

## CHEM TIPS

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### *Individualized instruction in undergraduate chemistry courses*

This paper describes a functional management system to individualize instruction in undergraduate chemistry courses. CHEM TIPS (*Chemistry Teaching Information Processing System*)<sup>1</sup> is designed to monitor each student's progress, to identify specific weaknesses and strengths in his understanding of course material, and to prescribe individual study assignments. One of the main objectives of CHEM TIPS is to obtain student feedback and to use it as a guide in modifying, if necessary, teaching strategies and efforts.

Seemingly contradictory statements are often made by students on course evaluation questionnaires

The professor is covering too much too fast. I'm confused.

The professor is going too slow. I'm bored.

If only the treatment of chemical bonding were more math oriented, I'd learn more.

The mathematical treatment of chemical bonding is clearly designed to add to my confusion.

The nuclear chemistry assignment was largely a waste of time, especially the first part, which was all busy work.

The nuclear chemistry assignment was largely a waste of time, especially the second part, which was all busy work.

These conflicting remarks stem from the professor's inability to individualize instruction in classes with about 25 or more students. The usual 2-4 examinations a semester are the best available indicators of class and individual student progress, yet they are not very useful from a teaching viewpoint. Examinations are concluding devices for segments of the course and provide summative evaluations as to whether or not students have "learned" the covered material. The pace of most courses usually does not allow those who did not do well on an examination to remedy their deficiencies. The course simply moves on to another unit. However, basic concepts and skills that may be missed are often the foundations upon which subsequent topics are based. For example, if a student has a poor grasp of stoichiometry he will likely have great difficulties learning equilibrium principles and their applications.

CHEM TIPS has been used in both semesters of a two-semester introductory course with an enrollment of about 1400 students, the vast majority of whom are not chemistry majors. They are assigned to lecture sections of about 350 students taught by professors and also assigned to discussion-laboratory sections of 22 taught by graduate teaching assistants. Typically, the teaching assistant (TA) is in charge of two sections. The weekly course format is: two lectures, two discussions, and a laboratory period of two or three hours. An outline of the course content is shown in Table 1. No high school chemistry is assumed; however, about 80% of the students have had some chemistry in high school. The laboratory work is well integrated with the lecture material. Each semester there are three hour examina-

Table 1. Topics in Introductory Course<sup>a</sup>

First Semester	
1	Stoichiometry and the Mole Concept (4)
2	Thermochemical Changes (2)
3	Gases and the Kinetic Molecular Theory (2)
4	Liquids and Solutions (4)
5	Electronic Structure of Atoms (3)
6	Chemical Bonding and Geometric Structure (4)
7	Chemistry of the Halogens (1)
8	Chemical Equilibrium (6)
Second Semester	
1	Ionic Equilibria, continued (2)
2	Coordination Compounds (3)
3	Electrochemistry (3)
4	Chemical Kinetics (3)
5	Nuclear Chemistry (3)
6	Chemistry of Carbon Compounds (9)
7	Biochemistry (3)

<sup>a</sup> The number of lectures devoted to each topic is shown in parentheses.

tions and a two-hour final examination given by each lecture professor and 8-12 short quizzes given by teaching assistants.

#### How and What CHEM TIPS Does

Through CHEM TIPS diagnostic or formative evaluations of the instructional program are made on a weekly basis. During the last 10-15 minutes of the second lecture of the week students take a short (5-12 questions) multiple-choice "survey" aimed to measure their grasp of current course content. The CHEM TIPS survey is optional and is not called a quiz since it does not form part of the student's grade. The surveys are scored and processed via a computer and the responses are measured against "decision rules" established by the professor. The "decision rules" are set when the professor selects the chemical concepts to be surveyed and writes the specific questions which will measure the student's knowledge of these concepts. While preparing the survey, the professor carefully selects incorrect responses to each question to anticipate student mistakes or misunderstandings. This is an essential task since remedial assignments are made on the basis of the student's responses to each question or group of related questions.

Figure 1 shows a sample survey administered recently in the first semester course. Within a few hours, typically two to three, after the survey is administered, individual Student Reports are generated on 8 1/2 x 11 paper along with Section Reports for the teaching assistants and a Class Report for the professor. The Student Reports are placed in a special box near the chemistry laboratory where they can be picked up at the student's convenience. The Student Report provides specific assignments and messages based on each student's performance. Those who opt not to take a survey also receive a Student Report which includes a summary of all assignments and appropriate messages. Figures 2, 3, and 4 show typical Student Reports. The Section Report and Class Report contain breakdowns of responses and a list of assignments for each student as shown in Figures 5 and 6. The teaching assistant report (Section Report) contains information to help him appraise the perfor-

<sup>1</sup> TIPS was originally developed and researched by Professor Allen C. Kelley, Department of Economics, Duke University. CHEM TIPS was first adapted and implemented in 1972 in a freshman chemistry course at the University of Wisconsin—Madison.



