

APPLICATIONS OF TECHNOLOGY IN TEACHING CHEMISTRY
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Paper 7

INTEGRATING COMPUTERS INTO THE HIGH SCHOOL CHEMISTRY CLASSROOM

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SCHEDULE: Short questions on this paper: July 6, 1993
Discussion of this paper: July 14 and 15, 1993

INTRODUCTION: A variety of uses for computers in the high school chemistry class will be presented. The effective use of tutorials with sample guidelines that have been successfully used for specific concepts will be shared. For more valuable sciencing spreadsheets using class data and calculations will be illustrated, along with graphing of data to enhance concept visualization. The data base capabilities of KC? Discoverer in teaching periodicity and the statistical evidence for improved student learning will be given. Concept stories produced on (IBM Storyboard Plus) which are shown on the liquid crystal display, or on individual monitors, can be used to aid in visualization. The Personal Science Laboratory interfacing value and uses will be given, and results and manipulation of PSL data by software will be illustrated if transmission of data on the electronic conference can be mastered. The use of Microsoft Works for classroom management and safety will be shared. The usefulness of Excelsior's gradebook will be discussed.

I. Beginning in 1987 with a grant from the Indiana Consortium for Computer & High Technology Education, our project was further funded from the Indiana Department of Education to increase the use of technology in the chemistry classroom. Our purpose was to use technology to enhance traditional instruction and to increase learning opportunities for students. The project "Classroom Without Walls" was comprised of Thomas Adams, then a doctoral candidate from Purdue University, and Dolores Handy and William Sondgerath, chemistry teachers at Harrison High School. A brief description follows on how we use computers and related technology in our classroom today. After each application that we were using at the time, post student survey question unless stated pre-test or statistic from Dr. Adams' doctoral thesis (May 1990) will be given to show significance if there is any. Mrs. Handy had two classes in the original study taught traditionally and two class using computers. Mr. Sondgerath had one class of traditional and one computer class.

A. We have the following hardware available:

In the classroom:

- 8-IBM Model/25
- 4-IBM Proprinter II
- 4-ESM Corporation printer switch boxes
- 1-IBM Model/30 (Mostly for teacher use.)
- 1-Sharp QA-50 Liquid Crystal Display

Outside the room:

- 1-Local Area Network (in media center)
- 30-IBM Model/25 (in media center)

STUDENT SURVEY

39. I (would have been) am pleased to have been placed in computer complemented chemistry class.

	%	Computer Students	Non computer Students
1. Strongly disagree		1.8	19.0
2. Disagree		5.4	10.3
3. Neither disagree or agree		34.9	32.8
4. Agree		44.6	32.8
5. Strongly agree		14.3	5.2
AVERAGE RESPONSE		3.64	2.95

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STUDENT SURVEY

40. Computers should be integrated into all of the chemistry classes next year.

	%	Computer Students	Non computer Students
1. Strongly disagree		3.6	17.2
2. Disagree		17.9	19.0
3. Neither disagree or agree		25.0	32.8
4. Agree		32.1	20.7
5. Strongly agree		21.4	10.3
AVERAGE RESPONSE		3.50	2.88

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II. Used extensively for tutorials in beginning chemistry is "Introduction to General Chemistry" by Stan Smith from the University of Illinois, published by Compress and specially adapted to Heath Chemistry. Fifty-five lessons in twenty instructional days are used, covering such topics as nomenclature, writing formulas, per cent composition, solutions, the gas laws, and acid-base chemistry. All Chemistry I students use tutorials and as they are working through the lessons, they complete guidelines so as not to race through their completion like some computer game. An example that we use for the gas law is given. (Spaces have been remove to conform with Chemconf guidelines.)

A. Chapter 7: Gas Laws
07GDE03

Name:
Date:

COMPRESS G: 3, 4

3. Pressure-Temperature Experiment

- a. What kind of gas is used in this experiment?
- b. What quantity of gas is put in the 22.4 L flask?
- c. What is the purpose of this experiment?
- d. Name the instrument used to measure pressure.

