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CHANGE IN SCIENCE ATTITUDE  
IN A "CHEMISTRY AND SOCIETY"  
COURSE FOR NONSCIENCE MAJORS

By

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A DISSERTATION

Submitted to

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## ABSTRACT

### CHANGE IN SCIENCE ATTITUDE IN A "CHEMISTRY AND SOCIETY" COURSE FOR NONSCIENCE MAJORS

By

Jeanette Mary Carrington

One of the most visible changes that has occurred in post-secondary chemistry education in the past several years has been the emergence of introductory courses designed specifically for nonscience majors.

This study begins by viewing some of the factors which have brought about this change and focuses on the development of such a course, "Chemistry and Society" at Eastern Michigan University. One of the main concerns in the implementation of this course was the development of a class which would offer to students who would not otherwise enroll in a chemistry course a unique exposure to an interesting and attainable overview of many facets of chemistry.

One of the major goals of this course was to change the students' attitudes toward science, the scientific

process, and their own ability to succeed in a science class. An instrument for measuring science attitude was devised and used to evaluate attitude change in the "Chemistry and Society" class and two other classes which were used as control groups.

The results of the study confirmed the hypothesis that the students who participated in the "Chemistry and Society" course did experience a measurable positive change in their attitudes toward science, and that this change was significantly larger than the change experienced by the other two groups tested.

In addition, qualitative analysis and discussion of the students' responses to various items on the questionnaire revealed that the course fulfilled the range of goals initially established for it.

To my father, who taught me how to think.

To K.C., who taught me how to think about chemistry.

To J.B., who helped me with so much of the rest.

## ACKNOWLEDGEMENTS

Many people played parts in helping this study become a finished reality---with their ideas, their discussions, and, above all, their encouragement. They include Dr. Stephen Schullery and Dr. Elva Mae Nicholson for their special help and support. Others in the Eastern Michigan University Chemistry Department were also instrumental---Dr. Ronald Collins, Dr. John Moore, and Dr. Stephen Brewer.

Appreciation also goes to Dr. Ira Wheatley, of the History Department, and the nice person in the Computer Center who secretly wrote the program to handle the data. The students who took part in the study made teaching these courses delightful and rewarding. Thanks go to them.

Brenda Manning, and many others---thank you for never doubting that I'd finish.

## TABLE OF CONTENTS

|                                                                                                     |     |
|-----------------------------------------------------------------------------------------------------|-----|
| LIST OF TABLES.....                                                                                 | vi  |
| CHAPTER I: INTRODUCTION AND STATEMENT OF<br>THE PROBLEM.....                                        | 1   |
| CHAPTER II: DEVELOPMENT AND DESCRIPTION OF<br>THE CHEMISTRY AND SOCIETY COURSE.....                 | 24  |
| CHAPTER III: DISCUSSION OF ATTITUDE MEASUREMENT.....                                                | 39  |
| CHAPTER IV: SUMMARY OF DATA: FALL 1980 STUDY.....                                                   | 49  |
| CHAPTER V: SUMMARY OF DATA: WINTER 1981 STUDY.....                                                  | 67  |
| CHAPTER VI: DISCUSSION OF RESULTS AND SUMMARY<br>OF THE STUDY.....                                  | 95  |
| APPENDIX A: SCIENCE ATTITUDE QUESTIONNAIRES.....                                                    | 104 |
| APPENDIX B: INDIVIDUAL ATTITUDE SCORES WINTER 1981....                                              | 123 |
| APPENDIX C: ITEM RESPONSE DATA<br>SCIENCE ATTITUDE QUESTIONNAIRE<br>CHEMISTRY 115: WINTER 1981..... | 126 |
| BIBLIOGRAPHY.....                                                                                   | 131 |

## LIST OF TABLES

|          |                                                                                                           |    |
|----------|-----------------------------------------------------------------------------------------------------------|----|
| TABLE 1  | NUMBER OF ARTICLES ON NONSCIENCE<br>MAJORS' CHEMISTRY COURSES<br>(THE JOURNAL OF CHEMICAL EDUCATION)..... | 9  |
| TABLE 2  | INTRODUCTORY CHEMISTRY COURSES OFFERED<br>AT EASTERN MICHIGAN UNIVERSITY.....                             | 12 |
| TABLE 3  | DIAGRAM OF ATTITUDE CHANGE HYPOTHESIS.....                                                                | 22 |
| TABLE 4  | LIST OF TOPICS COVERED IN CHEMISTRY 115.....                                                              | 26 |
| TABLE 5  | CATEGORIES OF QUESTIONS:<br>SCIENCE ATTITUDE QUESTIONNAIRE.....                                           | 48 |
| TABLE 6  | BACKGROUND DATA: CHEMISTRY 115: FALL, 1980..                                                              | 50 |
| TABLE 7  | GRADE DISTRIBUTION: CHEMISTRY 115:<br>FALL, 1980.....                                                     | 52 |
| TABLE 8  | ATTITUDES TOWARD SCIENCE CAREERS.....                                                                     | 55 |
| TABLE 9  | GENERAL REACTION TO SCIENCE AND TECHNOLOGY..                                                              | 56 |
| TABLE 10 | DEGREE OF CONTROL OVER<br>SCIENCE AND TECHNOLOGY.....                                                     | 58 |
| TABLE 11 | ROLE OF SCIENCE AND TECHNOLOGY<br>IN CAUSING PROBLEMS.....                                                | 59 |
| TABLE 12 | ABILITY OF SCIENCE AND TECHNOLOGY<br>TO SOLVE PROBLEMS.....                                               | 60 |
| TABLE 13 | CHANGE IN UNDERSTANDING SCIENCE.....                                                                      | 63 |
| TABLE 14 | SUBJECTIVE EVALUATION OF ATTITUDE CHANGE....                                                              | 64 |
| TABLE 15 | BACKGROUND DATA: CHEMISTRY 115:<br>WINTER, 1981.....                                                      | 68 |
| TABLE 16 | GRADE DISTRIBUTION: CHEMISTRY 115<br>WINTER, 1981.....                                                    | 69 |

|          |                                                                                   |     |
|----------|-----------------------------------------------------------------------------------|-----|
| TABLE 17 | ATTITUDE TOWARD SCIENCE CLASS.....                                                | 70  |
| TABLE 18 | ATTITUDE TOWARD SCIENCE COURSE<br>REQUIREMENTS.....                               | 71  |
| TABLE 19 | ATTITUDE TOWARD SCIENCE CAREERS.....                                              | 71  |
| TABLE 20 | ABILITY OF SCIENCE TO SOLVE PROBLEMS.....                                         | 72  |
| TABLE 21 | RATE OF CHANGE CAUSE BY SCIENCE.....                                              | 73  |
| TABLE 22 | VALUE OF SCIENCE AND TECHNOLOGY.....                                              | 74  |
| TABLE 23 | BACKGROUND DATA: CHEMISTRY 119,<br>WINTER 1981.....                               | 78  |
| TABLE 24 | GRADE DISTRIBUTION: CHEMISTRY 119<br>WINTER 1981.....                             | 79  |
| TABLE 25 | BACKGROUND DATA: HISTORY 100,<br>WINTER 1981.....                                 | 81  |
| TABLE 26 | BACKGROUND DATA: CHEMISTRY 115 STUDENTS<br>WINTER 1981 (FINAL QUESTIONNAIRE)..... | 83  |
| TABLE 27 | COMPARISON OF SCIENCE ATTITUDE SCORES.....                                        | 86  |
| TABLE 28 | MATCHED SCORES: CHEMISTRY 115 STUDENTS.....                                       | 88  |
| TABLE 29 | MATCHED SCORES: CHEMISTRY 119 STUDENTS.....                                       | 89  |
| TABLE 30 | MATCHED SCORES: HISTORY 100 STUDENTS.....                                         | 91  |
| TABLE 31 | COMPARISON OF STUDENT SCORES WITH GRADES:<br>CHEMISTRY 115.....                   | 93  |
| TABLE 32 | COMPARISON OF STUDENTS SCORES WITH GRADES:<br>CHEMISTRY 119.....                  | 94  |
| TABLE 33 | SUMMARY OF SCIENCE ATTITUDE CHANGE DATA....                                       | 98  |
| TABLE 34 | ATTITUDE SCORES: CHEMISTRY 115 (INITIAL)...                                       | 123 |
| TABLE 35 | ATTITUDE SCORES: CHEMISTRY 115 (FINAL)....                                        | 123 |

|          |                                                        |     |
|----------|--------------------------------------------------------|-----|
| TABLE 36 | ATTITUDE SCORES: CHEMISTRY 119 (INITIAL)...            | 124 |
| TABLE 37 | ATTITUDE SCORES: CHEMISTRY 119 (FINAL).....            | 124 |
| TABLE 38 | ATTITUDE SCORES: HISTORY 100 (INITIAL).....            | 125 |
| TABLE 39 | ATTITUDE SCORES: HISTORY 100 (FINAL).....              | 125 |
| TABLE 40 | ITEM RESPONSE DATA: CHEMISTRY 115,<br>WINTER 1981..... | 127 |

## CHAPTER I

### INTRODUCTION AND STATEMENT OF THE PROBLEM

The history of chemical education in the United States has followed very traditional patterns. The early years saw formal lectures with very limited active student participation. Laboratory instruction was virtually unknown until 1842 when Yale University introduced the first chemical laboratory course. Other universities followed suit and the practice was widespread by the end of the nineteenth century.

However, the methods of teaching chemistry did not reflect the rapid advances of this relatively new experimental science. New discoveries, new elements, and new theories led to an almost exponential growth in the discipline content. But the educational delivery processes remained relatively unchanged.

By the early decades of this century the realm of chemistry as a science had become divided into four major categories---organic chemistry with its emphasis on carbon compounds, inorganic chemistry which was concerned with the non-living world, analytic chemistry which dealt with the qualitative and quantitative measurement of matter, and the new exciting area of physical chemistry with its emerging theoretical and mathematical view of matter.

College and university chemistry curricula across the country centered uniformly around these four divisions and their traditional sequence of presentation.

Chemistry education was also uniform in terms of the students addressed. There were no special courses for students with differentiated needs. Chemistry majors, medical students, liberal arts majors, engineers, agriculture students---all students needing or wanting a chemistry course received essentially the same product.

The early teaching of chemistry focused on facts---descriptions of chemical reactions and properties, memorization of individual chemical processes, the learning of lists of details, quantities which react and apparatus used. While this classification of properties began to merge into unifying themes, chemical education through the 1950's focused primarily on the learning of facts and not on the abstractions or developing theories which might account for these facts.

In all of modern science education, perhaps nothing has had a more abrupt or significant impact on curriculum than the U.S.S.R.'s announcement of the launch of Sputnik in 1957. The American public felt that this country had been proven to be second-rate in the training of scientists and technicians. Many felt that science education lacked the necessary rigor and quality to keep this nation in contention in the areas of

scientific research and advances. With this adamant public support and accompanying generous government funding, efforts began in the development of federally-sponsored curriculum projects. Groups of highly respected discipline experts convened and began addressing the serious questions facing U.S. science education.<sup>1</sup> This impressive unified effort resulted in extensive programs aimed primarily at elementary and secondary school students. Among these were the BSCS Biology Series, Chem Study and the Chemical Bond Approach in chemistry, and the Harvard Project Physics. All of the programs produced were highly theoretical, discipline-oriented, content-centered materials involving the inquiry approach. It is interesting to note that these materials were produced by post-secondary or research level scientists, for the most part, and not by specialists in the teaching of science or the teachers at the levels where they were to be used.

In addition to the development of extensive new course materials, changes were introduced in the level at which science topics were injected into the educational process. Rigorous science education began much earlier than previously, resulting in elementary school children being introduced to many abstractions such as atoms,

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<sup>1</sup>Hulda Grobman, Developmental Curriculum Projects: Decision Points and Procedures (Itasca, Illinois: F.E. Peacock, 1970)

electrons, solutions, etc.

The results initially were impressive. The number of students graduating from high school with greater exposure to science grew. The number of students entering science careers at the post-secondary level soared. But the dream did not last long. Studies eventually showed that students emerging from these curricula did not fare any better than their predecessors. And science enrollments in colleges and universities began declining. In addition, these innovative curricula were having little impact on the teaching of science at the post-secondary level.

Slowly college textbooks did reflect some of the changes as they began to incorporate more theoretical and mathematical concepts. As a result, by the late 1960's, chemical education had moved almost totally toward the presentation of theoretical principles and almost totally away from the memorization of facts, discussion of historical issues, and analysis of practical applications of chemical concepts.<sup>2</sup>

Post-secondary chemical education still remained focused on one type of student---those whom educators believed needed an in-depth, highly theoretical treatment of the subject. College courses were offered as if all

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<sup>2</sup>John C. Bailar, Jr., "Chemical Education--Then and Now", The Journal of Chemical Education. Vol. 48, September 1971, p. 434.

students present in chemistry lectures and laboratories were earning degrees in chemistry. Yet even those who were chemistry majors were emerging from their training with inadequate knowledge of "real world" chemistry.<sup>3</sup>

Students who needed a course or two in chemistry as part of their curriculum for other areas of specialization were not receiving the practical knowledge that might be of use to them in their educations and professions. Students who might elect to take a basic chemistry course to learn something about a fascinating subject stayed away in large numbers.