Name \_\_\_\_\_  
Last First

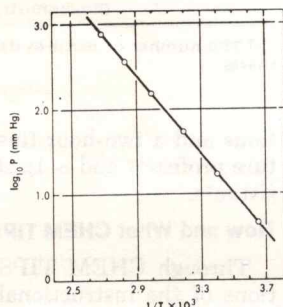
VAPOR PRESSURE AND SOLUBILITY

I.D. # \_\_\_\_\_

INSTRUCTIONS: Be certain to PRINT your name and all ten digits of your I.D. # legibly in the blanks provided. Go through the survey marking your responses. Then go back and circle the number of the one answer you have selected for each question in the box provided at the right. Only those answers which are marked in the box will be accepted!

CIRCLE YOUR ANSWERS HERE	
(1)	1 2 3 4
(2)	1 2 3 4
(3)	1 2 3 4
(4)	1 2 3 4
(5)	1 2 3 4
(6)	1 2 3 4
(7)	1 2 3 4
(8)	1 2 3 4
(9)	1 2 3 4
(10)	1 2 3 4

- One mole of  $H_2O(l)$  is placed in a 100 ml flask at 298°K and eventually a constant pressure of 24 torr is established. If a 200 ml flask were used instead, the final pressure would be:
  - 12 torr
  - 48 torr
  - 24 torr
  - 760 torr
- Which of the following substances has the highest vapor pressure at room temperature?
  - $H_2O$ , b.p. 100°C
  - Ether, b.p. 35°C
  - Ethyl alcohol, b.p. 79°C
  - Acetone, b.p. 57°C
- When a solid melts to a liquid
  - the container warms up.
  - the molecules become more randomly oriented.
  - the molecules become less randomly oriented.
  - the intermolecular forces become stronger.
- A solution contains 39 grams of benzene (GMW = 78) and 61 grams of toluene (GMW = 92); the mole fraction of benzene is
  - 0.39
  - 0.50
  - 0.61
  - 0.43



- Consider the plot shown here for water. The equation for this plot is:
 
$$\log P = \frac{-\Delta H_{vap}}{2.3RT} + B$$
 The heat of vaporization is
  - obtained by finding antilog P
  - equal to B
  - obtained from the slope of log P vs. 1/T
  - impossible to obtain from such a plot
- To prepare a 0.02M HCl solution one should
  - dilute 10 ml of 1.0M HCl to 100 ml
  - dilute 10 ml of 2.0M HCl to 100 ml
  - dilute 20 ml of 0.1M HCl to 100 ml
  - dissolve 0.2 moles of HCl in one liter of  $H_2O$
- A solution of a nonvolatile solute
  - freezes at a higher temperature than the pure solvent.
  - boils at the same temperature as the solvent.
  - boils at a higher temperature than the pure solvent.
  - boils at a lower temperature than the pure solvent.
- Which of the following has the lowest vapor pressure at 100°C.
  - pure  $H_2O$
  - 0.2M HCl solution
  - 0.2M  $MgSO_4$  solution
  - 0.2M  $Na_3PO_4$  solution
- How many grams of sodium chloride (GMW = 58) should be added to 10 Kg of water to prevent freezing at -8°C (for water  $k_f = 1.86^\circ C \cdot m^{-1}$ )
  - $1.3 \times 10^3$  grams
  - $5.8 \times 10^3$  grams
  - $1.86 \times 10^3$  gram
  - $4.3 \times 10^3$  grams
- The solubility of oxygen gas in water
  - increases with increasing temperature.
  - increases with decreasing temperature.
  - does not depend on temperature.
  - decreases with decreasing temperature.

Figure 1. Sample survey.

mance of his two individual sections by individual questions or groups of questions and to enable him to vary the way in which he handles each section. For example, in one section he may emphasize the application of the Kinetic Molecular Theory (low section scores on questions 3 and 10 on Survey #4); while in the other section, he may spend more time on Properties of Solutions (low section scores on 7, 8, and 9 on Survey #4). The Class Report gives the professor the same type of information for the entire class. Since the objective of CHEM TIPS is to obtain student feedback as a teaching aid, this information is not used as a basis for grading. Individual student scores are usually not

YOU SCORED X XXXXX XXXXX XX---/ ON THIS SURVEY  
X X X X X X X  
X X X X X  
X X X X X  
X X X X X  
X XXXXX XXXXX /---XX

FOR YOUR RECORDS, THE CORRECT ANSWERS FOR THE 10 QUESTIONS ON THIS SURVEY ARE 3 2 2 4 3 3 3 4 1 2.

YOUR CHEM TIPS PERFORMANCE INDICATES THAT YOU HAVE SUFFICIENT KNOWLEDGE OF BASIC CONCEPTS. HOWEVER, THIS HIGH ACHIEVEMENT SHOULD NOT BE CONSIDERED AS A MEASURE OF YOUR ULTIMATE SUCCESS IN THE COURSE. MAKE SURE THAT YOU KEEP UP WITH THE ASSIGNED COURSE WORK.

BULL SESSION

YOU ARE INVITED TO COME TO AN INFORMAL MEETING WITH YOUR LECTURE PROFESSOR ON THURSDAY, OCTOBER 10 FROM 7:30-10:00 PM IN THE FACULTY-ALUMNI LOUNGE (ROOM 9340). REFRESHMENTS WILL BE SERVED.