Is the instrument open-ended or close-ended?

Why is this information important?

- e. What happens to the pressure as the flask is warmed?
- f. When the gas is heated and the pressure difference is recorded, why must 76 cm. be added to the difference?
- g. After the flask has been placed in a beaker of water, you are asked to Heat and Cool. Record your data in the following TABLE:

T (C)	Left Arm (cm Hg)	Right Arm (cm Hg)	Difference (cm Hg)	Total Pressure (cm Hg)
-------	---------------------	----------------------	-----------------------	------------------------------

After you have completed and recorded the third reading, press 2 "to go on."

- h. Describe how the value of 0 cm Hg for pressure is obtained.
- i. What is the temperature of a gas, in degree C, whose pressure is 0 cm Hg?
- j. What name is given to this temperature?
- k. Write the equation which is used to convert a Celsius temperature to kelvins.
- l. Why must temperatures of gases be measured in Kelvins?
- m. What relationship exists between the pressure and the absolute temperature of a fixed quantity of an ideal gas?

4. Charles's Law (T-V)

a. Temperature-Volume Experiment

- 1.) What is the purpose of this experiment?
- 2.) In this experiment, what is kept constant: temperature, pressure or volume?
- 3.) Do at least 3 of the 8 experiments. Record your data in the following TABLE:

T (C)	Height of Column (mm Hg)
-------	--------------------------

After you have completed and recorded the third reading, press 2 "to go on."

- 4.) The computer converted "Height" in your TABLE into Volume." What other change did it make in the TABLE?
- 5.) What is the temperature, in C, where the volume of the gas becomes zero?
- 6.) What name is given to this temperature?
- 7.) The experiment you have just completed illustrates Charles's Law. Write Charles's Law, as it appears on your computer screen, in the space below.

b. Example Problems

- 1.) Write the equation which shows the volume of a gas is DIRECTLY PROPORTIONAL to its kelvin temperature, when the pressure and number of moles of the gas are held constant.
- 2.) Carefully observe how the Sample Problems are solved. Notice the computer program uses 0 K. Your textbook does not use the degree symbol with temperatures expressed in kelvins. Both these ways of expressing temperatures on the Kelvin Scale are acceptable. Also notice that all Celsius temperatures MUST be converted to kelvins in order to solve the problems.

c. Set up Problems

- 1.) Read the Instructions.
- 2.) Set up each of the four problems in the spaces provided below. Use the computer to check each setup. Correct your setups if needed.
 - a.)
 - b.)
 - c.)
 - d.)

I answered _____ problems out of _____ correctly.

d. Problems

- 1.) Read the instructions.
- 2.) Use loose leaf paper to set up each of the five problems given in the computer program. Calculate the answer for each problem. Use the computer to check your answers. Correct your work if needed.

When you have completed the problems, complete the following statement:

I answered _____ problems out of _____ correctly.

B. The following is a summary of CAI used in Chemistry I.

Topic	Computer Lessons	Time on Task Days-Hours	Total Days on Topic
Nomenclature	17	5-2.5	12
Mole Concept	22	8-3.7	17
Gas Laws	9	2-1.5	10
Periodicity	4	2-1.5	7
Solutions	7	2-1.4	5
TOTAL	59	19-10.6	50

C. STUDENT SURVEY-Computer Students only.

42. The use of the Compress Programs should be continued.

	# Students	% Students
1. Strongly disagree	2	3.6
2. Disagree	7	12.5
3. Neither disagree or agree	19	33.9
4. Agree	22	39.3
5. Strongly agree	6	10.7
AVERAGE RESPONSE	3.41	

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Questions:

1. What tutorials have you found to be useful in teaching high school chemistry?
2. What methods do you employ to evaluate concepts learned from using tutorials?

