to compete with industry standards. Professors are hired based on their research and the finances and contacts they can bring in rather than their ability to teach. These professors might view teaching an undergraduate courses in a resentful manner and show no real interest in their students[34]. Another factor of resentment among professors is that they are clearly undercompensated in comparison with their colleagues in the industry[11].

A 1990[31] Department of Education survey shows that while the number of incoming students increased by 7% and the faculty or teaching professionals increased by 6%, the number of non-academic professionals such as lawyers,accountants,systems-analysts etc increased by 61%. With the establishment of the computer-systems to take over most routine tasks, these jobs might be expected to decline. Instead 70% of the budget outlays goes towards their paychecks. On the other hand, faculty at University of Virginia, for example, took a 2% pay cut in Dec. 1990. At San Diego State University, 1000 faculty members have been fired or given early retirement by the university. Consequently student enrollment dropped because of decreased classes and increased class size. Not only are university faculty undercompensated in comparison with their colleagues in industry, their level of job satisfaction is also at a very low level due to the steady decline of student interest. Students need teachers more than they do

administrators. University of Virginia took a step in the right direction when it did not replace 2 vice-presidents, a director and 200 administrative staff. John Casteen III quotes , "It is a considerable lesson to discover that one-third of the people you no longer have were not really necessary to the academic operation of the university"[11].

Teacher development[37] is more important to the quality of education than administrative or even curriculum development as they have to conduct learning experiences that develops the students cognitive and perceptual abilities.

It is becoming increasingly difficult to make students responsible for their grades, especially in the introductory courses. It is normal for incoming freshmen to perform badly in their introductory courses ending up with low GPA's and then devoting the next 3 years to bringing them up to some kind of acceptable level. It is also a fact that students miss classes and related help sessions more in their first year than at any other time[34]. Therefore, we can safely assume that there is a some kind of a correlation between the grade for a course and student attendance for that class.

Chapter III

Overview of General Chemistry at Virginia Tech

Virginia Tech is a land-grant state university located in Southwest Virginia. It has an undergraduate student population of about 20,000. This university has been listed by the ACS as having 54 chemistry graduates, one of the highest number in 91-92[7]. What follows is a brief discussion of the general chemistry program at Virginia Tech including its problems and some possible solutions with particular attention to student grade and attendance history in the lecture portion of the course, student attitudes and the laboratory program .

1. Program Overview

There are three different kinds of introductory chemistry courses at Virginia Tech.

a. A liberal arts course for non-science majors.

b. A general course focussing on the basic principles for all non-chemistry science majors.

c. A more intensive version of 2. for chemistry and biochemistry majors.

Here we are concerned with the second, which is the general chemistry course for non-chemistry science majors. It is a two semester course; CHEM 1035 and CHEM 1045 for science (but non chemistry and biochemistry) majors. This course is a traditional, mainstream freshmen chemistry class with 3 hours of lecture credit and 1 hour of laboratory credit each term. This course is taken by approximately 2200 freshmen every year, half of whom are engineering majors and a quarter of whom are biology majors.

Zumdahl's widely adopted textbook was used in the lecture portion of the course during 1992-93.

There are 8 classes offered at different times during the week with approximately 500 students enrolled in three of the sections and 180 in the other five. This size unfortunately limits class participation but the professors try to make up for it by holding office hours and help sessions for the students at various times and by appointment and on the whole go beyond the call of duty in trying to maintain a rapport with their students. It was found on interviewing students of one class (Glanville), that those who attended the help sessions claimed that they got to know the professor really well, and that these sessions were what got them through the course. There are demonstrations held at practically every class to illustrate the subject matter and hold student interest.

There is a resource room available for the students where there are TA's present for the purpose of helping students with their lecture and laboratory material 4 days a week (Monday through Thursday) from 8 AM to 6 PM.

There are 'koofers' (old exams) available in the library which they can refer to. At one point the department had additional aids such as audio-tapes and computer work stations to help the students learn better.Unfortunately these aids were not made great use of.

The students are also supplied with the 'yellow pages' in their laboratory manual which is a guide for students new to college who are taking their first chemistry course. This manual provides them with pointers for doing well and explains in detail how the whole program is run and what students should expect and what preparations to make ahead of time so that they do not get intimidated. There are also pointers on how to study for the tests and where to get help in case of problems. A paragraph on past student's comments indicate what they thought was most important.