Figure 2. Sample student report I.

YOU CORRECTLY ANSWERED 7 OUT OF 10 QUESTIONS ON THIS SURVEY. THE FOLLOWING TABLE SUMMARIZES YOUR ANSWERS AS WELL AS THE CORRECT ANSWERS FOR THIS SURVEY. YOU ARE URGED TO MAKE SURE THAT YOU UNDERSTAND THE NATURE OF ANY INCORRECT RESPONSES WHICH YOU MADE.

TABLE OF RESPONSES

QUES. NUMB.	YOUR ANSW.	CORR. ANSW.	QUES. NUMB.	YOUR ANSW.	CORR. ANSW.	QUES. NUMB.	YOUR ANSW.	CORR. ANSW.
1.	3	3	5.	3	3	9.	2	1
2.	2	2	6.	3	3	10.	3	2
3.	2	2	7.	3	3			
4.	3	4	8.	4	4			

CONCENTRATION CALCULATIONS (QUESTIONS 4,6)

YOU NEED MORE DRILL WITH CONCENTRATION UNITS. GO TO THE FRESHMAN CHEMISTRY STUDY ROOM (1321) AND USE THE AUDIO-TAPE ENTITLED 'CONCENTRATION UNITS'. ALSO, RESTUDY P. 265-268 IN M&S.

KINETIC MOLECULAR THEORY (QUESTIONS 3,10)

YOU SHOULD BE ABLE TO APPLY THE KINETIC MOLECULAR THEORY TO ALL PHASES OF MATTER: GASES, LIQUIDS AND SOLIDS. REMEMBER THAT THE AVERAGE KINETIC ENERGY OF MOLECULES IS DIRECTLY PROPORTIONAL TO THE TEMPERATURE. RESTUDY P. 273-274 IN M&S.

PROPERTIES OF SOLUTIONS (QUESTIONS 7,8,9)

YOU SHOULD UNDERSTAND THE EFFECT OF NON-VOLATILE SOLUTES ON THE PROPERTIES OF SOLVENTS: SOLUTES LOWER THE VAPOR PRESSURE OF SOLVENTS AND RESULT IN LOWERING THE FREEZING POINT AND RAISING THE BOILING POINT OF THE SOLUTION. THE CHANGE IN TEMPERATURE,  $\Delta T$ , IS RELATED TO THE MOLALITY OF THE SOLUTION. STUDY P. 276-281 IN M&S. GO TO THE FRESHMAN CHEMISTRY STUDY ROOM (1321) AND USE THE AUDIO-TAPE ENTITLED 'COLLIGATIVE PROPERTIES'.

SPECIAL MESSAGE

YOU SCORED BELOW 60 ON THE FIRST HOUR EXAMINATION. THIS PERFORMANCE IS NOT INDICATIVE OF SATISFACTORY PROGRESS, YET YOU STILL HAVE MANY OPPORTUNITIES TO IMPROVE YOUR STANDING IN THE COURSE.

A SPECIAL HELP SESSION WILL BE HELD AT 1:20 P.M., FRIDAY, OCTOBER 4 IN ROOM 1351. DURING THIS SPECIAL SESSION I WILL ANSWER QUESTIONS AND GO OVER CONCEPTS THAT YOU ARE HAVING DIFFICULTIES WITH. PLEASE ATTEND AND COME PREPARED WITH QUESTIONS ABOUT WHAT IS COVERED IN MODULES 1,2,3, AND 4.

BULL SESSION

YOU ARE INVITED TO COME TO AN INFORMAL MEETING WITH YOUR LECTURE PROFESSOR ON THURSDAY, OCTOBER 10 FROM 7:30-10:00 PM IN THE FACULTY-ALUMNI LOUNGE (ROOM 9340). REFRESHMENTS WILL BE SERVED.

Figure 3. Sample student report II.

available either to the professor or to the teaching assistant. Rather, individual information is revealed through the nature of the student's assignment.

After the professor and TA's have received their Reports, these are then analyzed and discussed in staff meetings to discover the students' weaknesses and strengths and to make any alterations in the current teaching plan. By using CHEM TIPS information, the professor and TA's can use lecture and discussion time more effectively. Less time will be spent on chemical concepts which are understood well, while those that are unclear will be stressed.

For students having difficulties which individualized assignments cannot eliminate, special help sessions are arranged (see special message H on the Section Report). Stu-



MY RECORDS INDICATE THAT YOU DID NOT TAKE THIS SURVEY ON 10/2/74. AS A RESULT, AT THIS TIME I DO NOT HAVE ANY INDICATION OF YOUR UNDERSTANDING OF THE MATERIAL COVERED BY THIS SURVEY. IN THESE SITUATIONS, I ASSIGN A PROBLEM SET WHICH ASSURES ME THAT YOU ARE FAMILIAR WITH THE MINIMUM TOOLS REQUIRED TO MASTER THIS ASPECT OF CHEMISTRY 103. THIS ASSIGNMENT IS A MEANS OF ENSURING THAT I HAVE PROVIDED YOU WITH THE TOOLS NECESSARY TO MASTER MORE ADVANCED CONCEPTS.