III. KC? Discoverer by Journal of Chemical Education
 Software is used extensively during our study of periodicity. KC? Discoverer is large database consisting of up to 50 properties of an element. The relationship between any two properties can be graphed over the whole table, by part of the table, by family, or by period. It is most useful in studying various trends in the periodic table. We have found in our experiences that it is essential for student learning to have teacher-prepared worksheets or guidelines to accompany these tutorials. It will help students to focus on what they need to know rather than as a computer game! The following is a guide

that we use with KC? Discoverer.

A. KC? DISCOVERER
The Relationship Between

First Ionization Energy with Atomic Radius

DEFINITION: FIRST IONIZATION ENERGY the energy needed to remove the outermost electron from a neutral gaseous atom in the ground or unexcited state.

=> highlight "GRAPH one property against another" - press <Enter>

x-axis >< highlight "atomic number" - press <Enter>

type n to calculation question

y-axis >< highlight "atomic radius" press <Enter>

type e to enlarge x-axis range =>

From: type 0 - press <Enter>

To: type 20 - press <Enter>

y-axis range => press <Enter> twice to accept

default values

Compare the graph of the atomic radii on screen to the graph of the first ionization energy on page 323 of your text.

1. What similarities or differences in the trends do you see as one proceeds across a period/row on the periodic table?
2. What similarities or differences in the trends do you see as one proceeds down a group/family on the periodic table?
3. Explain why the similarities or differences exist.

B. STUDENT SURVEY

40. The use of KC? DISCOVERER of elemental periodicity should be continued.

	# Students	% Students
1. Strongly disagree	3	5.4
2. Disagree	5	8.9
3. Neither disagree or agree	21	37.5
4. Agree	21	37.5
5. Strongly agree	6	10.7
AVERAGE RESPONSE	3.39	

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C. The only statistically significant results impacted by using computers was the chapter on periodicity in which we used KC? DISCOVERER. Here follows a brief summary of test results.

Chapters presented by all traditional (no computers).

Group	Mean Score
Computer Class	74.99
Noncomputer Class	74.83

Chapter using the KC? database.

Group	Mean Score
Computer Class	78.90
Noncomputer Class	73.60

Questions:

1. How have you used KC? Discoverer that would be helpful for other chemistry teachers to know?
2. Are there other databases that you find useful?

IV. Another important component is the liquid crystal display (LCD), used to project concepts which are being taught to the total class when software is not available or appropriate for small group or individual instruction. The LCD is used for introducing technology or equipment that the students will be using, such as spreadsheeting and graphing. The graphics program which is used to design "concept stories" is IBM's Storyboard Plus. Included is a list of teacher-made concept stories which have been developed with the project.

A. Pictures, diagrams, definitions, and descriptions in a series of frames teach the following concepts.

- 1\Bonding
- 2\Density
- 3\Exo- and Endothermic
- 4\History of Atom
- 5\Mass Spectrometer
- 6\Forming Sodium Ion
- 7\Phase Diagrams (CO₂ and H₂O)
- 8\Colligative Properties
- 9\Molecular Model
- 10\Use of Buret
- 11\Heating Curve
- 12\Simple Orbitals
- 13\Part 1 Equilibrium (Qualitative)
Part 2 Equilibrium (Quantitative)

B. The concept stories can be utilized by the individual student, but usually they are used in large group instruction because they are not interactive. These presentations are very much like electronic overlays with ease of storage and retrieval. Here is a sample story on density (2\density above). This is a shortened version of 4 screens opposed to 14. Hopefully you can fill in screens. The screens are #6,8,10, and 13.

Get SONDP1
SONDP2
SONDP4
SONDP5

STUDENT SURVEY

41. The teacher should continue to use the liquid crystal display unit to project computer-generated images.

	# Students	% Students
1. Strongly disagree	2	3.6
2. Disagree	10	17.9
3. Neither disagree or agree	14	25.0
4. Agree	18	32.1
5. Strongly agree	12	21.4
AVERAGE RESPONSE	3.64	

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C. A sample of part of 2\Density is included.
Graphics: Complete

Questions:

1. Do you know of any good, reasonably priced color LCD's?

2. What have you done with visualization that could enhance chemistry instruction?

V. Harrison High School has Microsoft Works on its network. Students use word processing for lab reports and summary reports on current topics in chemistry, but students are not required to word process throughout the course.