It was found that very few students actually take the time to read this informative material. It would probably be a good idea to distribute these in Virginia's high schools where there is a better chance that they will read it as they would be eager to receive more information about what to expect.

In spite of all these resources, the class GPA for this course typically is between 1.8 and 2.2. The additional aids were not made great use of though the koofers were extremely popular.

One reason for these low grades was investigated by keeping track of attendance through the use of pop quizzes which is discussed in the next section.

The pattern of usage in the resource room was also investigated through a log book which was filled out by the students who used it. It was found that during fall of 1992, only 365, that is less than 15% of enrolled students visited the resource room.

About 45% were seeking lecture help and the remaining were seeking laboratory help. The evaluation comments by the students though were overwhelmingly positive (98%) with added comments like 'yes and thank you','two thumbs up','rewarding' etc. Only three students were unsatisfied with the help received.

2. **Attendance and Grade Correlation**

To find out how student attendance affects grades, general chemistry grades for three lecture sessions (Fall 1991, Spring 1992 and Fall 1992) taught by a single professor (Glanville) have been examined. The Fall class met at 8 AM on Mondays, Wednesdays and Fridays. The Spring class met at 3 PM on the same days.

a. **Procedures**

Hour exams were given at approximately three week intervals throughout the course. Hour exams and the final exam used locally written multiple-choice responses. The hour exams were weighted at 100 and the final at 200. The nominal grade scale used in the course was 90-100 A, 80-89B, 70-79 C, 60-69D and <60 F. Fall 1991 semester hour exams and the final had respectively 25, 25, 25, 25 and 40 questions. Spring 1992 had respectively 25, 25, 40 and 60 questions. Student responses were made by blackening forms that were optically scanned to produce magnetic grade files.

The results reported here were obtained by scaling the actual scores of each individual hour exam to an average of 75, and assigning letter grades according to the nominal scale.

For all three semesters, students who missed a hour exam were assigned their average grade for a missed hour exam provided they took a subsequent hour exam. When students stopped attending, as evidenced by missing hour exam scores, the zeroes were retained. A few scores (<1% of total hour exam scores) were assigned from make-up examinations. Students who dropped the course were excluded from consideration.

During Spring 1992 six quizzes were given and during Fall semester 1992 seven quizzes were given. These quizzes were each of less than five minutes duration and consisted of two or three questions. The quizzes were

given unannounced at 2-3 week intervals. The quizzes served as an attendance check.

b. **Results and Discussion**

Table III shows a summary of the grades assigned for all three semesters and a comparison of grades of individual students from successive hour exams.

This table also shows the grade of the students for the first hour exam and for the entire course. It is found that at the conclusion of the course, students tended to receive grades similar to the grade they received on the first exam. Thus about one-half the students received the same overall grade as they obtained on hour exam a; and about sixty percent had an average grade after hour exam 1 and hour exam 2 the same as their overall grade. Almost one-third of the students maintain an identical letter grade based on the running average of each of the successive hour exams. And about 70% of all students maintain a running average grade that does not change more than one letter grade.

Table III Correlation between grade for hour exams and course grade

	Fall 1991 (N=496)	Spring 1991 (N=144)	Fall 1992 (N=486)
Students with same letter grade on first hour exam and for course	51.2%	38.2%	48.2%
Students with same letter grade after two hour exams and for course	58.3%	52.8%	63.0%
Students with identical letter grade on running average after each hour exam and for course	29.4%	27.1%	30.8%
Students with letter grade in 2-grade range on running average after each hour exam and for course	69.1%	63.2%	69.1%

Table IV shows the subsequent course performance of students who made a letter grade of F on the first hour exam of the semester. Note that in both Fall 1991 and 1992 only a single student was able to improve an F grade to a B grade and none improved to an A.

Table IV Hour Exam Performance and course grade

		Fall 1991 (N= 496)	Spring 1991 (N=144)	Fall 1992 (N=486)
Students with F grade on hour exam I		103	34	95
Course Grade of those students	F	69	14	51
	D	19	15	30
	C	14	5	13
	B	1	0	1
	A	0	0	0

Just as getting an F grade on the first hour exam is a good predictor of eventual failure, so getting an A on the hour exam is an excellent predictor of success. Thus in Fall 1991, of the 75 students who got an A on the first hour exam, 48 (64%) received a course grade of A. During Spring 1992 of the 33 students who got an A on the first hour exam 21 (64%) received a course grade of A. And during Fall 1992 of the 88 students who got an A on the first hour exam 65 (74%) received a course grade of A.