CONCENTRATION CALCULATIONS (QUESTIONS 4,6)  
 YOU NEED MORE DRILL WITH CONCENTRATION UNITS. GO TO THE FRESHMAN CHEMISTRY STUDY ROOM (1321) AND USE THE AUDIO-TAPE ENTITLED 'CONCENTRATION UNITS'. ALSO, RESTUDY P. 265-268 IN M&S.

KINETIC MOLECULAR THEORY (QUESTIONS 3,10)  
 YOU SHOULD BE ABLE TO APPLY THE KINETIC MOLECULAR THEORY TO ALL PHASES OF MATTER: GASES, LIQUIDS AND SOLIDS. REMEMBER THAT THE AVERAGE KINETIC ENERGY OF MOLECULES IS DIRECTLY PROPORTIONAL TO THE TEMPERATURE. RESTUDY P. 271-274 IN M&S.

VAPOR PRESSURE (QUESTIONS 1,2,5)  
 YOU SHOULD KNOW WHAT IS MEANT BY 'VAPOR PRESSURE'. RESTUDY P. 235-241 IN M&S AND DO PROBLEMS 27 AND 29 ON PAGE 259. THE RELATIONSHIP BETWEEN VAPOR PRESSURE AND TEMPERATURE IS IMPORTANT AS IS THE DEFINITION OF BOILING POINT.

Figure 4. Sample student report III.

10/02/74	TEACHING ASSISTANT SUMMARY OF STUDENT PERFORMANCE CHEMISTRY 103 - PROFESSOR BASSAM SHAKHASHIRI SURVEY #4 - OCTOBER 2, 1974	PAGE 1
TA: MR. ESSENMACHER		
SECTION # AND TIME: 609, 2:25 TR		
NUMBER OF STUDENTS	22	290
NUMBER TAKING SURVEY #4, VAPOR PRESSURE & SOLUBILITY	18	254

TABLE OF AVERAGE SCORES		
	AVERAGE SAMPLE (N=18)	PCT. CORRECT CLASS (N=254)
G154 -- SURVEY #4, ALL 10 QUESTIONS	37.2	40.8
G176 -- QUESTIONS 4,6( CONC. CALCS)	41.7	38.0
G177 -- QUESTIONS 3,10(KINETIC MOL. THEORY)	52.8	56.7
G178 -- QUESTIONS 1,2,5(VAPOR PRESSURE)	37.0	43.7
G179 -- QUESTIONS 7,8,9( PROPERTIES OF SOL'NS)	24.1	29.1

ITEM ANALYSIS TABLE									
NO.	ANS.	PERCENT CORRECT		PERCENT IN SAMPLE SELECTING ALTERNATIVE RESPONSES *					
		SAMPLE (N=18)	CLASS (N=254)	1	2	3	4	5	NO RESP.
1	3	5	20	61	22	5	0	0	11
2	2	38	48	38	38	5	0	0	16
3	2	77	76	11	77	0	11	0	0
4	4	38	35	16	27	5	38	0	11
5	3	66	62	16	0	66	5	0	11
6	3	44	40	0	33	44	16	0	5
7	3	38	57	0	11	38	22	0	27
8	4	11	17	44	5	16	11	0	22
9	1	22	12	22	11	11	5	0	50
10	2	27	36	33	27	22	0	0	16

STUDENT NAME		MESSAGES							
		A	B	C	D	E	F	G	H
1	GOODSPEED, MARYBETH	***	***	***	***	***	***	***	***
2	GOSSE, DEBORAH ANN	***	***	***	***	***	***	***	***
3	GRYBOSKI, ANNE E	NO	YES	YES	YES	YES	YES	YES	NO
4	HANSEN, CATHRYN	NO	YES	YES	NO	YES	YES	YES	YES
5	HINTZ, MAX	NO	YES	YES	YES	YES	YES	YES	NO
6	JERRED, TODD R	NO	YES	NO	NO	YES	YES	YES	NO
7	JOHNSON, JOY	NO	YES	YES	NO	YES	YES	YES	NO
8	KEYS, KAREN ANNE	NO	YES	NO	YES	YES	YES	NO	YES
9	KOOPMAN, EDITH	NO	YES	NO	YES	YES	YES	NO	YES
10	KORTH, EVE MARIE	***	***	***	***	***	***	***	***
11	KROMBACH, ANDREW T	NO	YES	YES	NO	YES	YES	YES	NO
12	KUNDERT, KAY	NO	YES	YES	YES	NO	YES	NO	YES
13	LAIB, BARBARA ANN	NO	YES	YES	YES	YES	YES	YES	NO
14	LARSON, MARY ELLEN	NO	YES	YES	YES	YES	YES	YES	NO
15	LINDSTROM, CHERYL	NO	YES	YES	YES	YES	YES	YES	NO
16	LOPEZ, JUAN R	NO	YES	YES	YES	YES	YES	YES	YES
17	LOWNIK, STEVEN JAMES	NO	YES	YES	YES	YES	YES	YES	NO
18	LUBOTSKY, THOMAS	NO	YES	YES	YES	YES	YES	YES	NO
19	MUNDI, LINDA ELAINE	NO	YES	YES	YES	YES	YES	YES	NO
20	PENROSE, PATRICIA	NO	YES	YES	YES	YES	YES	YES	YES
21	PFEIFFER, PATRICIA K	NO	YES	YES	YES	YES	YES	YES	NO
22	SIMON, MARK ALLAN	***	***	***	***	***	***	***	***