But in the late 1960's and 1970's, some dissenting views on chemistry curriculum did begin to emerge. Perhaps spurred by the practical realities of the economy, the social issues of science and technological developments, the call for "relevance", declining enrollments, or a host of other possible factors, many chemical educators began to let go of their traditional views and began to recognize the need for resounding changes.

This same period witnessed a declining public confidence in science. During World War I and World War II the unified efforts of the scientific community had led to many valuable innovations in the fields of health,

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<sup>3</sup>Derek A. Davenport, "Elevate Them Guns a Little Lower", The Journal of Chemical Education, Vol. 45, June 1968, p. 419.

agriculture, defense, and the production of materials and products to better the quality of life. But in the 1960's and 1970's, the positive regard toward science declined for many reasons. According to one author<sup>4</sup>, science and the science education establishment had made the serious error of withdrawing from the real world. People no longer perceived science as touching their everyday lives. People began seeing science as much as a source of problems as a source of answers. Perhaps even more so. Accompanying this decrease in public enchantment with science and technology was the decrease in the number of students earning degrees in science. Proportionally, the number of nonscience majors enrolled in post-secondary chemistry courses grew significantly.

Many of the resounding changes in chemical education being called for centered around these concerns---making chemistry more "real", to have it reach more students, to reach these students more effectively, and to increase public awareness of and confidence in chemistry. Innovations were needed, not to attract large numbers of students into the profession (although this might be a pleasant by-product), but to make the study of chemistry

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<sup>4</sup>W. Conrad Fernelius, "Chemical Education: Whence From? Whither To?", The Journal of Chemical Education, Vol. 53, October 1976, pp. 632-633.

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rewarding to more students.<sup>5</sup>

As scientific issues and information became more and more a part of daily existence, science education needed to respond by addressing the real world and the diverse needs of the students entering chemistry classrooms.

This trend toward more relevance is a visible change, although it is not totally new and certainly not alone among patterns of curriculum changes in chemistry education. But it is a trend which has had noticeable effects on chemistry curriculum in colleges and universities across the country in the last few years. Descriptions of chemistry courses for nonscience and non-chemistry majors began appearing in the literature as early as the 1920's. Such early courses were quite rare and usually addressed the needs of very specific groups of students, such as students in agriculture.

In recent years such courses have become even more general and are usually described as courses for all non-chemistry majors. Courses appear with different names: "Chemistry and Society", "Chemistry of the Environment", "Chemistry for Those Who Rather Wouldn't", or with more traditional names and numbers which do not reveal their intended audience. Specific courses in this category arose

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<sup>5</sup>Anna J. Harrison, "The Role of Chemical Education", The Journal of Chemical Education, Vol. 48, November 1971, p. 719.

from differing sets of underlying reasons---the recognition that a larger segment of the educated public should have some knowledge in the practical areas of chemistry, the recognition that these students need a different emphasis in the chemistry courses that they complete, and a recognition that courses of this type might attract students who would not otherwise enroll in any chemistry course. The need to counteract declining enrollments and tight budgets has been a major force behind this movement.

The emerging importance and prevalence of courses of this type is witnessed by a quick review of articles in The Journal of Chemical Education, the most widely circulated periodical in which chemical educators share specifics of course development, methodology, and chemical research. Scattered articles dealing with specific chemistry courses for non-chemistry majors have appeared for the past fifty years. The number of such articles increased significantly in the early 1970's, reflecting the introduction of these courses at many schools during that time period. Table I lists the number of articles dealing with courses for nonscience majors for each year since 1951.

In addition to the evidence provided by these journal articles, other data supporting this pattern are available from several surveys conducted on random

TABLE 1  
NUMBER OF ARTICLES ON NONSCIENCE MAJORS'  
CHEMISTRY COURSES  
(THE JOURNAL OF CHEMICAL EDUCATION)

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| YEAR      | NUMBER OF ARTICLES | YEAR      | NUMBER OF ARTICLES |
|-----------|--------------------|-----------|--------------------|
| 1951..... | 1                  | 1966..... | 2                  |
| 1952..... | 3                  | 1967..... | 1                  |
| 1953..... | 2                  | 1968..... | 1                  |
| 1954..... | 1                  | 1969..... | 6                  |
| 1955..... | 1                  | 1970..... | 7                  |
| 1956..... | 0                  | 1971..... | 12                 |
| 1957..... | 0                  | 1972..... | 6                  |
| 1958..... | 1                  | 1973..... | 23                 |
| 1959..... | 1                  | 1974..... | 13                 |
| 1960..... | 1                  | 1975..... | 29                 |
| 1961..... | 4                  | 1976..... | 23                 |
| 1962..... | 4                  | 1977..... | 29                 |
| 1963..... | 4                  | 1978..... | 16                 |
| 1964..... | 6                  | 1979..... | 20                 |
| 1965..... | 1                  | 1980..... | 12                 |

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samples of four-year colleges and universities.<sup>6,7</sup> These studies, interpreted conservatively, show an increase from fewer than fifty per-cent of schools surveyed having such courses in the late 1950's to nearly sixty-five per-cent of the schools surveyed having such courses in 1976. While these data involve only American Chemical Society accredited four-year schools, the numbers would be higher were other four-year schools and two-year schools included. Such schools, especially community colleges, would be more likely to offer more general, popular topic courses for their more diverse student populace.

Reflecting this increased emphasis on courses designed for nonscience majors, the American Chemical Society sponsored a symposium on Science Courses for Nonscience Majors at its national meeting in San Francisco in April of 1968. Since then a special subcommittee of the curriculum committee dealing with this topic has been in existence.

That this trend is long lasting and continues to affect curriculum decisions in post-secondary science

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<sup>6</sup>Jack Vanderryn, "The Teaching of Chemistry to Non-Majors: A Survey", The Journal of Chemical Education, Vol. 35, May 1958, pp. 256-259.

<sup>7</sup>Rita G. Blatt, "An Investigation of Chemistry Courses for Nonscience Majors", The Journal of Chemical Education, Vol. 54, February 1977, pp. 89-90.



and chemistry departments is no longer questioned. The forces that led to the development of such courses (be they economic, pedagogical, or based on concerns for best serving students' needs) still exist. Not only are these courses emerging, but their very nature and approach is becoming increasingly different from the traditional skill and theory oriented general chemistry courses once provided for all students.

More and more chemical educators find themselves "increasingly convinced of the necessity to shift the objectives of (such) courses from the attainment of an understanding of chemical principles to the understanding of political, economic, and health issues affecting students today."<sup>8</sup>

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<sup>8</sup>Marie J. Piriano, "The Energy Crisis: A New Chemistry Course for Nonscience Majors", The Journal of Chemical Education, Vol. 51, December 1974, pp. 802-803.

STATEMENT OF THE PROBLEM

At Eastern Michigan University several introductory chemistry courses have been offered for many years.

TABLE 2

INTRODUCTORY CHEMISTRY COURSES  
OFFERED AT EASTERN MICHIGAN UNIVERSITY

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|               |                                          |
|---------------|------------------------------------------|
| Chemistry 101 | Science for Elementary Teachers          |
| Chemistry 105 | Survey of Chemistry                      |
| Chemistry 106 | Chemistry for Artists                    |
| Chemistry 115 | Chemistry and Society                    |
| Chemistry 116 | Chemistry and Society Laboratory         |
| Chemistry 118 | Contemporary Materials                   |
| Chemistry 119 | Fundamentals of Chemistry                |
| Chemistry 120 | Introduction to Organic and Biochemistry |
| Chemistry 131 | General Chemistry I                      |
| Chemistry 132 | General Chemistry II                     |

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Except for Chemistry 115 and 116, these courses are all designed to meet the needs of a specific group of students for whom the course is required. The Chemistry 105 course is designed for home economics students. The Chemistry 119 course is designed for non-chemistry majors who need a chemistry course in their curriculum. Chemistry 115, Chemistry and Society, is a course designed for the general student at Eastern Michigan University who is

required to take a certain number of "basic studies" science courses. All students are required to take some science courses, but they may select from among biology, earth science, physics, psychology, mathematics, or chemistry courses. In previous years, the number of students taking chemistry courses to meet this basic studies requirement has been relatively small. In the 1979-80 academic year, Chemistry 115 was offered but cancelled due to meager enrollment. In departmental discussions, the challenge of restructuring this course to attract more of this basic studies market surfaced. It was decided to try a different approach to attract these students and to attempt to develop a course which would gain a reputation as being interesting, informative, and possible to pass.

The writer volunteered to accept this assignment because of her experience in and preference for teaching introductory level courses, especially those designed for nonscience majors.

During the spring and summer of 1980 the course content was planned, a text selected<sup>9</sup> and an advertising campaign begun. Fliers were posted around campus and relatively large advertisements were placed in the student

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<sup>9</sup>John W. Hill, Chemistry for Changing Times, 3<sup>rd</sup> Edition (New York, Burgess Publishing Company, 1979).

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newspaper during the days of registration. Most important, it proved, was the contact made with the student advising office. The course instructor and another faculty member met with the entire staff and discussed with them the nature of the course, gave them copies of the text, and described the type of student who should be steered by them into this course. Letters were also written to various department heads advising them of the desirability of this course for their majors (business, humanities, computer science, and others) and asking their help in making students aware of this course.

The results were gratifying. Eighty-nine (89) students enrolled in Chemistry 115, the lecture course, and of these, eighty-three (83) enrolled in Chemistry 116, the accompanying but optional laboratory course. This success resulted in the two courses being offered again in the winter 1981 semester with enrollments of thirty-four (34) and thirty-one (31), respectively.

The planning for this course involved examining materials, texts, and syllabi from similar courses at other schools. One fact emerged as almost universal in this search. The courses which were being offered for non-science majors were, in most cases, merely condensed or edited versions of the majors' level courses. They often did not approach chemical topics any differently, only more slowly or more quickly, with some rearrangement of

topics, or with less detail.

Some chemical educators have begun to see the need for a totally different focus for this kind of course, as was discussed earlier. An ideal course for nonscience majors would emphasize the ideas and applications of chemistry and not the skills of chemical calculations and manipulations. Such a course would not need the mathematics, the theory, nor the dozens of different types of problems to solve that are so much a part of traditional chemistry courses.

This was the approach chosen which would best serve the intents and needs of the restructured Chemistry and Society course. The students would not receive a watered-down version of the "real" chemistry courses, but a unique course offering them knowledge about chemistry and how it enters into many facets of their daily lives. The goal was more to change how these students perceived chemistry and technology, to help improve their knowledge of important issues, and to help change in a positive way their attitudes toward science, the scientific process, and their own ability to learn some interesting chemistry.

The project undertaken was directed toward developing and teaching a nonscience majors' level chemistry course, "Chemistry and Society", and determining whether students' attitudes toward science changed in a measurable way during the course.

### SIGNIFICANCE OF THE STUDY

The increasing number of "relevant" nonscience majors chemistry courses offered at colleges and universities in this country has been justified by many factors. One of the primary benefits outlined by people supporting this movement has been the need to expose more of the public to the basics of chemistry in an effort to produce a more scientifically literate populace and to improve the image of chemistry and technology in society through this increased knowledge. Underlying these arguments is an assumption that a person's attitude toward science in general, and chemistry specifically, can be positively affected by such a course.

The significance of this study is to provide data that might support this contention and, as a result, offer one form of concrete justification for such courses to continue to be offered in post-secondary educational institutions. It has been recognized by other authors<sup>10</sup> that recent curriculum developments too often lack any systematic investigation of the effects of introducing these new courses of study or approaches to curriculum.

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<sup>10</sup>Ralph Tyler, Rober Gagne and Michael Scriven, Perspectives of Curriculum Evaluation, AERA Series on Curriculum Evaluation. Chicago: Rand McNally, 1967.

### PURPOSES OF THE STUDY

The purposes of this study are:

- (1) to select topics and approaches that would be effective in an introductory nonscience majors' course in Chemistry and Society
- (2) to measure the attitudes of students enrolled in this course toward science and the scientific process, and to determine if changes in these attitudes occur during the course, and
- (3) to provide information that might be of help to other chemical educators in designing, implementing, and justifying a course of this type.

### LIMITATIONS OF THE STUDY

This study is limited by the fact that attitudes toward science and attitude change are not easily quantifiable entities. Instruments to measure attitude change depend on subjective responses and thus are not easy to validate or test for reliability. While results from any attempt to measure attitude change contain useful information with which to determine patterns and possible generalizations, it becomes important not to attach too much meaning to numerical scores.

There also exists a limitation in attempting to infer a direct causal relationship between the activities in a specific class and any change in attitude which might occur. Such a relationship cannot be proven. Other factors inside and outside of the classroom could result in a

change in a student's attitude. This limitation is addressed in part by administering the attitude measurement test to other groups at the beginning and end of the same semester, including a group taking a more traditional required chemistry course and a group of students enrolled in a nonscience freshman level course. The possibility of a given student being present in two or more groups exists but can be detected and taken into account if necessary in the analysis of the data.

The study is also limited in the method of assigning numerical values to specific subjective responses and the manner of totalling scores to perform a descriptive analysis. These topics are discussed in more detail in a later section of this study.

The results of this study which are obtained apply to one course, taught by one instructor, under a specific set of conditions. The instructor's personality, method of presentation, and the students' reasons for taking the course can be as much a determinant in forming a student's attitude as the course content. This limitation is partially addressed by the testing of another chemistry class taught by the same instructor.