Table V Effect of final exam on grade

	Fall 1991 (N=496)	Spring 1991 (N=144)	Fall 1992 (N=486)
No effect	347 (70%)	94 (65%)	376 (77%)
Improved	78 (16%)	30 (21%)	54 (11%)
Diminished	71 (14%)	20 (14%)	56 (12%)
Total	496	144	486

Every teacher of freshman chemistry knows from personal experience that students have a very high expectation that they will significantly change their status by performing well on the final exam.

Unfortunately, this optimism is not justified by their actual performance. Table V demonstrates that the grades of three-fourths of the students did not change from their average after the hour exams. And, of the remaining students, about half improve and half diminish.

Table VI shows the correlation between attendance and the average numerical scores achieved by students on exams. The fact of the correlation is obvious; however it is not clear if the correlation simply reflects that better students tend to come to class more reliably or if coming to class more frequently causes greater learning. In the Fall of 1992 the average attendance rate of all students was 85% while in the Spring of 1992 it was 70%. The fall-off in student attendance as the semesters progress is shown in Table VII.

Table VI Number of Quizzes taken. (A measure of attendance)

	Number of Students	Average Overall Score
Spring Semester 1992		
6	52	82.4
5	28	78.0
4	17	73.6
3	18	74.3
2	17	67.2
1	8	49.4
0	4	49.4
Total	144	75.0
Fall Semester 1992		
7	231	78.7
6	135	75.3
5	57	75.7
4	30	66.2
3	25	61.0
2	7	50.4
1	0	----
0	1	9.1
Total	486	75.0

Table VII Percentage of students attending quizzes

	Spring 1992	Fall 1992
Quiz 1	88 %	98 %
Quiz 2	84%	94%
Quiz 3	59%	90%
Quiz 4	62%	85%
Quiz 5	67%	83%
Quiz 6	69%	81%
Quiz 7	--	70%

These quizzes were also a way of measuring class attendance.

One main conclusion drawn is that students arrive in freshman chemistry class with well-formed abilities (good and bad) and that not much is changed by their exposure to the class. Thus, most of the students who get A's in the course got A's in their first test and likewise for those

who earn F's. In between some students go up and some go down but it is not many who do so. This is scarcely surprising considering that, in a normal semester, the first exam is given after 7-8 lectures, providing the teacher with about 6 hours in a large lecture hall to change the educational patterns of 18 years.

The evidence of the correlation of exam averages with class attendance strongly suggests that it is the good students who show up in class regularly. It would be helpful if there could be an electronic system of checking attendance in the classroom after /before class without cutting into lecture time given the scope and the demands of the curriculum.

After the data for the Spring 1992 semester had been compiled it was decided to undertake an experiment in the Fall of 1992. In this experiment, two evening help sessions of two hour duration were offered for the first four weeks of the semester. Then, after the first test, the instructor (Glanville) personally called all of the students with a grade of F to warn them of the evidence gathered previous spring. Class announcements to the same effect were also made. A large number of help sessions (33) became a feature of the fall 1992 class. However to the discouragement of the instructor, comparing the results of fall '91 and fall '92 shows no evidence that any of these efforts had the effect of raising grades.

Two main objective conclusions have been reached :

1) Student performances are consistent from exam to exam. For example about half of all students receive a final grade identical to their score on the first hour exam, and about 30% of all students get identical letter grades for each hour exam. This evidence suggests that student performance is much more strongly influenced by their prior experiences than by their experiences in the general chemistry class room.

It would improve student proficiency and boost teacher morale if all students were to go through a "refresher" course first unless they pass a general chemistry proficiency test as suggested elsewhere in this report. It would also help in keeping students who are unprepared for the course from complaining about the unfairness of the course in general.The math department at Virginia Tech has a pre-calculus refresher course for those students judged not proficient enough in calculus and math. For this purpose, they have designed a math readiness formula:

MREADY = 7(SATM)/100 + 16(MGPA) +
11(CALC) - 6(RANK)/10 - 28

where

SATM = SAT math score
MGPA = Math GPA from high school (A=4, B=3, C=2, D=1, F=0)
CALC = Use 1 if one full year of high school calculus was completed
0 if not.
RANK = High school rank as expressed as percentage

Students with MREADY score below 60 are considered at risk for enrollment in the calculus courses.