46. The use of word processing in chemistry should be continued.

	# Students	% Students
1. Strongly disagree	2	3.6
2. Disagree	3	5.4
3. Neither disagree or agree	17	30.4
4. Agree	21	37.5
5. Strongly agree	13	23.2
AVERAGE RESPONSE	3.71	

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Questions:

1. Does anyone require word-processed reports?
2. Could you make a contribution on how you successfully utilize word processing in your chemistry program?

VI. Using/making spreadsheets and graphing is the aspect from Microsoft Works that is most used in our chemistry classes. Included is a list of spreadsheet templates which have been developed with the project.

A. SPREADSHEETS PREPARED FOR THE FOLLOWING IN HEATH CHEMISTRY: (D. C. Heath, 1987)

Experiment 1C: Analysis of Experimental Results
Experiment 2B: The Law of Definite Composition
Experiment 3A: Thickness of an Aluminum Sheet
Experiment 3Y: The Relationship Between the Mass & Volume of Cu
Experiment 2B: The Law of Definite Composition
(Students use data in Ch4 to find Empirical Formula)
Experiment 6A: Mole-Mass Reaction
Experiment 7B: The Molar Volume of a Gas
Experiment 17A: Heat of Reaction
Experiment 17B: Heat of Fusion

B. Spreadsheets for Other Labs:

Calorimeter Constant
Specific Heat of Unknown Metal
Enthalpy of Neutralization Reaction
Acid-Base Titrations: Standardization of NaOH with KHP
Acid-Base Titrations: Citric Acid in Grapefruit Juice
Acid-Base Titrations: Acetic Acid in Vinegar

C. One advantage of spreadsheeting is that students can readily relate a large collection of data to the concept the lab is teaching. Initially students enter individual data for the spreadsheet; they also have access to all other students' data as well. This allows them to understand the experiment more clearly. Eventually they construct the spreadsheet and learn to graph the data from it. The spreadsheet also makes it

easier for the instructor to check the students' lab results. So many of the aspects of spreadsheets are invaluable in the lab situation.

Five of those follow:

1) SEEING THE NEED TO ORGANIZE DATA IN AN ORDERLY ARRANGEMENT. As noted previously Microsoft WORKS is used; it is found on the LAN. The students are not given workshops on the spreadsheet in a long and formal way, but are gently introduced to it in a growing and more complex fashion. They begin by placing lab data in the spreadsheet template. This template has basically the same data format as their lab data spreadsheets from which they are copying into the computer. For example, in the lab in which magnesium ribbon is heated in a crucible with a partially opened cover, students record mass of crucible before, the mass of crucible with magnesium, and the mass of crucible and contents after heated. The mass of magnesium and the mass of the magnesium product is calculated in the spreadsheet for them. This data then is stored for a later development. The student begins to see the organization and orderly arrangement of the spreadsheet.

2) HAVING IMMEDIATE FEEDBACK TO DETERMINE IF MEASUREMENT SHOULD BE RETAKEN. The next step is to have them check the calculated-accepted value from the spreadsheet. If their values show more than 5% deviation (percent may vary from lab to lab), they are instructed to redo the measurements. The spreadsheet that follows (Figure 1) may be an example of how this is accomplished. As the students place their values into the spreadsheet, the % Error is calculated. If it does not fall within certain values, students must return and redo measurements of the sample.

3) GETTING A LARGE AMOUNT OF DATA TO FIND REGULARITIES. Students utilize and analyze all the data of the class or classes, and if even a greater collection is needed or desired, the data of previous year(s) can be merged into the file. The regularities can be visualized more easily for an even more valuable approach.

4) DOING A LARGE NUMBER OF CALCULATIONS OF THE SAME TYPE VERY QUICKLY. Students learn in this aspect to write formulas into the spreadsheet and to extend to calculate values for all data. The "wows and ohs" are worth it all at this point when students can see hundreds of calculations done in a few seconds. Readily determining averages and % excites the students.