Student participation in completing the attitude questionnaire was not one-hundred per cent. No mechanism was invoked to insure that every student in the groups tested completed a questionnaire at both the beginning

and conclusion of the semester. Students completing the courses would be more likely, perhaps, to have more positive attitudes toward the courses, toward the subject matter, and toward their own abilities to succeed. Final data from students who began the courses and subsequently failed or dropped out would not be included in the calculations of attitude change, and thus the data might be slightly biased toward a higher positive attitude at the end. The students with the more positive attitude changes would be more likely to complete the courses and thus to complete the final questionnaire.

#### DELIMITATIONS OF THE STUDY

The study was designed to test students enrolling in specific courses at Eastern Michigan University during two consecutive semesters.

The study was designed to measure average attitude change within a group of students, and while individual scores before and after the completion of the semester are analyzed where available, the hypothesis of the study centers on the class average attitude change.

The study is delimited to those changes in attitude toward science and the scientific process which can be measured by the specific testing instrument used. Some survey-type questions were also used and the students' subjective responses to them are included in the

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discussions of the results of the study.

### DESIGN OF THE STUDY

To measure the change in attitudes toward science and the scientific process, a questionnaire was developed based primarily on test items used in the National Assessment of Education Progress (NAEP) "Attitudes in Science" instrument. This test was administered to students at the beginning of the fifteen week semester and at the end of the same fifteen week semester.

During the fall semester, 1980, the science attitude test was administered to the Chemistry and Society class only. In addition, these students were asked to complete a subjective course and attitude evaluation at the end of the course.

During the winter semester, 1981, the science attitude questionnaire was administered to three groups of students at Eastern Michigan University:

- (1) those students enrolled in Chemistry 115, "Chemistry and Society",
- (2) students enrolled in a section of Chemistry 119, "Fundamentals of Chemistry", taught by the same instructor as the Chemistry 115 course. This is a course required by various curricula and which is more traditional in content, methodology, and chemical knowledge required, and
- (3) students enrolled in a section of History 100, "The Comparative Study of Religion".

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The hypothesis underlying this study is that a positive change in attitude toward science and the scientific process would be largest for the Chemistry 115 group. It might be assumed that the initial attitudes of this experimental group would be most like the initial attitudes of the students in the history course, since both courses involve mostly freshman level students with little formal exposure to chemistry who are not majoring in any area of science and whose areas of concentration do not require any formal training in chemistry. The group in the Chemistry 115 course would be exposed to course material which might affect their attitudes toward science. The group in the history class would not be exposed to similar course content and would not be expected to experience a noticeable change in their attitudes toward science.

The group in the Chemistry 119 course might be expected to have the highest initial positive attitude toward science since these are students going into programs where science will be an integral part. But the change in attitude would not be expected to be as large as that for the Chemistry 115 group since the emphasis of the Chemistry 119 course is the development of skills in chemistry and does not focus directly on students' attitudes toward chemistry. Thus the attitudes of the students in this group would start at a higher level but would not

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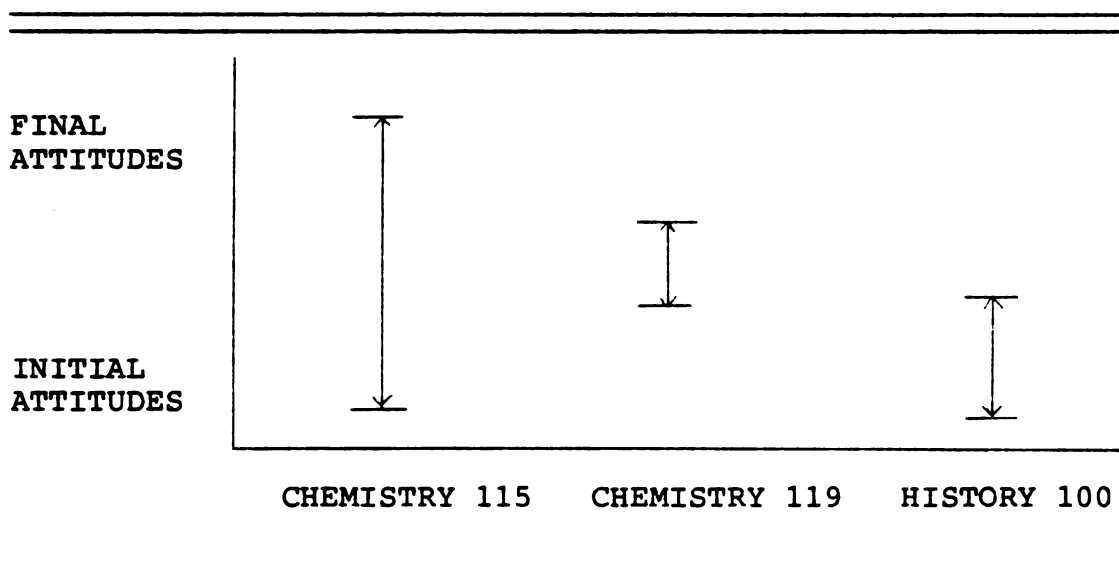
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undergo as large a change as that occurring in the Chemistry and Society group.

As Table 3 illustrates, it is the magnitude of the change in attitude which is of interest in this study.

TABLE 3  
DIAGRAM OF ATTITUDE CHANGE HYPOTHESIS



The questionnaires were passed out in class. Most students completed them outside of the actual class time. Participation was voluntary and no specific information was given to the students concerning the nature or purposes of the questionnaire. The students were requested to take the time to answer the questions as honestly as possible.

Students' names and student numbers were requested on the computer answer sheet for purposes of

cross-checking double enrollments and for determining which students did not finish the course or complete both questionnaires.

After the questionnaires were returned by the students, the responses to each question were coded on a five-point scale (in most instances) ranging from +2 for the most favorable response to -2 for the least favorable response. The use of a Likert-type scale has been indicated as being manageable, accurate, and the most widely used in determining qualitative data of this type.<sup>11</sup>

Analysis of the data and subsequent results and summaries are to be reported in the following sections of this study.

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<sup>11</sup>Robert Ebel, Essentials of Educational Measurement, (Englewood Cliffs, New Jersey, Prentice-Hall, 1972), p. 524.

CHAPTER II  
DEVELOPMENT AND DESCRIPTION  
OF THE CHEMISTRY AND SOCIETY COURSE

The development of an introductory chemistry course which would have appeal and value to the general non-science university student presented a personal and professional challenge. As state previously, the intent was to avoid the approach of offering a modified, supposedly easier, version of the traditional introductory chemistry course with its emphasis on theories, calculations, and all of the other skills offered to students who need additional chemistry in their programs.

The intended direction of the revised Chemistry 115 course was toward a non-skills oriented approach. The goal was a course which would offer the students a different view of chemistry, focusing on what chemistry is, how it touches almost every dimension of daily existence, and how the average citizen can make informed decisions about science and chemical issues.

The primary goal, then, was to select a series of topics, logically related and developed, the discussion of which would require a minimum amount of traditional chemical skills. Those skills which would be included would be justified on the basis of their role in developing the topic at hand. The course was to be formed on a

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framework of relevant topics, with the "hard-core" traditional chemical facts and theories interwoven only as needed to give substance to the topics in the framework.

In developing the actual lecture outline, lecture details, course format, and specific student objectives, the overall goals based on the nature of the course and the students enrolling were kept in central focus. Stated briefly, these goals were

- (1) to introduce the student to a series of chemical topics which would be of interest
- (2) to introduce the student to some of the human, social, philosophical, and ethical dimensions involved in science and technology
- (3) to introduce the student to the important differences between science (along with the scientific process) and technology (the application of scientific principles to practical usages)
- (4) to help the student to recognize that chemistry is not a mysterious, unfathomable, painful area of study accessible only to the select and abnormal few, but that it is filled with ideas, facts, explanations, and discoveries which are genuinely of interest and can be understood and appreciated without hours of rigorous study, and
- (5) to make it possible for the student to learn about chemistry and feel some degree of success from doing so.

Keeping these goals in mind, the following list of topics (Table 4) was chosen to provide the course content.

TABLE 4  
LIST OF TOPICS COVERED IN CHEMISTRY 115

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Introduction to the course, what science is, what  
chemistry is

Unit I: Energy

Nuclear energy (atomic structure, nuclear changes)

Other non-fossil energy sources

Fossil fuels (chemical change, chemical energy)

Unit II: Consumer Chemistry

Air quality

Water quality

Acids and bases

Pesticides

Food additives

Polymers

Unit III: Chemistry and Health

Important biomolecules

Chemistry and medicine, disease

Toxic substances

Chemistry of the mind

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A perusal of the available textbooks intended for courses of this type revealed that most authors chose to follow the traditional approach of introducing many chapters of chemical skills and theories, followed by later chapters of the "interesting stuff". Most, while purporting to be texts for nonscience majors, employed the format, topic sequence, and at times the rigor of a text appropriate for a majors' level chemistry course. As is typical in any development of a unique course, it is difficult to locate existing materials which do exactly what the instructor hopes to accomplish, and the development of the Chemistry 115 course proved to be no exception in this regard.

A textbook was chosen<sup>12</sup>, selected for its readability and sequence of topics, which corresponded quite closely in many areas with the sequence chosen for Chemistry 115, and for its inclusion of interesting and current applications and details. It is a well written and interesting book. While this text still devotes the first eight chapters to the "teaching of chemistry" before introducing the topics chosen for treatment in this course, it came the closest of all the books considered to matching the requirements of the course.

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<sup>12</sup>John W. Hill, op. cit.

### COURSE FORMAT AND MECHANICS

The Chemistry 115 course consisted of three fifty minute lecture periods per week for a fifteen week semester. Students who also enrolled in Chemistry 116, the corresponding optional laboratory course, met for two hours of laboratory activity per week for the semester.

At the beginning of the Chemistry 115 course, the students were given a list of lecture topics, on a day by day schedule, accompanied by the chapters in the text which related to the material which would be covered. They also received a course description listing pertinent course information---an examination schedule, the instructor's office hours, grading criteria, and other details.

Attendance in lecture was not mandatory but the students were informed that tests would be composed of questions based totally on material presented in lecture. Films were shown during several of the lecture periods, and a small number of lectures were given by other faculty members when the topic covered corresponded to an area of their expertise. Demonstrations of various physical and chemical phenomena were incorporated where pertinent and sometimes just for fun.

The student's grade in the course was determined by the total number of points earned out of a maximum of four-hundred fifty (450). Final grades were tabulated on a straight scale (90% and above = A, 80% to 89% = B, etc.)



and were not based on a class performance curve.

Four hour-long, multiple-choice examinations were administered during the course, each worth up to one-hundred (100) points. In addition, the students were expected to report on outside readings, lectures, field trips, science programs on television, etc. to earn up to fifty (50) additional points. Some field trips and lectures by outside speakers were arranged through the university science departments and the Chemistry 115 students were encouraged to participate in these.

Much of the course material was summarized in hand-outs which were distributed to the students at the time that the material was being presented in lecture. This occurred for the most part during the early topics of the course since these were often topics which were not covered directly or in the same manner by the textbook as they were in class. Many of the later topics did correspond more closely to the presentation offered in the book.

In addition, the students were given a review/study guide sheet approximately one week prior to each exam. These contained lists of specific skills and concepts which the students would be expected to know for each topic which would be covered on the exam. There was no cumulative final exam for the course.

The lists of student learning objectives for each exam follow on the next several pages.