A similar formula might be used to pre-screen chemistry students at Virginia Tech.

The students might also benefit from supplemental instruction where the material is reviewed and problems worked out in groups instead of help sessions where they need to come prepared with questions.

2) There is a strong positive correlation between students hour exam averages and their attendance in class.

In order to understand the 'attendance' problem, it is necessary to understand student attitudes. Almost all of these students come from high schools where the teachers have no direct power over the students. Even in cases of unfinished work, it is the parent who has to take the responsibility to see that the student completes it and turns it in. Thus when students first enter college, for the first time there is nobody looking over their shoulder telling them what to do. It is impossible to expect them to take responsibility for their actions overnight especially when they have never done so before. Even responsible students want to have 'fun' the first semester before they settle down. Thus it is important to foster helpful student attitudes during the first week or two of the semester. Ideally, this process should start at the high school level itself if not earlier.

III Student Attitudes

A survey was taken of 180 students out of a class of 500 regarding all aspects of college life including attendance (See Appendix A). This was an impromptu survey conducted on the last day of class and was done using no controlling factors. Following is an abbreviated questionnaire with student responses. An indepth interview was done with some of the student volunteers and their opinions have also been summarized below (See Appendix B).

Table VIII Survey Questions. All answers are in percentages.

Questions	none	1 to 3	4 to 6	7 to 10	11 or more
How many of the 36 lectures did you miss	15	46	17	9	6
How many of the 16 help sessions did you attend	46	26	14	7	1

1:Strongly agree 2:Agree 3:Disagree 4:Strongly disagree

Table IX Questionnaire Results

Questions	1	2	3	4
Correlation between attendance and grades	16	51	19	7
Policy of being questioned on topics discussed in class which are not in text.	34	42	10	7

Table X Questionnaire Results. Contd...

Questions	Yes	No
Are you in favor of unannounced quizzes	26	67
Do you want to be forced to study hard	63	28
If this was not a required course, would you have taken it	18	74

1:Bad 2:poor 3:fair 4:good 5:excellent

Table XI Questionnaire Results. Contd...

Questions	1	2	3	4	5
Pre-college chemistry preparation	13	18	29	27	7
How would you answer above in Aug 1992	8	13	30	30	11

1:much worse 2:somewhat worse 3:about the same

4:somewhat better 5:much better

Table XII Questionnaire Results. Contd...

Question	1	2	3	4	5
Your frequency of attendance for an eight A.M class	33	21	34	4	2

1:substantially increase 2:somewhat increase 3:about the same

4:somewhat decrease 5:substantially decrease 6:no opinion

Table XIII Questionnaire Results. Contd...

Looking back at your year of college, what would you have changed about your level of:	1	2	3	4	5	6
effort	22	50	19	2		
social life	10	24	53	6	1	
participation in campus clubs,sports etc.	12	32	47	2	1	
alcohol consumption	7	8	56	3	2	14

Table XIV Questionnaire Results. Contd...

In your opinion how should other freshmen change their level of:	1	2	3	4	5	6
effort	25	47	13	1	0	7
social life	3	7	39	26	4	12
participation in campus clubs,sports etc.	5	32	34	6	1	16
alcohol consumption	5	3	17	23	30	14

Summarizing, fiftyone percent agreed that there was a correlation between class attendance and their grade though sixtyseven percent did not like the unannounced quizzes as a way of forcing them to come to class.

On the whole the students were satisfied with their pre-college preparation though many admitted after taking the general chemistry course that it could have been better.

Timing of the course is very important. eight o'clock AM classes were not popular.

The majority of the students thought they should have worked harder though they would maintain their social life, extra curricular activities, and alcohol consumption at the same level.

On the other hand, with regard to their friends and peers, the majority of these students said that their friends should increase their level of effort while curbing their social life and alcohol consumption.

In addition to the survey, an indepth follow-up interview was conducted of 23 student volunteers from the class and some elaboration of the raw survey came from the follow-up phone survey (See Appendix B).