\*\*\* DID NOT RECEIVE STUDENT REPORT #4

15 STUDENTS MET THE FOLLOWING CRITERIA:

G176 FROM 0 THROUGH 1

AND THEREFORE RECEIVED MESSAGE C:

CONCENTRATION CALCULATIONS  
 YOU NEED MORE DRILL WITH CONCENTRATION UNITS. GO TO THE FRESHMAN CHEMISTRY STUDY ROOM (1321) AND USE THE AUDIO-TAPE ENTITLED 'CONCENTRATION UNITS'. ALSO, RESTUDY P. 265-268 IN M&S.

14 STUDENTS MET THE FOLLOWING CRITERIA:

G177 FROM 0 THROUGH 1

Figure 5. Sample section report.

PROPERTIES OF SOLUTIONS (QUESTIONS 7,8,9)  
 YOU SHOULD UNDERSTAND THE EFFECT OF NON-VOLATILE SOLUTES ON THE PROPERTIES OF SOLVENTS. SOLUTES LOWER THE VAPOR PRESSURE OF SOLVENTS AND RESULT IN LOWERING THE FREEZING POINT AND RAISING THE BOILING POINT OF THE SOLUTION. THE CHANGE IN TEMPERATURE, DELTA T, IS RELATED TO THE MOLALITY OF THE SOLUTION. STUDY P. 276-281 IN M&S. GO TO THE FRESHMAN CHEMISTRY STUDY ROOM (1321) AND USE THE AUDIO-TAPE ENTITLED 'COLLIGATIVE PROPERTIES'.

EXTRA HELP AVAILABLE  
 THE FRESHMAN CHEMISTRY STUDY ROOM (1321) IS OPEN MTWR 9:55-4:30 AND F 9:55-NOON. THE AVAILABLE RESOURCES (AUDIO-TAPES, LECTURE NOTES, PROBLEM BOOKS, ETC.) SHOULD HELP YOU IMPROVE YOUR PERFORMANCE IN THIS COURSE.

MORE HELP AVAILABLE  
 FREE TUTORING IS AVAILABLE TUESDAYS AND WEDNESDAYS, 7-9 PM, FROM THE PROFESSIONAL CHEMISTRY FRATERNITY (ALPHA CHI SIGMA), 619 NORTH LAKE STREET. CALL 255-1102 ONE DAY IN ADVANCE FOR AN APPOINTMENT.

BULL SESSION  
 YOU ARE INVITED TO COME TO AN INFORMAL MEETING WITH YOUR LECTURE PROFESSOR ON THURSDAY, OCTOBER 10 FROM 7:30-10:00 PM IN THE FACULTY-ALUMNI LOUNGE (ROOM 9340). REFRESHMENTS WILL BE SERVED.

AND THEREFORE RECEIVED MESSAGE D:

KINETIC MOLECULAR THEORY  
 YOU SHOULD BE ABLE TO APPLY THE KINETIC MOLECULAR THEORY TO ALL PHASES OF MATTER: GASES, LIQUIDS AND SOLIDS. REMEMBER THAT THE AVERAGE KINETIC ENERGY OF MOLECULES IS DIRECTLY PROPORTIONAL TO THE TEMPERATURE. RESTUDY P. 271-274 IN M&S.

17 STUDENTS MET THE FOLLOWING CRITERIA:

G178 FROM 0 THROUGH 2

AND THEREFORE RECEIVED MESSAGE E:

VAPOR PRESSURE  
 YOU SHOULD KNOW WHAT IS MEANT BY 'VAPOR PRESSURE'. RESTUDY P. 235-241 IN M&S AND DO PROBLEMS 27 AND 29 ON PAGE 259. THE RELATIONSHIP BETWEEN VAPOR PRESSURE AND TEMPERATURE IS IMPORTANT AS IS THE DEFINITION OF BOILING POINT.

18 STUDENTS MET THE FOLLOWING CRITERIA:

G179 FROM 0 THROUGH 2

AND THEREFORE RECEIVED MESSAGE F:

PROPERTIES OF SOLUTIONS  
 YOU SHOULD UNDERSTAND THE EFFECT OF NON-VOLATILE SOLUTES ON THE PROPERTIES OF SOLVENTS. SOLUTES LOWER THE VAPOR PRESSURE OF SOLVENTS AND RESULT IN LOWERING THE FREEZING POINT AND RAISING THE BOILING POINT. THE CHANGE IN TEMPERATURE, DELTA T, IS RELATED TO THE MOLALITY OF THE SOLUTION. STUDY P. 276-281 IN M&S. GO TO THE FRESHMAN CHEMISTRY STUDY ROOM (1321) AND USE THE AUDIO-TAPE ENTITLED 'COLLIGATIVE PROPERTIES'.