STUDENT LEARNING OBJECTIVES: CHEMISTRY 115

## First Exam:

## I. Introduction, history

know the formal definition of chemistry

know what chemistry attempts to study

know some of the important ideas contributed by the Greeks and the influence of some of the erroneous Greek views of nature

know the goals and actual contributions of the alchemists

be able to discuss and know the important ideas in the changing views of the atom

know the meaning of these terms: element, compound, atom, molecule, nucleus

## II. Atomic structure

know the three important particles which comprise the atom (proton, neutron, electron); know their charges, relative masses, and where they occur in the atom

know the meaning of atomic number and how it relates to the identity of the atom

know the meaning of the term "isotope"; know how isotopes differ, how they are the same; know the meaning of atomic mass

## III. Nuclear changes

be able to describe in general terms the three major spontaneous radioactive processes--alpha, beta, and gamma emission

know why new nuclei may be formed during alpha and beta processes

be familiar with the concept of half-life; know how half-life gives some indication of how rapidly a given isotope is giving off radiation

know in general what is meant by artificial nuclear changes; know the meaning of these terms: transmutation, artificial isotopes, transuranium elements

#### IV. Fission and fusion as energy sources

know what the ultimate source of energy is for all nuclear reactions (the conversion of mass into energy)

know the general definition of fission; know the important features of a fission reaction--that more neutrons can be formed than are initially used; know the relative amounts of energy formed compared with conventional energy sources

know the meaning of critical mass, chain reaction, daughter nuclei, heavy water, enriched fuel

know the general principles of a nuclear power plant, how it differs and how it is similar to conventional power plants

know the means by which the reaction rate in a fission power plant can be controlled

be able to list and discuss the advantages and the disadvantages of fission power plants

know the approximate level of current usage of nuclear power in the United States

know the general definition of fusion; know that it is the process occurring in stars; know the general features of fusion and the relative amounts of energy produced

be able to list and discuss the advantages and the disadvantages of the use of fusion in power plants

know the current level of research and technology in the development of fusion as a power source

#### V. Other non-chemical sources of energy

be able to describe briefly the use of geothermal, tides, wind, hydroelectric power as energy sources

know the feasibility and limitations of these energy alternatives as well as their current level of use in the United States

be able to discuss some of the important issues in the use of solar energy--the feasibility of using it on a large scale, the technological difficulties, the advantages, the limitations, and the important modifications needed

## Second Exam:

## I. Energy from chemical reactions

know that compounds are held together by chemical bonds which involve the losing, gaining, or sharing of electrons

know that most chemical reactions are exothermic (give off energy) while some others are endothermic (absorb energy)

know that a combustion reaction is the reaction of a substance with oxygen and that these reactions are almost always exothermic

know the definition of organic compounds and the reasons why carbon is unique in its ability to form so many compounds

know what hydrocarbons are, what some of their important properties are, and why they are important as fuels

know what the actual source of fossil fuels is; know some of the history of the use of these substances as fuels; know the relative U.S. consumption of fossil fuels compared to other industrialized nations

a. natural gas: recognize the formula for methane; know the advantages and disadvantages of natural gas as a fuel; know the relative amounts of this fuel available; know something about the possibility of renewing supplies of it from organic wastes

b. petroleum: know some of the important groups of compounds in this category--gasoline, kerosene, etc.; know some of the important functions of the refining process; know what "cracking" means; know the importance of petroleum to the chemical industry; know what octane rating means and how the quality of gasoline can be improved

c. coal: know something about the relative availability of coal, especially as compared with the other fossil fuels; know the types of coal and their properties in burning; know what effect the presence of sulfur has; know the major advantages and disadvantages using coal as a power source; know the general differences between strip mining and deep mining; know what coal gasification is

other energy alternatives: know that green plants can be used directly as energy sources (the work of Melvin Calvin); know how coal gasification, oil shale, and recycling can present partial answers to the energy problem

## II. Air quality

know the approximate composition of unpolluted air

know the levels of the atmosphere which become affected by pollutants

know the definition of a pollutant

know the relative amounts of air pollution in the United States (140,000 tons per day); know the relative amounts of this contributed by transportation, industry, nature

know what is meant by a thermal inversion and why it causes such severe problems with air safety

specific air pollutants:

- a. oxides of sulfur ( $\text{SO}_2$ ,  $\text{SO}_3$ ): 15% of total  
know the main source of these; know that they are considered the worst by WHO; know some of their properties and the types of damage they cause; know that they react with water to form acid rain
- b. oxides of nitrogen (primarily  $\text{NO}_2$ ): 13%  
know the sources of this pollutant, some of its properties and the type of damage it causes; know that it plays an important role in photochemical smog; know that it also reacts with water to form acid rain
- c. oxides of carbon ( $\text{CO}$ ,  $\text{CO}_2$ ): 49% of total  
know the sources of these; know the properties of  $\text{CO}$ , its toxicity, occurrence; know the properties of  $\text{CO}_2$ ; the greenhouse effect--know what this is and what the potential problems are with it
- d. hydrocarbons: 16% of total  
know the general properties and the names of some of the most important ones; know what the sources of these as pollutants are; know what problems they cause; know some of the natural sources of pollutants of this type

e. ozone ( $O_3$ )

know the relationship of ozone to elemental oxygen; know its relative instability; know the sources of it in the lower atmosphere and what problems it causes there; know its properties, such as toxicity and the type of damage it causes; know that it is a natural component of the stratosphere; know its role in absorbing ultraviolet radiation and the benefits of this; know the nature of the controversy over fluorocarbons and their possible effect on the ozone layer

## f. particulates

know what this means; know which pollutants fall into this category; know the main reasons why they cause damage; know specific sources and problems with lead and asbestos; know the relationship of particulates with weather changes

## III. Water quality

know the natural components of water in the environment (minerals, dissolved oxygen, acids, etc.)

know the problems which limit the amount of usable water on earth

know and be able to discuss some of the important properties of water which cause it to be such a good solvent and to function in so many other ways

know what is meant by hard water

know why water for human use must be treated and know what procedures this involves; know the relationship of certain diseases to water quality; know what chemicals are used for water purification and some of the potential problems associated with them; know why fluorine is added to water; know some of the natural contaminants of water; know the nature, source, and problems caused by some of the added contaminants--phosphates, organic compounds, nitrates, mercury, lead, heat; know what is meant by ppm and how this quantity relates to total amount of pollutants present; know some of the limitations of measuring water purity

Third Exam:

## I. Pesticides

know the reasons why pesticides are needed;  
know the relative amounts of crop damage  
and insect-carried diseases

know some of the history of DDT, its great  
successes, some of the problems which have  
surfaced, why it was banned in 1972

know some of the other alternatives in the area  
of insect control: organic phosphorus  
compounds, carbamates (know some examples of  
these as well as the advantages and dis-  
advantages they present)

know some of the other techniques used, know in  
general what they are and how they work---  
pheromones, juvenile hormone, sterilization  
by radiation, use of natural predators

## II. Food additives

know the important differences between the terms  
natural and artificial compounds

know the general classifications of food addi-  
tives; know why they are added; know some  
examples of the major ones used

be able to discuss the safety, advantages, and  
disadvantages of the food additive industry

be able to discuss the history of the regula-  
tions of food additives and the role of the  
FDA

## III. Introduction to some organic chemistry

identify some of the main classes of organic  
compounds: hydrocarbons, alcohols, aromatics,  
acids, amines

know that properties and behavior of organic  
compounds can be generalized to a great  
degree based on the functional groups present

be able to make some generalizations about some  
compounds based on their functional group

know that carbon compounds contain either sin-  
gle, double or triple bonds between carbon  
atoms and that the type of bonds present  
has a great effect on the properties

#### IV. Polymers

know the meaning of the terms polymer and monomer

know some of the naturally occurring polymers

recognize the names of some of the important  
synthetic polymers; know something about the  
history of how these compounds were developed

know some of the examples of the uses of polymers

know some of the general properties of polymers

know some of the problems associated with the  
disposal of synthetic polymers; know the  
limitations of the methods using burial,  
burning, and recycling

know some of the possible solutions to the  
problems of disposal of synthetic polymers

#### V. Some polymers used as food

know the four most important elements in living  
systems

know some of the important minerals needed for  
good health and what their metabolic roles are

know what vitamins are, in general; know the  
difference between water-soluble and non-water  
soluble vitamins; know which are which and  
what their important metabolic roles are

know in general what carbohydrates are; know some  
examples of the important monosaccharides, di-  
saccharides and polysaccharides; know the role  
of enzymes in metabolizing carbohydrates; know  
why humans cannot digest cellulose; know the  
general relationship of carbohydrates to the  
body's storage and use of energy

know the general definition of lipids and what  
their general properties are; know their use  
as an energy source in the body; know the  
relative amounts of energy obtained; know the  
meaning of saturated versus unsaturated fats  
and what relationship this might have to good  
health; know some of the major roles of lipids  
in the body other than as an energy source

know that proteins are polymers of amino acids;  
be able to recognize the structure of an  
amino acid; know that all living systems use  
the same amino acid building blocks; know the  
important roles of proteins in the body, par-  
ticularly the roles of enzymes

FOURTH EXAM:

## I. Chemistry and disease control

know something about the major causes of death  
know the meaning of the word "chemotherapy"  
know something about the history of the use of chemicals in treating disease  
know what synthetic drugs are and when they first appeared  
know why deaths from infectious diseases have decreased and other causes have increased  
know the relationship between the chemistry of a disease process and controlling it  
know that some diseases can be managed but can not yet be cured; know some examples  
know the difference between cure and immunization  
know what is meant by resistant strains of bacteria and why this has caused problems  
know the major categories of antibiotics  
know some of the problems which can result from food and drug interactions

## II. Over-the-counter medications

know what aspirin is (its chemical name); know in general what it does; know that it is the most widely sold non-prescription drug; know some its potential side-effects  
be able to recognize and discuss some of the real and advertized differences in such medications

## III. Chemical toxicity

know the general definition of a poison or toxin  
know the general classifications of poisons: corrosives (acids, bases, phosphates, etc.), oxygen transport poisons ( $\text{CO}$ ,  $\text{CH}_4$ ), heavy metals, nerve poisons, cyanide  
know the mechanisms of these general classes of poisons  
know that a knowledge of the chemistry of a poison can lead to a knowledge of potential antidotes; know some examples of chemical antidotes

know the important categories of compounds which affect cell growth and reproduction: mutagens, teratogens, carcinogens

know that most cancers are environmentally caused

know some examples of cancer-causing materials, both naturally occurring and synthetic

know and be able to discuss some of the factors which make the study and control of cancer so complex

know what is meant by chemical synergism; know how this term relates to the discussion of cancer causes

know some of the proven techniques for curing cancer; know the roles of radiation therapy, surgery, and specific types of chemotherapy

know what interferon is and how it relates to the discussion of cancer therapy

#### IV. Chemistry of the mind

know the general classes of external compounds (chemicals) which affect the mind: stimulants, depressants, hallucinogens; know the important examples of each, levels of misuse, valid medical uses of some of them

know that the body produces its own natural opiates and stimulants; know that these are chemically related to some synthetic drugs; know that these chemicals are responsible for emotional states and mood changes and some mental disorders

know that the endorphins and enkaphalins are naturally-occurring morphine-like proteins in the human brain, that they cause euphoria, and that they are generated in response to external and internal stimuli; know some examples of how they interact

know that the brain produces three important neurotransmitters: dopamine, serotonin, and norepinephrine; know that these are chemically related to amphetamines and cause similar biological responses; know something about the role of these three in various types of emotional disorders and how they have been very important in the treatment of some mental diseases

### CHAPTER III

#### DISCUSSION OF ATTITUDE MEASUREMENT

The study of attitudes has been a standard feature of social psychology during the past fifty years.<sup>13</sup> One author<sup>14</sup> defines an attitude as "an enduring system of positive or negative evaluations, emotional feelings and pro or con action tendencies with respect to a social object".

It is recognized that attitudes, though defined by different authors in different ways, possess certain general features. The concept of an attitude, for example, is not a directly observable variable, but is classified as being hypothetical or latent. Attitudes are inferred from other observable variables---a person's behavior in certain situations or their subjective responses on an attitude survey.

Attitudes are learned. They can be formed from many stimuli and often are brought about through exposure to additional information on a subject. Attitudes vary in

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<sup>13</sup>M.E. Shaw and J.M. Wright, Scales for the Measurement of Attitudes (Chicago, Illinois; The University of Chicago Press, 1959).

<sup>14</sup>David Krech, Richard Crutchfield and Egerton Ballachy, Individual in Society (New York, McGraw-Hill Book Company, Inc. 1962), p. 224.

quality and intensity on a continuum ranging from positive through neutral to negative. Though attitudes are developed from a person's experience with ideas, events, or other people, once initially formed, they tend to be relatively stable and enduring. They change slowly, and even then, only changes in intensity or slight shifts in the position on the positive-negative continuum are usually all that are observed. Severe or drastic changes in attitudes do not usually occur, unless precipitated by a highly significant event. The direction and degree of attitude change which might be induced by external factors is a function of many variables such as the source, the medium, the form, and the content of the information which has altered it.<sup>15</sup>

The more central an attitude is to a person's value system, the more resistant it is to change. Conversely, attitudes about subjects that are not perceived as directly affecting a person's daily life are more easily altered. The individual's commitment to and personal involvement in such attitudes is not large.

In some individuals, attitudes toward science, for example, may be comparatively easy to change (at least to a slight degree) if the individual does not perceive scientific facts and issues as playing important roles in

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<sup>15</sup>Ibid, p. 226.

his or her life. If this same person were to change their perception of the importance of these issues, his or her attitudes toward science would become more centralized and thus more resistant to challenge or modification.

The measurement of any attitude can be complex because of the absence of directly quantifiable dimensions. Observing an individual's behavior and extrapolating attitudes from those observations is a tedious, inefficient, and not necessarily valid method of attitude measurement. A more commonly accepted and manageable method involves the evaluation of an individual's subjective responses to a series of questions in an instrument designed to assess attitudes. This method, too, has limitations. The quantity being measured is the individual's response, not necessarily his or her attitude. A person might claim, knowingly or unknowingly, to have attitudes which really are not present. This limitation exists whenever an indirect variable is being measured by means of a more directly observable one.

Another limitation of attitude assessment via subjective questionnaire exists in the realm of scoring. Attitudes do not exist in discrete quanta of measurable size. An absolute scale cannot be constructed. Attitudes can only be assessed on a relative continuum.

Instruments used to measure attitudes have invoked many elaborate scaling techniques. Two techniques have

emerged as the most commonly employed<sup>16</sup>, the method developed by Thurstone<sup>17</sup> involving scaled statements, and the method developed by Likert<sup>18</sup>. In this latter approach, statements designed to be either favorable or unfavorable are responded to on a five-point scale (strongly agree, agree, no opinion, disagree, strongly disagree) or some variation of this.

The use of a Likert-type scale has been proven to be as valid as any of the other more elaborate systems which might be used, and it is one of the most direct and efficient to employ.

Numbers derived from an attitude assessment, no matter which scaling technique is involved, have no absolute meaning in and of themselves. They are useful for comparative purposes---to determine if a specific group of subjects differs in attitude from some other group of subjects. Magnitudes of differences must be interpreted cautiously.