From the interviews, surprisingly, class size was not regarded as a problem factor for these students. Of course almost all of them were intimidated during their first week as freshmen, but as all of them were able to get hold of their professor easily and were provided with sufficient number of help sessions and office hours to clear their doubts, they did not consider the large classes as being detrimental to their performance in general chemistry.

All the students were unanimously in favor of computerized 'tutorials' and 'koofers' which they could access from their rooms.

All of the students were also unanimously against any mandatory attendance policies, and would rather be given pop quizzes as a means of forcing them to come to class and they suggested that it be held at the end of class, and on the same days lecture.

The majority of students also thought that the professor should force them to study harder. Therein lies part of the answer to the attitude problem. The students obviously do not understand responsibility until it is too late. Therefore at least for the first semester until they learn to take college life seriously, there should be some way of enforcing attendance and serious study. One way worth following up is by offering financial incentives such as refunding money spent on textbooks if the student gets an 'A' grade in the course.

IV. **Laboratory**

Graduate teaching assistants (GTAs), have the primary role of supervising and teaching the general chemistry laboratory classes. They also are responsible for assigning grades at the end of the semester. There are approximately 30 general chemistry GTAs funded by the department each semester. They are responsible for 3 or 4 laboratory sections consisting of 24 students each and serve resource room time[38].

They are provided with the following books to help them.

a. General Chemistry GTA Handbook

Since it is not possible to monitor every GTA during every laboratory, this book, published by the department, provides them with instructional information,policy and procedure guidelines to use in teaching the laboratory. This manual covers contingencies from their very first meeting and check in till the time they hand in the student grades.

Every experiment has a briefing which the GTA imparts to the students; the necessary transparencies are already prepared and available. This is followed by safety aspects, logistics, things to look out for and finally a note on how the student should perform the calculations and write the report.

The acceptable answers/data are also given so there is no room for doubt[27].

b. Experiments in General Chemistry

This is the student laboratory manual; and GTAs use this in conjunction with GTA handbooks. This manual, also published by the department contains detailed explanations of all the experiments the students will perform along with notes on how to write reports, how to do the calculations, safety aspects, etc. along with pre-laboratory questions which the students must answer before they come to class.

c. Handbook for Teaching Assistants.

Published by the Journal of Chemical Education, this document contains useful advice for the beginning teacher of chemistry laboratories- how to handle interactions with students, ethical matters, etc.

d. GTA Handbook

Published by Virginia Tech Graduate School, it contains useful information relating to campus-wide matters and policies at Virginia Tech.

e. Course Syllabus.

The course syllabus is a single page summary of the sequence of lecture and laboratory material to be covered during the semester. It also specifies the dates on which exams will be given in the laboratory classes. The

syllabus for each course is included in the GTA handbook and the laboratory manual.

f. Lecture course text : currently Chemistry, second edition, by Steven S. Zumdahl, published by D.C. Heath and company,Lexington MA.

g. Safety in Academic Chemistry Laboratories.

Published by the ACS, Laboratory safety is an important aspect of teaching in the general chemistry program. Safety indoctrination meetings are scheduled by the chemistry department.

Wishlist.

Even though the laboratories are running fairly well, there is always room for improvement.

The following are some suggestions which may be investigated for implementation during the construction of the new laboratories.

With five GTAs and 100 students in a laboratory, it is very difficult to hear the briefings. What is needed are 5 adjoining partitioned classrooms with seating capacity for 30 students on one side and equipment like blackboards, reference books, VCR and TV, audio players and computer work stations on the other to serve as the briefing room as well as the resource room. The briefing sessions by the Teaching Assistants could be eliminated and a VCR cassette shown in its stead. Doing this will

eliminate the problem most freshmen have of understanding foreign accents. Since most students finish early, they might be tempted to use the resource room to get help with post-laboratory questions right there or look up the 'koofers' or class problems on the computer. Instead of typing up formal reports, it would be easier on the students to adopt the carbonless notebooks adopted by the organic laboratories to eliminate writing the procedure twice.

One other major complaint of all students is that this course involves far too much work for one credit. Maybe a compromise could be worked at by assigning two credits for the course. It is also hoped that consistency from GTA to GTA is maintained and therefore, students have equal oppurtunity for fair grades.

Chapter IV

Conclusion

The importance of a good education is for students to develop a love of learning and to try to get them to pursue higher goals. To educate the students and to drag them up to a certain minimal level of achievement is not an insignificant task[39]. The process has to start at the high school level if not earlier.