15 STUDENTS MET THE FOLLOWING CRITERIA:

G154 FROM 0 THROUGH 5

AND THEREFORE RECEIVED MESSAGE G:

EXTRA HELP AVAILABLE  
 THE FRESHMAN CHEMISTRY STUDY ROOM (1321) IS OPEN MTWR 9:55-4:30 AND F 9:55-NOON. THE AVAILABLE RESOURCES (AUDIO-TAPES, LECTURE NOTES, PROBLEM BOOKS, ETC.) SHOULD HELP YOU IMPROVE YOUR PERFORMANCE IN THIS COURSE.

MORE HELP AVAILABLE  
 FREE TUTORING IS AVAILABLE TUESDAYS AND WEDNESDAYS, 7-9 PM, FROM THE PROFESSIONAL CHEMISTRY FRATERNITY (ALPHA CHI SIGMA), 619 NORTH LAKE STREET. CALL 255-1102 ONE DAY IN ADVANCE FOR AN APPOINTMENT.

6 STUDENTS MET THE FOLLOWING CRITERIA:

G161: EXAM 1 SCORE LESS THAN 60

AND THEREFORE RECEIVED MESSAGE H:

SPECIAL MESSAGE  
 YOU SCORED BELOW 60 ON THE FIRST HOUR EXAMINATION. THIS PERFORMANCE IS NOT INDICATIVE OF SATISFACTORY PROGRESS, YET YOU STILL HAVE MANY OPPORTUNITIES TO IMPROVE YOUR STANDING IN THE COURSE.

A SPECIAL HELP SESSION WILL BE HELD AT 1:20 PM, FRIDAY, OCTOBER 4 IN ROOM 1351. DURING THIS SPECIAL SESSION I WILL ANSWER QUESTIONS AND GO OVER CONCEPTS THAT YOU ARE HAVING DIFFICULTIES WITH. PLEASE ATTEND AND COME PREPARED WITH QUESTIONS ABOUT WHAT IS COVERED IN MODULES 1,2,3, AND 4.

18 STUDENTS MET THE FOLLOWING CRITERIA:

G154 FROM 0 THROUGH 10

AND THEREFORE RECEIVED MESSAGE I:

BULL SESSION  
 YOU ARE INVITED TO COME TO AN INFORMAL MEETING WITH YOUR LECTURE PROFESSOR ON THURSDAY, OCTOBER 10 FROM 7:30-10:00 PM IN THE FACULTY-ALUMNI LOUNGE (ROOM 9340). REFRESHMENTS WILL BE SERVED.



PROFESSOR SUMMARY OF CLASS PERFORMANCE  
CHEMISTRY 103 - PROFESSOR BASSAM SHAKHASHIRI

SURVEY #4 - GIVEN 10/02/74

	CLASS
NUMBER OF STUDENTS	290
NUMBER TAKING SURVEY #4, VAPOR PRESSURE & SOLUBILITY	254

TABLE OF AVERAGE SCORES

	AVERAGE PCT. CORRECT
	CLASS (N=254)
G154 -- SURVEY #4, ALL 10 QUESTIONS	40.8
G176 -- QUESTIONS 4,6 (CONC CALCS)	38.0
G177 -- QUESTIONS 3,10 (KINETIC MOL. THEORY)	56.7
G178 -- QUESTIONS 1,2,5 (VAPOR PRESSURE)	43.7
G179 -- QUESTIONS 7,8,9 (PROPERTIES OF SOL'NS)	29.1

ITEM ANALYSIS TABLE

NO.	ANS.	PERCENT CORRECT	PERCENT IN CLASS SELECTING ALTERNATIVE RESPONSES					
			1	2	3	4	5	NO RESP.
CLASS (N=254)								
1	3	20	59	17	20	0	0	3
2	2	48	44	48	2	1	0	3
3	2	76	5	76	11	4	0	1
4	4	35	22	24	12	35	0	4
5	3	62	13	5	62	10	0	6
6	3	40	2	29	40	20	0	7
7	3	57	7	11	57	17	0	5
8	4	17	35	13	18	17	0	15
9	1	12	12	24	18	17	0	26
10	2	36	34	36	13	9	0	5

Figure 6. Class report for survey #4.

dents who understand the material well are invited to participate in optional enrichment programs such as special lectures on advanced topics or group discussions of environmental and societal questions relating to chemistry. Sample enrichment messages are shown in Figure 7.

#### Preliminary Assessment of Effectiveness

CHEM TIPS is now in its third year. Several professors have adopted it for use in undergraduate courses here at Wisconsin and elsewhere.<sup>2</sup> Each professor writes his own questions, decision rules, and messages to fit his instructional objectives and style. The impact of utilizing the CHEM TIPS approach is currently under scrutiny by each user. The general impression of the University of Wisconsin users is one of satisfaction with the frequent feedback on student progress.