In the measurement of attitude change within a given group of respondents, the precise method of scoring and its

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<sup>16</sup>Ebel, op. cit., p. 524.

<sup>17</sup>L.L. Thurstone, The Measurement of Values (Chicago, Illinois; The University of Chicago Press, 1959).

<sup>18</sup>R. Likert, "A Technique for the Measurement of Attitudes", Archives of Psychology, Vol. 22, October 1932, pp. 1-55.

statistical validity becomes less critical since it is a change in score, on a qualitative level, which is the variable of interest.

In the study described here, the purpose is to determine whether a change in attitude, as measured on a constructed attitude assessment instrument, occurred. The concern is not what the quantitative magnitude of that change might have been or to make conclusions based on specific numbers, although these numbers will be examined.

Numerous tests for the measurement of attitudes toward science have been developed, many of them for specialized groups of students. The most comprehensive materials in this area are part of the National Assessment of Educational Progress, developed by the Educational Commission of the States. This organization was established in the late 1960's to address the challenge of assessing the nation's progress in its educational endeavors.

Yearly, since 1964, this group has surveyed nine, thirteen, and seventeen-year olds, as well as young adults, in ten areas of learning.

The assessment tests which NAEP uses evolved from years of collaboration by educators, scholars, and lay persons throughout the country. They began by designing objectives based on general goals for each learning area. Test items were then developed from these objectives. Extensive reviews preceded the administration of the tests

to small samples of subjects. The final assessments which became part of the project are thus some of the most highly accredited, closely scrutinized tests in both cognitive and affective areas. Many of these materials containing released items are available for use by educators who might recognize them as fitting their specific testing needs.

As part of their 1976-77 nationwide assessment, the NAEP included items intended to investigate attitudes toward science.

The affective assessment is comprised of eight logically organized groups of test items, each of which measures closely related attitudes considered important by science educators. These eight areas tested are:

- (1) Attitudes toward science classes. Attitudes assessed in these questions are all related to classroom experiences and how the students felt about them. The original NAEP materials included checklists to assess the extent of the student's involvement in science-related activities outside of the classroom.
- (2) Vocational and education intentions. These questions address the student's attitudes and plans regarding further study in science and the possibility of their considering entering a science-related career.
- (3) Personal involvement in science. The purpose of these questions is to determine whether students believe society-related science problems personally affect them or whether students feel that they can have any impact on changing social conditions. Some items deal with whether or not students are willing to work directly in helping to solve some problems.
- (4) Usefulness of science education. These questions are intended to assess the student's opinions

about the utility of the skills, procedures, and ideas of science that they are learning in school.

- (5) Confidence in science. These questions center on the student's belief that science is of benefit to society. It assesses their confidence whether science can help solve world problems.
- (6) Support of research. In these questions, students are asked to indicate whether research should be allowed and/or supported in certain specific areas. These questions can also determine whether students correctly perceive the relationship between seemingly obtuse areas of research and useful discoveries.
- (7) Controversial issues. These questions seek to determine the student's attitudes toward seemingly dangerous, non-traditional, or questionable areas of scientific research. Though "right" answers do not exist for these questions, they are useful for determining students' opinions and any shift in opinions about the role of scientific research.
- (8) Awarenessss. These questions determine whether or not students are aware of the assumptions, values, and processes involved in science. These questions have a more cognitive content than some of the other areas because they are testing the student's awareness of the scientific process.

The attitude assessment used in this study (Appendix A) is composed of items from the National Assessment of Educational Progress Attitudes Toward Science test which was part of the 1976-77 national assessment. Those items were selected which were perceived to be most directly related to testing attitudes about science among college level students. Those questions which dealt with science classroom activities, which were geared toward the K-12 age students, and which asked about involvement in

science-related activities (looking through a telescope, and questions of that type) were omitted along with others which were deemed peripheral to this study.

During the testing of the first group of Chemistry 115 students (fall semester, 1980), two questionnaires were used. The first contained questions primarily from the NAEP materials, with some additional ones composed by the writer. This questionnaire was administered to the class during the first and last weeks of the fifteen week semester.

A second survey/questionnaire was distributed to the fall semester group at the end of the course only. It contained more direct questions, to be answered subjectively, concerning the students' perception of any attitude changes they felt may have occurred.

The qualitative results and discussion of these two questionnaires are contained in the later chapters of this study. Copies of the actual surveys used are in Appendix A.

For the winter 1981 assessment (involving the three test groups---Chemistry 115, Chemistry 119, History 100) the attitude assessment based on the NAEP materials was refined and written in a format which facilitated computer scoring. It contained one-hundred eight (108) items.

Sixty-eight (68) of the items contained five-point responses (strongly agree, agree, no opinion, disagree, strongly disagree) which were scored on a +2 through -2

scale.

Thirty-one (31) items had four possible responses and were scored on a +2 through -1 scale.

Nine (9) items had three possible responses, and these were scored as +2, +1 or 0.

In assigning numerical values to the responses, one concern was consistency. The most favorable response was assigned a value of +2 in all instances. Some questions did not have highly unfavorable response choices, which is the reason that the lowest score possible varies for some of the questions.

In using a scale of this type for scoring, it is important to recognize that applying number values to qualitative variables has many shortcomings. The magnitude of difference between a -2 and a -1 response, for example, though scored the same, most likely does not represent the same attitude difference as that between a 0 and a +1 response. Equally spaced intervals cannot be assumed in scoring of this type.

The major flaw in this numeric assignment is perhaps obvious---not all questions are of equal value in their ability to assess science attitudes. A "strongly agree" response to "Science makes our lives better" (question 95) does not carry the same value, intrinsically, as a "strongly agree" response to "Would you be interested in designing and building things?" (question 30). Yet in the

scoring, they are assigned equal value.

This concern is mitigated by the over-riding caveat that no significance (statistical or otherwise) is attached to specific individual scores, but rather to whether scores change in an upward direction over the course of the fifteen week semester. Some attempt is made in the analysis of the data and the discussion which follows to examine the responses to specific questions which qualitatively might be more related to the attitudes which are of interest in this study.

In concluding the discussion of the testing instrument used, Table 5 lists the categories of questions which the specific items in the attitude questionnaire used represent.

TABLE 5  
CATEGORIES OF QUESTIONS:  
SCIENCE ATTITUDE QUESTIONNAIRE

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|                  |                                                                     |
|------------------|---------------------------------------------------------------------|
| QUESTIONS 1-11   | Attitudes toward science classes                                    |
| QUESTIONS 12-19  | Personal involvement in science activities                          |
| QUESTIONS 20-40  | Vocational attitude toward science                                  |
| QUESTIONS 41-55  | Personal involvement in solving<br>scientifically-related problems  |
| QUESTIONS 56-65  | Attitudes toward the ability of science<br>to solve social problems |
| QUESTIONS 66-70  | Attitudes toward the effect of science<br>on society                |
| QUESTIONS 71-89  | Specific areas of research to be funded                             |
| QUESTIONS 90-108 | Understanding of the scientific process                             |

CHAPTER IV  
SUMMARY OF DATA:  
FALL 1980 STUDY

BACKGROUND INFORMATION

Chemistry 115, Chemistry and Society, was offered during the fall semester, 1980, for three semester hours of credit. Eighty-nine (89) students initially enrolled for the course. Three students withdrew from the course prior to the first exam and three more withdrew after the first exam. A total of eighty-three (83) students, therefore, completed the course. Of these, fifty-three (53) were female and thirty (30) were male.

In the first week of the course, these students were asked to complete a short questionnaire to supply data both to the chemistry department administration and for the purposes of this study. Sixty-seven (67) students completed this initial questionnaire which dealt with background data on the students.

Some students left some of the response areas blank, explaining why the numbers do not add up to sixty-seven in all cases. A summary of the most pertinent responses compiled from these questionnaires is contained in Table 6.

In looking at this information, several pertinent facts emerge. One of the considerations behind revamping this course was to bring students into a chemistry course

TABLE 6  
BACKGROUND DATA:  
CHEMISTRY 115: FALL, 1980

|                                                                                        | Yes | No |
|----------------------------------------------------------------------------------------|-----|----|
| Have you had any previous chemistry course?                                            | 25  | 39 |
| Would you have taken another chemistry course had you not signed up for Chemistry 115? | 16  | 50 |

|                                         | Advisor | Other |
|-----------------------------------------|---------|-------|
| How did you find out about this course? | 58      | 9     |

| Grade Level | Freshman | Sophomore | Junior | Senior |
|-------------|----------|-----------|--------|--------|
|             | 42       | 14        | 8      | 2      |

|                      |               |    |
|----------------------|---------------|----|
| Major area of study: | Business      | 31 |
|                      | Science       | 1  |
|                      | Law           | 2  |
|                      | Humanities    | 5  |
|                      | Communication | 4  |
|                      | Education     | 2  |
|                      | Undecided     | 20 |

who would not otherwise elect to take one. The second response in Table 6 shows a satisfying testimony that the course was indeed tapping a "new market" and was not merely pulling students from other chemistry courses.

The analysis of the students' major areas of study also reveals that the course was attracting the intended market---nonscience majors. The one declared science major in the class was a biology major and a personal friend of the instructor. The large number of students from the college of business is partially a reflection of a very positive recruiting effort by the dean of the College of Business in recommending this course to his college's students.

The answers to the third question summarized in Table 6 indicate the strong role that an effective advising program can have on student enrollment decisions, particularly among freshman students. As was mentioned earlier, an integral component of the advertising for this course involved talking with the staff of advisors and encouraging them to direct students toward this course.

The retention data for this course are comparatively high---eighty-three (83) completing the course out of the eighty-nine (89) initially enrolling. This, perhaps, reflects success in the effort to produce a course which would not only attract students, but keep them interested and provide them with a positive, primarily successful

experience in a chemistry course.

Attrition rates for other freshman-level chemistry courses at Eastern Michigan University average from 10% to 15%. For example, in a Chemistry 119 course (Fundamentals of Chemistry) taught by the writer during the fall 1980 semester, seventy-seven (77) out of ninety-three (93) students completed the course---an attrition rate of 17%. The Chemistry 115 attrition rate for the fall 1980 semester was just under 7%.

The grades earned by the eighty-three (83) students who completed Chemistry 115 were distributed as shown in Table 7.

TABLE 7  
GRADE DISTRIBUTION:  
CHEMISTRY 115: FALL, 1980

| GRADE | PERCENTAGE<br>(POSSIBLE<br>POINTS) | NUMBER OF<br>STUDENTS | PERCENTAGE<br>OF CLASS | MALE | FEMALE |
|-------|------------------------------------|-----------------------|------------------------|------|--------|
| A     | 90-100%                            | 12                    | 14.5                   | 3    | 9      |
| B     | 80-89%                             | 33                    | 39.8                   | 12   | 21     |
| C     | 65-79%                             | 28                    | 33.7                   | 14   | 14     |
| D     | 55-64%                             | 7                     | 8.4                    | 1    | 6      |
| E     | below 55%                          | 3                     | 3.6                    | 0    | 3      |

Seventy-three (73), or 88%, of those completing the class earned a grade of C or better in Chemistry 115. This is the result of many factors. First, the course was not intended to be as rigorous as a skills-oriented traditional chemistry course. It was designed to be equivalent in scope and difficulty with survey courses in other science disciplines. The students were informed from the beginning that this course would not provide them with the needed prerequisites to move on to higher level chemistry courses.

Secondly, the students enrolled in the course were given guidelines and clear explanations of what they would be expected to do to succeed in the course. Most were enthusiastic and concerned enough to heed these guidelines. Attendance was consistently high, and preparation for exams was evident. Students actively participated in class discussions and were not reluctant to ask questions which would clear up any points of confusion. Outside lecturers who worked with the class commended them for their level of interest and attentiveness.

The objective format of the tests, written directly from the study objectives provided to the students, the requirement to complete outside readings and activities, and the straight scale used in determining student grades contribute to a satisfaction on the part of the instructor and departmental colleagues that this grade

distribution is fair, realistic, and consistent with the stated goals of the Chemistry 115 course.

SCIENCE ATTITUDE QUESTIONNAIRE: FALL 1980

Appendix A contains a copy of the science attitude questionnaire which was distributed to the Chemistry 115 class at the beginning and at the end of the fall 1980 semester. No mechanism was established for scoring this survey. The purpose of gathering these responses was to assist in obtaining a general overview of student attitudes toward science and any change which might occur in those attitudes.

The focus of this research is the data gathered during the winter 1981 semester, but a brief look at some of the responses from the fall 1980 group is of interest and provides some background for discussion.

On the initial questionnaire, eighty-two (82) students responded. Seventy-nine (79) students responded on the questionnaire at the end of the semester. The values listed in the following tables are expressed as percentages---and the overall change is expressed as a percentage also. Values are calculated to two significant figures and are not intended to be interpreted too rigorously but rather as qualitative indications of changes which might be taking place.

TABLE 8  
ATTITUDES TOWARD SCIENCE CAREERS

| QUESTION                                                                                                                    | PERCENTAGE RESPONDING<br>AGREE OR STRONGLY AGREE |       |        |
|-----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-------|--------|
| 1. For me, the education and training needed to prepare me to work in a scientific field would open many job opportunities. | Initial                                          | Final | Change |
|                                                                                                                             | 67%                                              | 77%   | +10%   |

It is perhaps surprising that the number of initial positive responses to this question was so high, considering the students' choices of majors as reflected in an earlier table. The slight change in attitude which seems to have occurred here could reflect an overall increase in awareness of the role of science in so many facets of our society.