Many high schools other than the 'schools for the gifted' suffer from lack of sufficiently qualified teachers and/or facilities and other equipment due to lack of finances. Moreover, not enough students are exposed to the sciences at the high school due to various levels of tracking. There are not sufficient staff development programs to encourage teachers to improve their competency. Many students consider the sciences and especially chemistry, boring and difficult to comprehend. Many students due to lack of facilities are not given the chance to work in the laboratories to learn the subject matter. There is no coordination between high shool teachers and college professors. This country also does not have a national curriculum with the result that students enter college with widely differing abilities.

There are commercialized institutions who have admission standards which depend on the students ability to pay rather than student potential thereby lowering the standards of higher education in this country. This eventually poses a problem for the industries who have to deal with mediocre workers who have insufficient knowledge about their subject matter.

Due to insufficient preparation at the pre-college level, many of these students do not understand the material and need remediation programs.

It is necessary to have sufficient faculty members who are dedicated to improving the quality of education and who find satisfaction in doing so. Unfortunately some of the major causes of faculty resentment are undercompensation compared with their colleagues in industry and their students apparent lack of interest and unwillingness to learn the subject matter

It is necessary for every department to maintain its standards and present a united front in spite of complaints from poor performers and hence should not admit any student into a course for which he/she is not qualified[39]. For the students to come in with the right attitude and a desire to perform well, it is necessary to put pressure on the students to do well.

From the survey conducted at Virginia Tech, it is evident that student performance is much more strongly influenced by their prior experiences rather than their experiences at college.

It is also evident that there is a correlation between attendance and grades and that those students who have a deire to perform well and come to class regularly do get good grades.

Class size was not considered to be a major problem though it was indicated that they wanted to be forced to study hard.

Motivated students found help sessions to be useful.

In addition to the many changes which are needed to combat the above stated problems it is also necessary to ensure that students accept responsibility for learning and approach it with the right attitude and spirit and put in serious effort in what they do so that they may be productive members of this society.

Bibliography

1. Tomorrow. The Report Of The Task Force For The Study Of Chemistry Education In The U.S ACS, Washington D.C (Oct 1984). **Eric Document 251 294.**

2. Alsalam,Ogle,Rogers and Smith. The Condition Of Education - 1992. **National Centre For Education Statistics.**

3. The Continuing Crisis In Science Education. The A.A.A.S responds. A report to the Board of Directors. (1986). **Eric Document 295 836.**

4. Entry Level Undergraduate Courses In Science And Mathematics: An Investment In Human Resources. Sigma Xi. **Eric Document ED 342 649.**

5. Gillespie, J. Ronald. (v68 n3 p192 Mar 1991) What Is Wrong With The General Chemistry Course. **Journal Of Chemical Education.**

6. ACS Committee On Professional Training 1989 Annual Report. (v68 n18 p29-35 2. Apr 30 1990) **Chemical and Engineering News.**

7. ACS Committee On Professional Training, 1992 Annual Report.(Aug 9, 1993). **Chemical and Engineering News.**

8. Snyder, D. Thomas. Digest Of Education Statistics - 1992. **National Centre For Education Statistics.**

9. Kreiger, James. (v67 n48 p54-55 Nov 27 1989) ACS Presents Science Report To Congress. **Chemical And Engineering News.**

10. Hirsch Jr, E.D. (April 18 '93). Don't ask Va. colleges to cater to the ill-prepared. **Roanoke Times and World News.**

11. Based on author's teaching experience and opinions of other teachers.

12. Rutherford. F,James. (v8 n2 p126-127 1988). STS perspectives: STS- Here Today And ....? **Bulletin Of Science ,Technology and Society.**

13. Worthy, War. (v67 n9 p4 Feb 27 1989). Scientific Literacy: Sweeping Changes In Teaching Urged. **Chemical and Engineering News.**

14. Educational Foundations For Tomorrows Information Scientist: A report From A.A.A.S. (v15 n5 p21 Jun-Jul 1989). **Bulletin Of The American Society For Information Science.**

15. Mara Sapon-Shevin. Gifted Education and the protection of Privelege: Breaking the silence, Opening the discourse 'Beyond Silenced Voices' State University of New York, Albany 1993.