On the Madison Campus a systematic study of the effectiveness of CHEM TIPS and other instructional aids has begun. During the 1973-74 Spring Semester four lecture sections of the second semester course were taught by three different lecturers, all of whom used CHEM TIPS. One lecturer was responsible for two lecture sections. He used CHEM TIPS in one section which was designated the "Experimental Group;" but not in the other which was designated the "Control Group." The Experimental and Control Groups took the same examinations.

A questionnaire was distributed halfway through the semester to the Experimental and Control Groups in an attempt to obtain student response to CHEM TIPS. Common questions were asked of both groups although additional questions pertaining to CHEM TIPS were asked of the Experimental Group only. One noteworthy result con-

YOUR PERFORMANCE ON THIS WEEK'S CHEM TIPS SURVEY INDICATES SUFFICIENT UNDERSTANDING OF THE BASIC PRINCIPLES OF ELECTRO-CHEMICAL CELLS. IF YOU ARE INTERESTED IN LEARNING ABOUT FUEL CELLS, I URGE YOU TO READ THE ARTICLE "FUEL CELLS: DISPERSED GENERATION OF ELECTRICITY" WHICH APPEARED IN THE DECEMBER 22, 1972 ISSUE OF SCIENCE MAGAZINE. YOU MAY PICK UP A COPY OF THIS ARTICLE FROM THE LIBRARIAN IN THE FRESHMAN CHEMISTRY STUDY ROOM (1321). FEEL FREE TO DISCUSS IT WITH ME OR WITH YOUR T.A.

YOUR PERFORMANCE ON THIS WEEK'S CHEM TIPS SURVEY INDICATES SUFFICIENT UNDERSTANDING OF THE PRINCIPLES OF CHEMICAL KINETICS. YOU WILL BE INTERESTED IN READING THE ARTICLE "UNCONVENTIONAL APPLICATIONS OF THE ARRHENIUS LAW" WHICH APPEARED IN THE MAY, 1972 ISSUE OF THE JOURNAL OF CHEMICAL EDUCATION. COPIES OF THIS ARTICLE ARE AVAILABLE IN THE FRESHMAN CHEMISTRY STUDY ROOM (1321).

THE ARTICLE "HUMAN COSTS OF NUCLEAR POWER" WHICH APPEARED IN THE AUGUST 11, 1972 ISSUE OF SCIENCE MAGAZINE IS OF CONSIDERABLE INTEREST. I URGE YOU TO PICK UP A COPY OF THIS ARTICLE FROM THE FRESHMAN CHEMISTRY STUDY ROOM (1321). I WILL LEAD A SPECIAL DISCUSSION ON THIS TOPIC AT 4:30 PM NEXT MONDAY IN ROOM B351; YOU ARE INVITED TO PARTICIPATE.

YOUR PERFORMANCES ON THE THIRD HOUR EXAM AND THE LAST CHEM TIPS SURVEY INDICATE THAT YOU HAVE A GOOD KNOWLEDGE OF THE VALENCE BOND APPROACH TO CHEMICAL BONDING. YOU ARE INVITED TO ATTEND A SPECIAL ENRICHMENT LECTURE ON MOLECULAR ORBITAL THEORY TO BE HELD AT 1:20 PM, FRIDAY, NOVEMBER 16 IN ROOM 1351. PLEASE PICK UP A COPY OF A SPECIAL HANDOUT, ENTITLED "SIMPLE MOLECULAR ORBITAL THEORY" FROM THE FRESHMAN CHEMISTRY STUDY ROOM (1321) AND BRING IT WITH YOU ON FRIDAY.

YOUR SCORES ON THE FIRST AND SECOND HOUR EXAMINATIONS IN CHEMISTRY 104 WERE OUTSTANDING. IF YOU ARE INCLINED TO DO SO, I WOULD LIKE TO SUGGEST THAT YOU TAKE ON A SPECIAL PROJECT DEALING WITH A TOPIC OF INTEREST TO YOU. PLEASE SEE ME FRIDAY AT 1:30 IN THE FRESHMAN CHEMISTRY STUDY ROOM (1321).

Figure 7. Sample enrichment messages.

cerns the students' attitude towards their teaching assistant. The data in Table 2 indicate that student ratings of teaching assistants are influenced<sup>3</sup> by the use of CHEM TIPS. Furthermore, the questionnaire revealed substantial interaction between students in the Experimental Group and those in the other three lecture sections. This interaction is undesirable from the viewpoint of assessing the impact of CHEM TIPS by comparing examination scores; however, this extent of interaction among students is heartening from an educational viewpoint! The mean score and standard deviation for three hour examinations for the Experimental Group (163 students) was  $66 \pm 12$  and that for the Control Group (167 students) was  $66 \pm 11$ ; the respective medians were 67 and 65. Further studies dealing with student attributes and performance are underway and will be reported upon completion.