TABLE 9  
GENERAL REACTION TO SCIENCE AND TECHNOLOGY

2. Which of these words best describes your general reaction to science and technology?

| RESPONSE             | PERCENTAGE OF STUDENTS CHOOSING THIS RESPONSE |       |        |
|----------------------|-----------------------------------------------|-------|--------|
|                      | Initial                                       | Final | Change |
| FEAR OR ALARM        | 11%                                           | 10%   | -1%    |
| EXCITEMENT OR WONDER | 26%                                           | 38%   | +12%   |
| SATISFACTION OR HOPE | 39%                                           | 49%   | +10%   |
| INDIFFERENCE         | 26%                                           | 11%   | -15%   |

The number of students initially expressing fear or alarm is relatively small, proportionally, so it is not surprising that more of a change did not occur in this category. In later questions, students indicated that they felt to a larger extent that science and technology were responsible for many of society's problems, reflecting perhaps an actual increase in the amount of fear or alarm with which students are reacting toward science and technology.

The next two descriptors in Table 9 do show a slight trend in the anticipated direction. Perhaps it is most interesting that fewer students indicated that their major response to science and technology was a feeling of indifference after completing the course.

The third question on this initial questionnaire asked the students how they generally felt when they were in a science class. To highlight one response category, initially nineteen (19) students out of eighty-two (82) responding said that they felt dumb while in a science class. This number changed to sixteen (16) out of seventy-nine (79) by the end of the semester. Expressed another way, initially 23% of the students responded that they felt stupid. After the completion of the course, 20% still responded this way. This datum is interesting in light of the grade distribution of the class. An optimistic interpretation is that the students may still feel "dumb", but for different reasons after learning an appreciation of the complexity and scope of what there is to know.

Tables 10 through 12 on the following pages summarize data from some of the other pertinent questions on the questionnaire administered to the fall, 1980 group.

TABLE 10

## DEGREE OF CONTROL OVER SCIENCE AND TECHNOLOGY

4. Do you feel that the degree of control that society has over science and technology should be increased, decreased, or remain the same?

| RESPONSE        | PERCENTAGE OF STUDENTS RESPONDING |       |        |
|-----------------|-----------------------------------|-------|--------|
|                 | Initial                           | Final | Change |
| INCREASED       | 18%                               | 23%   | + 5%   |
| DECREASED       | 15%                               | 14%   | - 1%   |
| REMAIN THE SAME | 32%                               | 42%   | +10%   |
| NO OPINION      | 31%                               | 24%   | - 7%   |

TABLE 11

## ROLE OF SCIENCE AND TECHNOLOGY IN CAUSING PROBLEMS

5. Do you feel that science and technology have caused most, some, few, or none of these problems?

| CATEGORY OF PROBLEM | PERCENTAGE RESPONDING<br>"MOST" OR "SOME" |       |        |
|---------------------|-------------------------------------------|-------|--------|
|                     | Initial                                   | Final | Change |
| POLLUTION           | 66%                                       | 81%   | +15%   |
| DISEASE             | 33%                                       | 44%   | +11%   |
| DRUG ABUSE          | 48%                                       | 74%   | +26%   |
| ENERGY SHORTAGES    | 52%                                       | 65%   | +13%   |
| INFLATION           | 33%                                       | 37%   | + 4%   |

TABLE 12

## ABILITY OF SCIENCE AND TECHNOLOGY TO SOLVE PROBLEMS

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6. For the most part, do you feel that science and technology will eventually solve most, some, few, or none of the problems such as pollution, disease, drug abuse, etc.?

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| RESPONSE | PERCENTAGE RESPONDING |       |        |
|----------|-----------------------|-------|--------|
|          | Initial               | Final | Change |
| MOST     | 27%                   | 38%   | +11%   |
| SOME     | 57%                   | 56%   | - 1%   |
| FEW      | 11%                   | 6%    | - 5%   |

---

In looking at the data in these last three tables, some discussion seems warranted. First of all, in Table 10, there does not appear to be much of a change in any of the categories except that more students at least ventured an opinion on the final survey.

In Table 11, the responses certainly contained some unanticipated results. Especially noticeable is the increase in the number of students who felt that science and technology were responsible for problems of disease (an increase of 11%) and the problems of drug abuse (an increase of 26%). Such attitudes were not intended as any

part of the message in the treatment of any part of the course. It is interesting to conjecture why such an attitude change might result. Again, it may be a result only of an increased awareness of the role of science and technology in so many dimensions of daily life---both good and bad dimensions. These data are also somewhat humbling to an instructor who feels that he or she is generating mostly positive attitudes about a chosen field. The last statistic somewhat alleviates the worry that these values are based directly on class discussions since it shows an extrapolation beyond what would normally be expected and a possible lack of discrimination in assigning blame for society's ills.

In Table 12, the responses show some positive change in attitude toward the benefits to society that science and technology might provide.

SUBJECTIVE SURVEY: FALL, 1980

At the end of the course, in addition to the science attitude questionnaire, the Chemistry 115 students were asked to complete a course evaluation form (Appendix A). Several questions related to course format, difficulty, choice of topics, etc. The last page of the three-page survey contained questions asking for the students' opinions regarding comprehension and attitude changes that occurred during the semester. These questions and their responses are summarized in Tables 13 and 14.

TABLE 13  
CHANGE IN UNDERSTANDING SCIENCE

| 1. Please answer honestly whether BEING IN THIS COURSE has changed your attitudes in any way about the following: |     |     |           |
|-------------------------------------------------------------------------------------------------------------------|-----|-----|-----------|
|                                                                                                                   | YES | NO  | UNCERTAIN |
| Do you have a better understanding of what science is?                                                            | 89% | 10% | 1%        |
| Do you have a better understanding of what chemistry is?                                                          | 94% | 6%  | 0%        |
| Do you have a better understanding of how scientific problems are solved?                                         | 84% | 15% | 1%        |
| Do you have a better understanding of what it is possible for scientists to know?                                 | 85% | 13% | 1%        |
| Do you have a better understanding of some of the philosophical and ethical questions relating to science?        | 69% | 28% | 4%        |
| Do you have a better understanding of how chemistry relates to other areas of study?                              | 93% | 7%  | 0%        |
| Do you have a better understanding of how chemistry relates to YOUR everyday life?                                | 99% | 1%  | 0%        |

TABLE 14  
SUBJECTIVE EVALUATION OF ATTITUDE CHANGE

2. Indicate whether your attitude is MORE POSITIVE, LESS POSITIVE, or ABOUT THE SAME as when you started this course.

| ATTITUDE                                                                                      | MORE<br>POSITIVE | LESS<br>POSITIVE | SAME |
|-----------------------------------------------------------------------------------------------|------------------|------------------|------|
| about your ability to<br>understand science                                                   | 69%              | 2%               | 29%  |
| about the benefits of<br>chemistry to the quality<br>of life in our society                   | 67%              | 1%               | 32%  |
| about the need for laws<br>to regulate science                                                | 55%              | 5%               | 40%  |
| about the requirement that<br>all students take science<br>courses in college                 | 33%              | 7%               | 60%  |
| about your ability to make<br>intelligent decisions on<br>some important scientific<br>issues | 79%              | 4%               | 17%  |

In looking at the responses in Table 13, lengthy interpretation or discussion is not needed. Evaluated for what they are---the students' answers to a direct question about any increase in understanding in various areas which they felt occurred---they indicate clearly that the students felt that the course decidedly had an affect on many areas.

These data, while subject to the limitations of all directly-asked subjective data of this type, are perhaps the most convincing in any judgement of whether the initial course goals were achieved.

The last question on the questionnaire was the question dealing with the students' perceptions about their own attitude changes. These responses were summarized in Table 14.

The first, second, and last items in this group are the most pertinent to this study. All indicate that more than two-thirds of the students felt that their attitudes about understanding science and the benefits of science had become more positive. The responses to the last item were decisively indicative that the students felt they were more able to make intelligent decisions in scientific areas as a result of being in the Chemistry and Society course.

Again, these data are the most direct in determining that the hypothesis that attitudes toward science can be

changed in a positive direction by participation in this chemistry course is valid.

The data summarized in these two table (Table 13 and Table 14) clearly indicate that the students left the course with more positive feelings about science, about their ability to understand science and chemistry, and about the benefits of science and chemistry to society.

CHAPTER V  
SUMMARY OF DATA:  
WINTER 1981 STUDY

BACKGROUND INFORMATION: CHEMISTRY 115 STUDENTS

At the beginning of the winter 1981 semester, thirty-four (34) students enrolled for Chemistry 115, Chemistry and Society. Two students withdrew from the course before the first exam and one withdrew after the first exam. Of the thirty-one (31) students who completed the course, fifteen (15) were female and sixteen (16) were male.

As in the fall semester, an initial questionnaire was distributed in order to ascertain certain background information about these students. Twenty-eight (28) students completed this questionnaire.

Table 15 contains a summary of the pertinent responses from this survey.

Again, these data support the contention that the course was attracting students from the targeted market---nonscience majors who most likely would not have otherwise enrolled in a chemistry course. The fact that eight of the students enrolled based on a recommendation from someone who had taken the course in the fall spoke highly of the positive effect the course did have on the members of the fall class.

TABLE 15  
BACKGROUND DATA:  
CHEMISTRY 115: WINTER, 1981

|                                                                                        | Yes | No |
|----------------------------------------------------------------------------------------|-----|----|
| Have you had any previous chemistry course?                                            | 10  | 18 |
| Would you have taken another chemistry course had you not signed up for Chemistry 115? | 8   | 20 |

|                                         | Advisor | Friend | Other |
|-----------------------------------------|---------|--------|-------|
| How did you find out about this course? | 14      | 8      | 3     |

|             | Freshman | Sophomore | Junior | Senior |
|-------------|----------|-----------|--------|--------|
| Grade Level | 15       | 5         | 5      | 3      |

|                      |            |    |
|----------------------|------------|----|
| Major area of study: | Business   | 13 |
|                      | Humanities | 6  |
|                      | Education  | 4  |
|                      | Psychology | 1  |
|                      | Undecided  | 4  |

For the thirty-one (31) students who completed the course, the grades were distributed as shown in Table 16.

TABLE 16  
GRADE DISTRIBUTION:  
CHEMISTRY 115: WINTER, 1981

| GRADE | PERCENTAGE<br>(POSSIBLE<br>POINTS) | NUMBER OF<br>STUDENTS | PERCENTAGE<br>OF CLASS | MALE | FEMALE |
|-------|------------------------------------|-----------------------|------------------------|------|--------|
| A     | 90-100%                            | 10                    | 32%                    | 3    | 7      |
| B     | 80-89%                             | 9                     | 29%                    | 5    | 4      |
| C     | 65-79%                             | 11                    | 36%                    | 8    | 3      |
| D     | 55-64%                             | 0                     | 0                      | 0    | 0      |
| E     | below 55%                          | 1                     | 3%                     | 0    | 1      |

The proportion of passing and relatively high grades is not inconsistent with the stated goals of the course and the motivational level of the students participating in the course.

SCIENCE ATTITUDE QUESTIONNAIRE: WINTER, 1981

The revised science attitude questionnaire was administered to the Chemistry 115 class during the first and last weeks of the winter semester. Tables 17 through 22 detail responses to selected items from the questionnaire.