16. Walker, Noojin. (v 59 n 6 June 1982). Assumptions about high school chemistry topics. **Journal Of Chem Edn.**

17. Zimelis,J. (v 58, p 488 1981) Assumptions About High School Chemistry Topics. **Journal Of Chemical Education.**

18. Shankar, Albert. (Dec 6 1992). Our Easy Schools. **New York Times.**

19. Dockweiler, C.J. Science Education Reform. Implications For Teacher Education. Conference Proceedings. (College Station Texas May 17-18 1991). **Eric Document 340 707.**

20. Science For All Americans: A Project Report On Literacy Goals In Science, Math and Technology. 1989 **Eric Document 309 059**

21. Koprowicz, Constance. Science Education In The States- A Survey. **Eric Document 347 087.**

22. Shankar, Albert. (Sun Nov 15 1992). U.S Colleges and Universities. **The New York Times.**

23. Welsh, Patrick. (Sun Apr 4 1993). Dear Warm Body... **The Washington Post.**

24. Shankar, Albert. (Apr 1993). Best By What Standards. **New Republic.**

25. Lundeberg, A. Mary. (v 27 n 2 pp 145-155 1990) Supplemental Instruction In Chemistry **Journal Of Research In Science Teaching.**

26. Brookhart, Victoria. (April 1991). School science as a rite of passage. **Eric Document 337355**

27. Fernandez, E.Jack. and Worrell, H. Jay. (v 68 n 7 July 1991). Meeting one challenge for the 90's. **Journal of Chemical Education.**

28. Wheately,W., McGinn,C., Gottstein,W., Whitehead,D., Durr, G. (v67 n8 p689(2) Aug 1990) Retired Chemists And The Small College Chemistry Department. **Journal Of Chemical Education.**

29. Paige, Harvey. (v59 n12 Dec 1982) Industrial Chemistry In The Classroom. **Journal Of Chemical Education.**

30. Haensel,Vladimir. (v59 n2 p96-97 Feb 1982) Catalysis: Significance In Industry And Relevance In Chemical Education. **Journal Of Chemical Education.**

31. Wagner, Betsy. and Bowermaster, David. (Nov. 1992). B.S. Economics. **The Washington Monthly.**

32. Cullotta, Elizabeth. (v250 n4986 p 1327-30 Dec 7 1990). Can Science Education Be Saved ? **Science.**

33. Boyd, Vivian; and others. (86) Audio-Tutorial tapes as aids to college chemistry Pre-registrants: A pilot study. **Eric Document 278 936**

34. Foley, A. James, and K. Robert. (69) The College Scene Students tell it like it is Cowles Book Company

35. Miller, Harlan. (May 6 1993) Spring of discontent. **Spectrum.** (a faculty-staff tabloid of VPISU)

36. An Exploration Of The Nature And Quality Of Undergraduate Education In Science,Math and Engineering. A report Of The National Advisory Group Of Sigma Xi, The Scientific Literacy Society. Jan 23-26 1989. **Eric Document ED 318634.**

37. Beasely, F.Warren. (v69 n1 Jan 1992) The Unbalanced Chemical Equation. **Journal Of Chemical Education.**

38. Glanville, O. James,Russell, A.Robert,Staskun, G.Mina (v68 n2 Feb 1991) Do The Students Think We Are Running The General Chemistry Laboratories Better? **Journal Of Chemical Education.**

39. Shankar, Albert. (Aug 8 1993). Students As Customers. **New York Times.**

Appendix A

Survey Questionnaire

Virginia Tech -- Student Perceptions of Instruction 04/28/93

Jim Glanville, Chemistry Course number 1036, Index number 0818

In addition to the standard list of questions in the left hand column of the "Student Perceptions of Instruction" form I and Ms. Gita Srinivasan are interested in your answers to the following list of questions. Darken the circle of your answer in Supplementary Questions List 1.

If you would be willing and interested to participate in a more detailed follow-up survey conducted by Ms. Srinivasan over the summer please leave her information about how you can be reached during June and July. State whether you will respond to a questionnaire, respond to a telephone interview, or both.