The Experimental Group responses to the questions dealing with CHEM TIPS are summarized in Table 3. There is little doubt that students respond favorably to CHEM TIPS as evidenced by the tabulation in Table 3. More than half the students completed the suggested assignments and found them helpful. The vast majority indi-

Table 2. Means of Total Responses to Four Questions by the Control and Experimental Groups<sup>a</sup>

	Control	Experimental	t-value <sup>b</sup>
Your TA provides ample opportunity for students to ask questions	4.25 $\pm$ 0.71	4.42 $\pm$ 0.77	-2.18
Your TA's explanations are clear	3.67 $\pm$ 0.95	4.03 $\pm$ 1.0	-3.34
Your TA is an effective teacher	3.65 $\pm$ 0.93	3.99 $\pm$ 1.1	-3.02
Your TA takes an active interest in the progress of his (her) students	3.61 $\pm$ 0.97	3.85 $\pm$ 1.2	-1.99

<sup>a</sup> The questions are on a 1-5 scale: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree.

<sup>b</sup> The number of responses from the Control and Experimental Groups are 167 and 163, respectively; at the 99.5% confidence level, the null hypothesis "there is no significant difference between the responses of the control and experimental groups" can be rejected for all four questions.

<sup>2</sup> Users in freshman chemistry courses include: E. M. Larsen and R. M. Roder (UW-Madison), R. B. Siebring (UW-Milwaukee), N. A. Coward (UW-Superior), R. R. Roskos (UW-LaCrosse), C. M. Lang (UW-Stevens Point), M. Hanna (Univ. of Colorado), D. R. Eckroth (City Univ. of New York), P. R. Certain (UW-Madison) is currently using CHEM TIPS in the undergraduate physical chemistry course.

<sup>3</sup> I hasten to mention that a score of 3.0 (the neutral point) or above is indicative of a satisfactory rating.



**Table 3. Experimental Group Responses to CHEM TIPS Questions**

1. How often does your TA discuss the CHEM TIPS questions in quiz section?	always (27%) frequently (33%) rarely (29%) never (8%)
2. Do you usually prepare for the CHEM TIPS surveys?	yes (15%) no (85%)
3. How many surveys have you taken this semester (6 were given so far)?	3 or less (10%) 4 (10%) 5 (17%) 6 (60%)
4. Do you complete the suggested assignments you receive on the CHEM TIPS messages?	yes (55%) no (40%)
5. If yes, do you find the assignments helpful?	Yes (98%) no (2%)
6. Do you feel that CHEM TIPS helps you learn the course material better?	much better (26%) somewhat better (63%) does not help (8%)
7. Has CHEM TIPS changed any of your study methods of this course?	Increased frequency of reviewing the covered course material (28%) changed my method of preparation for exams (22%) did not change any of my studying habits (42%)
8. How many CHEM TIPS questions do you usually guess at per survey?	2 or less (57%) 3 (16%) 4 or more (12%)
9. Do you think the CHEM TIPS program should be continued in the future?	yes (91%) no (5%)
10. Do you discuss your CHEM TIPS surveys with students from other lecture sections?	yes (33%) no (65%)

cated that CHEM TIPS helps them learn the course material better and advocate its continued use.

The above preliminary results seem to indicate that CHEM TIPS creates a better atmosphere to learn in. However, it should be pointed out that CHEM TIPS is only one of numerous instructional aids utilized at Wisconsin. Students who feel CHEM TIPS is valuable may be reflecting opinions about any of the components of the instructional aids system such as Study Room, audio-tutorial lessons, videotapes, etc. Although the instructional aids existed before initiating CHEM TIPS, they are now used more frequently by students in CHEM TIPS lecture sections.

#### A Word about Cost

The cost of using computers varies from one institution to another. For example, on the Madison campus the charge for one hour of computer time is \$217; additional charges are made on the basis of the number of cards read, the number of lines printed, and the total number of pages. At the Stevens Point campus there is no charge for using computer facilities for instructional purposes. Thus, it is impossible to give an all-purpose figure for the computer

cost of using CHEM TIPS; the Madison campus cost per student per survey is about \$0.12.

Professors who use CHEM TIPS require the help of an assistant who takes care of such details as keypunching, simulation of reports, picking up reports from the computer center and placing them in CHEM TIPS boxes, etc. These duties amount to about 10 hours per week and can be assigned to an undergraduate hourly helper or made part of a teaching assistant's workload. The direct cost for computer usage and hourly help is less than \$2 per student per semester.

Some concern may be expressed about the hidden cost of professional time spent in writing questions and messages. The essential components of every teacher's activities include decisions about concepts and topics to be taught, how they are taught, and the determination of what students have learned. The time spent on such efforts does not constitute a hidden cost; on the contrary, it is part of a teacher's normal activities. It is true that some time must be devoted initially to become acquainted with the mechanics of CHEM TIPS. However, this is true of any innovation that a teacher wishes to use. In my experience, preparation of survey questions and associated messages has increased the efficiency and quality of my weekly preparation for the course. This, coupled with the TA's use of the information available on Section Reports, has enhanced the quality of our teaching efforts. The quick feedback about class progress is most valuable in terms of modifying the course pace and teaching strategies.

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I wish to express deep appreciation for the most dependable work of David B. Shaw and Jerry L. Walsh. The contributions of Dr. Dennis L. Heuring helped the successful launching of CHEM TIPS in 1972.

Very special thanks are due Allen C. Kelley. Our collaboration continues to be fruitful and mutually rewarding.

#### General References

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