TABLE 17  
ATTITUDE TOWARD SCIENCE CLASSES

| QUESTION                                                                           | PERCENTAGE RESPONDING<br>(initial-final) |       |           |        |
|------------------------------------------------------------------------------------|------------------------------------------|-------|-----------|--------|
|                                                                                    | ALWAYS                                   | OFTEN | SOMETIMES | SELDOM |
| 1. For you, how often are the things you studied in science classes interesting?   | 5-20                                     | 52-65 | 29-15     | 14-0   |
| 2. For you, how often are the things you studied in science classes too difficult? | 5-0                                      | 24-10 | 52-40     | 19-45  |
| 5. How often have science classes made you feel stupid?                            | 0-5                                      | 19-15 | 43-20     | 19-35  |
| 6. How often have science classes made you feel confident?                         | 0-0                                      | 19-25 | 38-70     | 35-5   |

TABLE 18  
ATTITUDE TOWARD SCIENCE CLASS REQUIREMENTS

| QUESTION                                                                   | PERCENTAGE RESPONDING<br>(initial-final) |       |               |          |
|----------------------------------------------------------------------------|------------------------------------------|-------|---------------|----------|
|                                                                            | STRONGLY<br>AGREE                        | AGREE | NO<br>OPINION | DISAGREE |
| 10. Science should be required for all getting a college degree.           | 14-25                                    | 33-40 | 19-20         | 29-15    |
| 11. Much of what is learned in science classes is useful in everyday life. | 0-25                                     | 52-65 | 33-10         | 14-0     |

TABLE 19  
ATTITUDE TOWARD SCIENCE CAREERS

| QUESTION                                                                                                                    | PERCENTAGE RESPONDING<br>(initial-final) |          |
|-----------------------------------------------------------------------------------------------------------------------------|------------------------------------------|----------|
|                                                                                                                             | DEFINITELY YES                           | PROBABLY |
| 40. The education and training needed to prepare me to work in a scientific field would open many job opportunities for me. | 0-10                                     | 43-65    |

TABLE 20  
ABILITY OF SCIENCE TO SOLVE PROBLEMS

Questions 56 through 64 describe problems the world is facing. How much do you think that the application of science can help solve these problems?

| PROBLEM                           | PERCENTAGE RESPONDING<br>(initial-final) |       |           |
|-----------------------------------|------------------------------------------|-------|-----------|
|                                   | NONE                                     | SOME  | VERY MUCH |
| to prevent world-wide starvation  | 0-0                                      | 33-45 | 67-55     |
| to prevent an energy shortage     | 0-0                                      | 19-30 | 81-70     |
| to find cures for diseases        | 0-0                                      | 9-0   | 91-95     |
| to control weather                | 28-20                                    | 52-65 | 19-15     |
| to prevent birth defects          | 5-0                                      | 28-60 | 67-40     |
| to save our natural resources     | 9-0                                      | 47-55 | 43-45     |
| to reduce air and water pollution | 9-0                                      | 28-45 | 62-55     |
| to reduce world overpopulation    | 24-15                                    | 43-50 | 33-35     |

TABLE 21  
RATE OF CHANGE CAUSED BY SCIENCE

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|                                                                                                      |                                          |
|------------------------------------------------------------------------------------------------------|------------------------------------------|
| 67. Do you feel that science and technology change things too fast, too slowly, or just about right? |                                          |
| RESPONSE                                                                                             | PERCENTAGE RESPONDING<br>(initial-final) |
| TOO FAST                                                                                             | 24-10                                    |
| TOO SLOWLY                                                                                           | 24-35                                    |
| JUST ABOUT RIGHT                                                                                     | 38-45                                    |

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TABLE 22  
VALUE OF SCIENCE AND TECHNOLOGY

| QUESTION                                                                                                                                            | PERCENTAGE RESPONDING<br>(initial-final) |               |               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|---------------|---------------|
| 68. Do you feel that science and technology have changed life for the better or for the worse?                                                      | BETTER<br>43-30                          | WORSE<br>5-5  | BOTH<br>48-55 |
| 69. Do you feel that science and technology have caused most of our problems, some of our problems, a few of our problems, or none of our problems? | MOST<br>5-5                              | SOME<br>57-55 | FEW<br>38-35  |
| 94. Science is extremely valuable to society.                                                                                                       | STRONGLY AGREE                           |               |               |
|                                                                                                                                                     | AGREE                                    | NO OPINION    |               |
|                                                                                                                                                     | 45-35                                    | 45-55         | 10-10         |
| 95. Science makes our lives better.                                                                                                                 | 30-25                                    | 50-60         | 15-15         |

The questions in Table 17 relate to the students' feelings about science classes and their feelings of success in science classes. All of the responses, including the items not directly listed in Table 17, revealed an increase toward positive feelings. These data relate directly to one of the stated goals of the course--to increase the students' positive attitude toward their own ability to do well in a science class.

Table 18 summarizes the positive change that occurred in some aspects of the students' attitudes toward science classes in general. The response to Question 11 shows a decided positive change concerning the relevance of what is learned in science classes. This again relates to one of the stated objectives of this course.

Table 19 is shown for purposes of comparison with the fall, 1980 group. The results were essentially the same as for the earlier group. This reflects perhaps more than anything else an increased awareness of the diverse roles of science and scientists in our society and the possible prestige and variety associated with working on scientific problems.

The data summarized in Table 20 show an increased belief that science can play a role in solving specific problems (the number of students responding "none" in the various categories did decrease). But the number of students who felt that science could do "very much" in

alleviating these problems also decreased over the course of the semester (except in the case of preventing wars, an interesting anomaly). The "regression toward the mean" (changes toward a more centralized, middle-of-the-road view) present in these responses reflect, perhaps, a hybridization of hope and realism, both based it could be argued on the students' exposure to issues, facts, and discussions presented in the Chemistry 115 class.

The responses in Table 21 may be interpreted as reflecting a slightly increased level of confidence in science and technology's role in changing various aspects of our society.

In looking at Table 22, the responses to the questions listed there reflect an ambivalence that is not necessarily contradictory to the goals of the course. They reflect, perhaps, an appreciation of the complex issues involved in any science/society interface and the healthy realization that questions of responsibility or blame are neither simple nor clearly defined. The last two questions (94, 95) in Table 22 again reflect the "regression toward the mean" phenomenon seen in some earlier responses.

BACKGROUND INFORMATION: WINTER 1981 TEST GROUPS

The Science Attitude Questionnaire (Form II, Appendix A) was also administered to two other classes at Eastern Michigan University during the winter semester of 1981--- a Chemistry 119 class, "Fundamentals of Chemistry" for non-chemistry majors, and a section of History 100, "The Comparative Study of Religion".

The questionnaire was administered twice in each of these classes, as it was in the Chemistry and Society class. The students were asked to complete the questionnaire during the first week of the semester and again during the last week of the semester.

The second time that the questionnaire was distributed it was attached to a cover sheet on which were questions asking for some pieces of background information about the students. This information was used to compile the background data contained in Tables 23 and 25.

CHEMISTRY 119

Fifty-five (55) students completed the initial questionnaire. Forty-one (41) completed the final questionnaire at the end of the course. A total of sixty-seven (67) students completed the course (in the section tested).

For the forty-one (41) students providing the cover sheet data on the final questionnaire, Table 23 summarizes their responses.

TABLE 23

BACKGROUND DATA: CHEMISTRY 119, WINTER 1981

| TABLE 1 |  |  |  |  |  |  |  |  |  |  |  |  |
|---------|--|--|--|--|--|--|--|--|--|--|--|--|
| 1966-67 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1967-68 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1968-69 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1969-70 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1970-71 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1971-72 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1972-73 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1973-74 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1974-75 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1975-76 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1976-77 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1977-78 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1978-79 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1979-80 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1980-81 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1981-82 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1982-83 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1983-84 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1984-85 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1985-86 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1986-87 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1987-88 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1988-89 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1989-90 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1990-91 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1991-92 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1992-93 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1993-94 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1994-95 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1995-96 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1996-97 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1997-98 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1998-99 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1999-00 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2000-01 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2001-02 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2002-03 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2003-04 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2004-05 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2005-06 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2006-07 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2007-08 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2008-09 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2009-10 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2010-11 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2011-12 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2012-13 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2013-14 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2014-15 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2015-16 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2016-17 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2017-18 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2018-19 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2019-20 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2020-21 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2021-22 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2022-23 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2023-24 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2024-25 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2025-26 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2026-27 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2027-28 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2028-29 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2029-30 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2030-31 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2031-32 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2032-33 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2033-34 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2034-35 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2035-36 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2036-37 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2037-38 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2038-39 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2039-40 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2040-41 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2041-42 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2042-43 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2043-44 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2044-45 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2045-46 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2046-47 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2047-48 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2048-49 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2049-50 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2050-51 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2051-52 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2052-53 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2053-54 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2054-55 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2055-56 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2056-57 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2057-58 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2058-59 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2059-60 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2060-61 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2061-62 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2062-63 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2063-64 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2064-65 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2065-66 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2066-67 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2067-68 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2068-69 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2069-70 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2070-71 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2071-72 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2072-73 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2073-74 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2074-75 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2075-76 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2076-77 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2077-78 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2078-79 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2079-80 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2080-81 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2081-82 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2082-83 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2083-84 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2084-85 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2085-86 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2086-87 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2087-88 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2088-89 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2089-90 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2090-91 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2091-92 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2092-93 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2093-94 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2094-95 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2095-96 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2096-97 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2097-98 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2098-99 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2099-00 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2100-01 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2101-02 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2102-03 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2103-04 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2104-05 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2105-06 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2106-07 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2107-08 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2108-09 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2109-10 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2110-11 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2111-12 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2112-13 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2113-14 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2114-15 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2115-16 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2116-17 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2117-18 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2118-19 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2119-20 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2120-21 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2121-22 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2122-23 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2123-24 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2124-25 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2125-26 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2126-27 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2127-28 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2128-29 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2129-30 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2130-31 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2131-32 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2132-33 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2133-34 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2134-35 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2135-36 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2136-37 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2137-38 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2138-39 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2139-40 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2140-41 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2141-42 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2142-43 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2143-44 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2144-45 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2145-46 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2146-47 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2147-48 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2148-49 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2149-50 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2150-51 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2151-52 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2152-53 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2153-54 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2154-55 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2155-56 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2156-57 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2157-58 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2158-59 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2159-60 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2160-61 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2161-62 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2162-63 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2163-64 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2164-65 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2165-66 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2166-67 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2167-68 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2168-69 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2169-70 |  |  |  |  |  |  |  |  |  |  |  |  |

TABLE 24

GRADE DISTRIBUTION: CHEMISTRY 119, WINTER 1981

| STUDENTS ANSWERING QUESTIONNAIRE |    |            |
|----------------------------------|----|------------|
| GRADE                            | N  | PERCENTAGE |
| A                                | 17 | 41%        |
| B                                | 10 | 24%        |
| C                                | 12 | 29%        |
| D                                | 1  | 2%         |
| E                                | 0  | 0          |
| OVERALL CLASS (n = 80)           |    |            |
| GRADE                            | N  | PERCENTAGE |
| A                                | 25 | 31%        |
| B                                | 24 | 30%        |
| C                                | 22 | 28%        |
| D                                | 4  | 5%         |
| E                                | 5  | 6%         |

HISTORY 100

Sixty-seven (67) students completed the initial questionnaire in this class. Thirty-six (36) completed the final questionnaire. Eighty-two (82) students completed the History 100 course.

For the thirty-six (36) students providing the background information on the final questionnaire, Table 25 summarizes their responses.

As shown in this table, eight of the students had taken college level chemistry courses. None of them had taken Chemistry 115. One student was a senior chemistry major. His scores were not used in the tabulation of the initial and final class averages of the scores on the attitude survey.

TABLE 25

BACKGROUND DATA: HISTORY 100, WINTER 1981

| SEX                         |    | MALES    |    |           |    | FEMALES    |    |        |    |         |    |    |    |         |  |   |  |           |  |   |  |              |  |   |  |            |  |   |  |             |  |   |  |     |  |   |  |
|-----------------------------|----|----------|----|-----------|----|------------|----|--------|----|---------|----|----|----|---------|--|---|--|-----------|--|---|--|--------------|--|---|--|------------|--|---|--|-------------|--|---|--|-----|--|---|--|
|                             |    | 13       |    |           |    | 23         |    |        |    |         |    |    |    |         |  |   |  |           |  |   |  |              |  |   |  |            |  |   |  |             |  |   |  |     |  |   |  |
| GRADE LEVEL                 |    | FRESHMAN |    | SOPHOMORE |    | JUNIOR     |    | SENIOR |    |         |    |    |    |         |  |   |  |           |  |   |  |              |  |   |  |            |  |   |  |             |  |   |  |     |  |   |  |
|                             |    | 4        |    | 19        |    | 4          |    | 9      |    |         |    |    |    |         |  |   |  |           |  |   |  |              |  |   |  |            |  |   |  |             |  |   |  |     |  |   |  |
| PREVIOUS COLLEGE CHEMISTRY? |    | YES      |    |           |    | NO         |    |        |    |         |    |    |    |         |  |   |  |           |  |   |  |              |  |   |  |            |  |   |  |             |  |   |  |     |  |   |  |
|                             |    | 8        |    |           |    | 28         |    |        |    |         |    |    |    |         |  |   |  |           |  |   |  |              |  |   |  |            |  |   |  |             |  |   |  |     |  |   |  |
| MAJOR AREA OF STUDY         |    | Business |    | 15        |    | Humanities |    | 4      |    | Science |    | 2  |    | Medical |  | 3 |  | Education |  | 4 |  | Broadcasting |  | 1 |  | Industrial |  | 1 |  | Social Work |  | 2 |  | Law |  | 2 |  |
| AGE                         | 18 | 19       | 20 | 21        | 22 | 23         | 24 | 26     | 27 | 30      | 32 | 33 | 36 |         |  |   |  |           |  |   |  |              |  |   |  |            |  |   |  |             |  |   |  |     |  |   |  |
| n                           | 2  | 6        | 8  | 8         | 2  | 1          | 1  | 2      | 1  | 1       | 1  | 1  | 1  |         |  |   |  |           |  |   |  |              |  |   |  |            |  |   |  |             |  |   |  |     |  |   |  |

CHEMISTRY 115

Twenty-one (21) students completed the initial questionnaire in the Chemistry and Society class during the winter 1981 semester. Twenty (20) students completed the questionnaire at the end of the course. Thirty-one (31) students completed the course. Background data for the thirty-one (31) students completing the course were summarized at the beginning of this chapter (Table 15).

For the sake of comparison, data for the twenty (20) students completing the final questionnaire are summarized in Table 26 in the same manner that data from the other classes tested during the winter semester were summarized in the preceding tables.