1. Not counting exam days and snow days I gave 36 lectures this semester. How many did you miss?

   1. none 2. 1 to 3 3. 4 to 6 4. 7 - 10 5. 11 or more

2. So far this semester I have offered 16 formal (scheduled) help sessions. How many did you attend?

   1. none 2. 1 to 3 3. 4 to 6 4. 7 - 10 5. 11 or more

3. There is a strong correlation between a student's class attendence and the average test and exam score that student achieves. Do you?

   1. strongly agree 2. agree 3. disagree 4. strongly disagree

4. I try to encourage students to come to class by asking questions (such as the one about arsenic poisoning in China) that will only be known by students who attended the lecture in which the topic was discussed. How do you feel about this policy?

   1. strongly agree 2. agree 3. disagree 4. strongly disagree

5. This semester, several students have told me that they would like to have had unannounced quizzes because such quizzes "force" them to come to class. Are you such a student?

   1. yes 2. no

6. How would you now characterize your pre-college chemistry preparation?

   1. bad 2. poor 3. fair 4. good 5. excellent

7. How would you have answered the previous question in August of 1992?

   1. bad 2. poor 3. fair 4. good 5. excellent

8. If I had taught this course same course at 8:00 am what would have happened to your frequency of attendence?

   1. much worse 2. somewhat worse 3. about the same
   4. somewhat better 5. much better

9. If this course was not required by your major would you have taken it anyway?

   1. yes 2. no

10. Looking now back at your year of college, what in retrospect would you change about your level of effort

    1. substantially increase 2. somewhat increase 3. about the same
    4. somewhat decrease 5. substantially decrease

11. Looking now back at your year of college, what in retrospect would you change about your level of social life

    1. substantially increase 2. somewhat increase 3. about the same
    4. somewhat decrease 5. substantially decrease

12. Looking now back at your year of college, what in retrospect would you change about your level of participation in campus clubs, sports, and similar activities

    1. substantially increase 2. somewhat increase 3. about the same
    4. somewhat decrease 5. substantially decrease

13. Looking now back at your year of college, what in retrospect would you change about your level of alcohol consumption

    1. substantially increase 2. somewhat increase 3. about the same
    4. somewhat decrease 5. substantially decrease 6. no opinion

14. If I try to force you to study hard I am

    1. doing you a favor 2. not doing you a favor

15. In your opinion how should freshman students at Virginia Tech (not you personally) change their level of effort

    1. substantially increase 2. somewhat increase 3. about the same
    4. somewhat decrease 5. substantially decrease 6. no opinion

16. In your opinion how should freshman students at Virginia Tech (not you personally) change their level of social life

    1. substantially increase 2. somewhat increase 3. about the same
    4. somewhat decrease 5. substantially decrease 6. no opinion

17. In your opinion how should freshman students at Virginia Tech (not you personally) change their level of participation in campus clubs, sports, and similar activities

    1. substantially increase 2. somewhat increase 3. about the same
    4. somewhat decrease 5. substantially decrease 6. no opinion

18. In your opinion how should freshman students at Virginia Tech (not you personally) change their level of alcohol consumption

    1. substantially increase 2. somewhat increase 3. about the same
    4. somewhat decrease 5. substantially decrease 6. no opinion

Appendix B

Followup Telephone Interview

The follow up informal telephone interview was conducted with 23 student volunteers whose average grade for the course was a "C". This survey does have its limitations in the fact that it was not done using any kind of controlling factors and only a very small section of the student population was interviewed. The main purpose of this interview was to understand student perceptions of the course in more detail. Given below is a list of questions asked.

1) What was your grade for the course?

2) Describe your high school chemistry course. Do you feel that it prepared you sufficiently for college?

3) What was your overall impression of the general chemistry course?

4) Were you intimidated by the large class size?

5) How many chemistry classes did you miss during the semester and for what reasons?

6) Did you go to any of the help sessions why/why not?

7) Were you prompt in doing your homework and reading assignments?

8) Was your professor easily available to you when you had problems with the subject matter?

9) Do you feel that there is a correlation between attendance and grades?

10) How do you feel about mandatory attendance as a way of forcing students to come to class regularly?

11) How often did you go to the resource room for help ?

12) Did you use 'koofers' to study for exams and did you have any trouble obtaining them?

13) What are some improvements you would like to see as far as improving the course ? examples : supplemental instruction, computer tutorials, etc.

14) Was your experience in the laboratory a pleasant one?

15) Did you face any problems with peer pressure outside the classroom with regards to alcohol consumption, partying etc.?