5) CONSTRUCTING AND CREATING FORMULAS. In this lab situation the data referred to above from the heating of magnesium is retrieved from the student's data disk. Then students are instructed how to put formulas into the spreadsheet to calculate the mass of oxygen; then the moles of magnesium and the moles of oxygen; and finally, the mole ratio to determine the empirical formula.

Designing and constructing a spreadsheet follows, which is the culmination of every step thus far with a small amount of discussion about headings and spacings. Two spreadsheets constructed are the pressure vs. volume relationship in Boyle's Law, and pressure vs. absolute temperature in Gay-Lussac's Law.

Get Sond1 spreadsheet & chart 1

Sond2 spreadsheet & chart 1

The last aspect will examine what Microsoft WORKS calls charts. For this discussion they will be called graphs. Truly the trends and regularities can be magnified by a thousandfold. Just as a picture represents a "thousand words," a graph conceptionally concretizes data proportionately.

The variation of volume vs. area in this aluminum sheet gives slope which is the thickness. The results of the graph greatly enhance the learning in the experiment.

Get Sond3 spreadsheet & chart1 & chart2

The data from the spreadsheet can readily be transferred to a graph. The value of the software allows the student to practice the skills associated with graphing such as: 1) Selecting appropriate title; 2) Determining appropriate axis for each variable; 3) Labeling the axes with variable and unit; 4) Selecting reasonable integrals on each axis; 5) While not allowing students to plot a point, the software does allow different legends for noting different data sources; and 6) Drawing the best fit line or curve for points.

Most of the spreadsheets could be done with a single computer in the lab. Certainly the collection of the data and filing from year to year is most useful for the teacher. If the teacher finds that he needs a calculator in his hand when grading lab reports, a spreadsheet on the screen, (or even better, a printed one) can be invaluable in making the evaluation process much more efficient.

STUDENT SURVEY

44. The use of computer spreadsheets to analyze lab data should be continued.

	# Students	% Students
1. Strongly disagree	2	3.6
2. Disagree	3	5.4
3. Neither disagree or agree	19	33.9
4. Agree	27	48.2
5. Strongly agree	5	8.9
AVERAGE RESPONSE	3.54	

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STUDENT SURVEY

45. The preparation of graphs from computer spreadsheets should be continued.

	# Students	% Students
1. Strongly disagree	2	3.6
2. Disagree	3	5.4
3. Neither disagree or agree	21	37.5
4. Agree	28	50.0
5. Strongly agree	2	3.6
AVERAGE RESPONSE	3.45	

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Questions:

1. In what ways do you find spreadsheeting and graphing from the computer useful?
2. Do you have any unique use of spreadsheets and graphs from the computer?

VII. Another feature of our technology is the purchasing of

Personal Science Laboratory, which has improved the laboratory interfacing capabilities. The thermistor is used to learn such concepts as heating curves, heat of fusion, and heat of reaction. It certainly is convenient not to clean up mercury spills. One major use of the pH probe is to plot the neutralization curves involving various combinations of strong/weak acids and strong/weak bases.

STUDENT SURVEY

40. The use of the computer to interface with laboratory should continued.

	# Students	% Students
1. Strongly disagree	2	3.6
2. Disagree	3	5.4
3. Neither disagree or agree	14	25.0
4. Agree	23	41.1
5. Strongly agree	14	25.0
AVERAGE RESPONSE	3.96	

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Questions:

1. What types of experiments involving interfacing do you use, or would you like to use?
2. Do you have any advice for someone starting to use interfacing?

VIII. For the instructor the Excelsior Grade Book is a most useful and powerful management tool. Keeping students informed of their continual progress, whether for eligibility for extra curricular activities, or for their own curiosity, is most efficient. Questions on attendance can be answered quickly. Statistics on graded material can be determined instantaneously.

Questions:

1. Do you have a powerful gradebook?
2. Do you have any suggestions to other teachers in using such a management tool?

IX. The only reason that I place Safety in Science Lab last is that it is the last software that we have obtained. It is a tremendous source of case studies, suggestions, and checklists which can be used to promote safety. Using the software to develop a school safety policy was very helpful. We are in the process of remodeling our school. A safety checklist for needed safety design in the chemistry classroom, the chemistry prep room, and the chemical storage room was given to the architect to incorporate into the new plans. THE TOTAL SCIENCE SAFETY SOFTWARE SYSTEM was most useful in this design. Other helpful uses include student safety contracts, inventorying, printing bottle labels, accident reports and many more. Using the software to develop school safety policy was very helpful. Part of our policy is included for your inspection. Teachers, administrators, and school board members should not be overwhelmed by the number and type of lawsuits filed in the United States. THEY SHOULD NOT BECOME PARANOID ABOUT THEIR FEAR OF OUR LEGAL SYSTEM TO THE POINT OF AVOIDING VALUABLE SCIENCE

ACTIVITIES. This policy should be a guideline of recommendations from science teachers for improving science teaching and for facilitating the continuous process of safety assessment and correction.

1. Limiting science labs to when only regular teacher is present unless sub has appropriate training.
2. Limiting the use of science lab to science only (no study halls or extra curricular activities which are not science related unless conducted by the regular science teacher).
3. Limiting lab enrollment to 24 students per teacher. If less than 24 lab stations in room, then only one student per station.
4. Limiting the numbers of handicapped (emotionally, mentally, physically) in a lab.
5. Separate science budget for safety items only.
6. Accident report filed on each accident or incident (near accident) occurring in the science setting.
7. THE WORD SAFETY SHOULD APPEAR ON EVERY DEPARTMENT MEETING AGENDA. It will remind personnel of critical items they may need to discuss with other team members.
8. Each science class should be instructed on each item of safety equipment and its use.
9. In the beginning of the course an overview of safety procedures should be given.
10. Before each lab safety precautions should be given.
11. Student safety contracts should be used to help assure that critical safety items are covered with all students every semester or school year.
12. Safety must become central in all science courses and facility planning and modification.
13. The goggle law must be followed.
14. If students are in the science room or prep area, a science teacher must be in the room.
15. All showers, eyewashes, fire extinguishers, exhaust hoods or fans, and other safety equipment should be checked regularly for proper operation by corporation maintenance staff with supervision by the science teacher in assigned to lab.
16. Every science lab should have a supplied first aid kit and check regularly.
17. All new science teachers should be given a orientation on safety equipment and procedures by department head or designee.
18. All science rooms must have working emergency call buttons.
19. Any student who disregards safety by unacceptable conduct which endangers other students or self must be removed from lab area with a failing grade on that lab or activity. On the second offense the students should be removed from the class.

Questions:

1. Would software like this be valuable to you?
2. Have you found any safety software that would be useful to other chemistry teachers?

CONCLUSION: Through our project we have gained a better insight of how the tools of technology can enhance traditional instruction, providing still another tool in teaching. A second advantage is that "Classroom Without Walls" increases students' opportunities to work with technology that many will face in future education and/or employment. Probably the most significant outcome that we confirmed was the comfort level in the use of computers by the students which is illustrated by the following graphic.

Get SOND4

Sources of Software

Storyboard Plus from IBM
Microsoft WORKS for IBM PC's and Compatibles
PSL(Personal Science Laboratory) from IBM

COMPRESS(tutorials)
P.O. Box 102
Wentworth, NH 03282

(KC? Discoverer)
Journal Chemical Education Software
University of Wisconsin-Madison
Department of Chemistry
1101 University Avenue
Madison, WI 53706

Excelsior Software, Inc.(grades)
P. O. Box 3416
Greeley, CO 80633

Gerlovich, J., T. Gerard, K. Hartman,
THE TOTAL SCIENCE SAFETY SOFTWARE SYSTEM,
Sargent-Welch Scientific Co.,
Skokie, IL, 1988, 1-800-323-4341