TABLE 26

BACKGROUND DATA: CHEMISTRY 115 STUDENTS  
WINTER 1981  
(FINAL QUESTIONNAIRE)

| SEX                   | MALES     |  |    |           |    |    | FEMALES |  |        |
|-----------------------|-----------|--|----|-----------|----|----|---------|--|--------|
|                       | 10        |  |    |           |    |    | 10      |  |        |
| GRADE LEVEL           | FRESHMAN  |  |    | SOPHOMORE |    |    | JUNIOR  |  | SENIOR |
|                       | 8         |  |    | 4         |    |    | 4       |  | 4      |
| MAJOR AREA OF STUDY   | Business  |  |    |           |    |    | 11      |  |        |
|                       | Music     |  |    |           |    |    | 2       |  |        |
|                       | English   |  |    |           |    |    | 3       |  |        |
|                       | Education |  |    |           |    |    | 2       |  |        |
|                       | Undecided |  |    |           |    |    | 1       |  |        |
| AGE                   | 18        |  | 19 | 20        | 21 | 22 | 26      |  |        |
| n                     | 3         |  | 4  | 4         | 4  | 3  | 1       |  |        |
| FINAL GRADE IN COURSE | A         |  |    |           |    |    | B       |  | C      |
|                       | 8         |  |    |           |    |    | 8       |  | 4      |

ATTITUDE CHANGE DATA

The three groups (Chemistry 115, Chemistry 119 and History 100) were tested twice during the winter 1981 semester, once during the first week and once during the last week of the semester. The students responded to the questionnaire on a standard multiple-choice format computer answer sheet. Six sets of student scores were generated, an initial and a final score for three groups of students.

The questionnaire contained one-hundred eight (108) items, each with a maximum point value of +2. Thus the maximum score possible on the questionnaire was 216 points. Questions varied in the value of the least favorable response as was discussed in Chapter III of this study.

A computer program was developed to score the individual answer sheets and to calculate average scores for each of the six sets of tests. An item analysis was also performed for each of the six sets, as well as overall for all six sets combined.

For each of the six sections, the data obtained were the individual student scores and the item analysis in terms of percentage of respondents marking each choice for each question, as well as the average score for the set.

The earlier discussion of percentage responses to selected items from the questionnaire was derived from these computer results.

The initial purpose of this study was to use the science attitude questionnaire to determine the following:

- (1) whether students enrolled in Chemistry 115, Chemistry and Society, experienced a positive change in their attitudes toward science, as measured by their scores on the questionnaire,
- and, (2) whether the change in score for the students enrolled in Chemistry 115 differed from the change in scores measured for the students enrolled in the other two test groups.

The hypothesis underlying the study, qualitatively expressed, was that the change in score would be larger for the Chemistry 115 group than for either of the two other groups tested. It was also conjectured that the Chemistry 115 group and the history group would be most similar in their initial attitudes (as reflected by their initial scores) while the Chemistry 119 group would most likely start at a higher level.

The data, as tabulated by the computer program, which directly relate to these hypotheses are summarized in Table 27.

TABLE 27  
COMPARISON OF SCIENCE ATTITUDE SCORES

| CLASS         | INITIAL MEAN | FINAL MEAN | CHANGE |
|---------------|--------------|------------|--------|
| CHEMISTRY 115 | 65.1         | 80.6       | +15.5  |
| CHEMISTRY 119 | 86.6         | 94.8       | + 8.2  |
| HISTORY 100   | 66.2         | 69.7       | + 3.5  |

Individual scores with calculated means, medians, and ranges for the six sets of data are included in Appendix B.

These data indicate that the initial hypothesis was supported. Again, no attempt is made here to attach quantitative significance to any of the specific values, but the trends are clear.

- (1) The average change in attitude for the Chemistry 115 groups was larger than for the other two groups (15.5 as compared with 8.2 and 3.5).
- (2) The initial average attitude score for the Chemistry 115 group and the History 100 group were quite similar (65.1 and 66.2, respectively).
- (3) The initial average attitude score for the Chemistry 119 group was higher than for the other two groups (86.6 as compared with 65.1 and 66.2).

While these data form the major portion of the results of this study, it also proves interesting and informative to look at students' matched scores where they are available. Some students did not put their name or student number on the answer sheet while others did not complete both of the questionnaires. Thus the total number of students for whom matched scores are available is less than the total for any one of the surveys. These matched data are contained in Tables 28, 29, and 30.

TABLE 28  
 MATCHED SCORES: CHEMISTRY 115 STUDENTS

| SCORE <sub>1</sub>             | SCORE <sub>2</sub> | CHANGE                  | GRADE IN COURSE |
|--------------------------------|--------------------|-------------------------|-----------------|
| 86                             | 125                | +39                     | A               |
| 70                             | 109                | +39                     | A               |
| 49                             | 86                 | +37                     | C               |
| 42                             | 72                 | +30                     | A               |
| 38                             | 65                 | +27                     | B               |
| 38                             | 62                 | +24                     | B               |
| 41                             | 56                 | +15                     | A               |
| 38                             | 51                 | +13                     | B               |
| 75                             | 87                 | +12                     | C               |
| 103                            | 114                | +11                     | A               |
| 33                             | 33                 | 0                       | C               |
| 90                             | 89                 | - 1                     | A               |
| 108                            | 103                | - 5                     | B               |
| 49                             | 44                 | - 5                     | B               |
| 64                             | 57                 | - 7                     | B               |
| 119                            | 99                 | -20                     | A               |
| AVERAGE CHANGE: MATCHED SCORES |                    | AVERAGE CHANGE: OVERALL |                 |
| +13.1                          |                    | +15.5                   |                 |

TABLE 29  
MATCHED SCORES: CHEMISTRY 119 STUDENTS

| SCORE <sub>1</sub> | SCORE <sub>2</sub> | CHANGE | GRADE IN COURSE |
|--------------------|--------------------|--------|-----------------|
| 79                 | 114                | +43    | A               |
| 43                 | 70                 | +27    | C               |
| 35                 | 61                 | +26    | B               |
| 81                 | 102                | +21    | A               |
| 59                 | 80                 | +21    | A               |
| 59                 | 79                 | +20    | C               |
| 97                 | 115                | +18    | A               |
| 27                 | 44                 | +17    | C               |
| 54                 | 72                 | +16    | A               |
| 98                 | 113                | +15    | C               |
| 62                 | 93                 | +13    | C               |
| 63                 | 75                 | +12    | B               |
| 60                 | 72                 | +12    | B               |
| 75                 | 86                 | +11    | C               |
| 78                 | 88                 | +10    | C               |
| 51                 | 61                 | +10    | A               |
| 86                 | 96                 | +10    | B               |
| 80                 | 88                 | + 8    | D               |
| 69                 | 76                 | + 7    | A               |
| 85                 | 91                 | + 6    | B               |
| 117                | 119                | + 2    | A               |
| 86                 | 88                 | + 1    | A               |
| 120                | 121                | + 1    | B               |
| 119                | 119                | 0      | B               |

TABLE 29 (CONT'D)

| SCORE <sub>1</sub>             | SCORE <sub>2</sub> | CHANGE | GRADE IN COURSE         |
|--------------------------------|--------------------|--------|-------------------------|
| 149                            | 148                | - 1    | A                       |
| 90                             | 89                 | - 1    | A                       |
| 108                            | 102                | - 6    | A                       |
| 140                            | 133                | - 7    | A                       |
| 107                            | 93                 | -14    | A                       |
| 155                            | 141                | -14    | B                       |
| 108                            | 93                 | -15    | A                       |
| 141                            | 124                | -17    | B                       |
| AVERAGE CHANGE: MATCHED SCORES |                    |        | AVERAGE CHANGE: OVERALL |
| + 7.9                          |                    |        | +8.2                    |

TABLE 30  
 MATCHED SCORES: HISTORY 100 STUDENTS

| SCORE <sub>1</sub>             | SCORE <sub>2</sub> | CHANGE                  |
|--------------------------------|--------------------|-------------------------|
| 77                             | 141                | +64                     |
| 38                             | 75                 | +37                     |
| 55                             | 80                 | +25                     |
| -13                            | 6                  | +19                     |
| 46                             | 63                 | +17                     |
| 20                             | 35                 | +15                     |
| 67                             | 79                 | +12                     |
| 59                             | 68                 | + 9                     |
| 87                             | 95                 | + 8                     |
| 69                             | 77                 | + 8                     |
| 31                             | 39                 | + 8                     |
| 71                             | 75                 | + 4                     |
| 83                             | 85                 | + 2                     |
| 118                            | 120                | + 2                     |
| 92                             | 91                 | - 1                     |
| 58                             | 53                 | - 5                     |
| 69                             | 64                 | - 5                     |
| 26                             | 17                 | - 9                     |
| 101                            | 90                 | -11                     |
| 123                            | 112                | -11                     |
| 41                             | 26                 | -15                     |
| 96                             | 60                 | -36                     |
| AVERAGE CHANGE: MATCHED SCORES |                    | AVERAGE CHANGE: OVERALL |
| + 6.3                          |                    | +3.5                    |

The values in these preceding tables of matched scores show the wide range in the amounts by which the scores changed for all three groups. The average changes in individually matched scores followed much the same patterns and were quite close in magnitude to the overall group averages.

In the two chemistry classes, where final grade information was available and possibly pertinent to the students' attitude changes, there does not appear to be a correlation between student grades and the magnitude of their attitude score change.

However, in breaking this information down in another manner, a pattern does emerge which indicates that the students with the higher overall attitude score, rather than change in score, did tend to earn the higher grades in the course. Possible reasons for this pattern are discussed in the next chapter.

The student grade information as compared with their final attitude score is contained in Tables 31 and 32.

TABLE 31

COMPARISON OF STUDENT SCORES WITH GRADES: CHEMISTRY 115

| GRADE                                    | A   | B    | C    |
|------------------------------------------|-----|------|------|
| STUDENT<br>ATTITUDE<br>SCORES<br>(final) | 125 | 103  | 87   |
|                                          | 114 | 103  | 86   |
|                                          | 112 | 77   | 68   |
|                                          | 109 | 65   | 33   |
|                                          | 99  | 62   |      |
|                                          | 89  | 57   |      |
|                                          | 72  | 51   |      |
|                                          | 56  | 44   |      |
| N                                        | 8   | 8    | 4    |
| AVERAGE                                  | 97  | 70.3 | 68.5 |
| CLASS AVERAGE                            |     | 80.6 |      |

TABLE 32

COMPARISON OF STUDENT SCORES WITH GRADES: CHEMISTRY 119

| GRADE         | A    | B    | C    | D  |
|---------------|------|------|------|----|
|               | 148  | 141  | 137  | 88 |
|               | 133  | 124  | 113  |    |
|               | 119  | 121  | 104  |    |
|               | 119  | 118  | 93   |    |
| STUDENT       | 115  | 96   | 89   |    |
| ATTITUDE      | 114  | 91   | 88   |    |
| SCORES        | 112  | 75   | 86   |    |
| (final)       | 102  | 72   | 79   |    |
|               | 102  | 66   | 72   |    |
|               | 93   | 61   | 70   |    |
|               | 89   |      | 70   |    |
|               | 88   |      | 44   |    |
|               | 80   |      |      |    |
|               | 76   |      |      |    |
|               | 72   |      |      |    |
|               | 69   |      |      |    |
|               | 61   |      |      |    |
| N             | 17   | 10   | 12   | 1  |
| AVERAGE       | 99.5 | 96.5 | 87.1 | 88 |
| CLASS AVERAGE |      | 95.8 |      |    |

## CHAPTER VI

### DISCUSSION OF RESULTS AND SUMMARY OF THE STUDY

The purposes of this study, as outlined in Chapter I, were:

- (1) to select topics and approaches which would be effective in an introductory nonscience majors' course in "Chemistry and Society"
- (2) to measure the attitudes of students enrolled in this course toward science and the scientific process and to determine if changes in these attitudes occur during the course, and
- (3) to provide information that might be of help to other chemical educators in designing, implementing, and justifying a course of this type.

Some of the processes involved in addressing the first purpose were detailed earlier. The Chemistry 115 course, Chemistry and Society, which resulted from these efforts was viewed by the instructor, the other members of the Eastern Michigan University Chemistry Department, the university administration, and the students as an effective, successful and interesting introductory course. The hoped for publicity and "word of mouth" reputation that would continue to attract students into the course did seem to materialize.

During the two semesters involved in this study, fall 1980 and winter 1981, the level of student participation, enthusiasm, and achievement spoke well of the accomplishment of this first goal.

The course attracted the students for whom it was designed---primarily freshman and sophomore level non-science majors who were taking the course to satisfy the university's basic studies requirement. The students themselves responded for the most part that they would not have otherwise enrolled in a chemistry course.

The measurement of student attitude change during the course, both by direct subjective surveys and by the questionnaire developed from the National Assessment of Educational Progress materials, did indicate that the students' feelings about science and about their own ability to be successful in a science course improved.

During the fall 1980 semester, while no actual scoring of the attitude questionnaire was attempted, the results of the students' surveys verified this positive attitude change. The students displayed a greater willingness to venture opinions on many topics after completing the course. They displayed a change in their perception of some of the causes of social problems and an increased confidence in the ability of science to solve some of these problems.

They responded by decisive margins that being in the course had increased their understanding of science, chemistry, the relationship of chemistry to other areas of study, and the importance of chemistry in their everyday lives. They also reported that their attitudes about the benefits of science, the need for more people to study science, their own abilities to succeed in understanding science, and to make intelligent decisions on scientific issues had increased in a positive direction as a result of the Chemistry and Society course.

During the winter 1981 semester, a more in-depth measurement of science attitude change was undertaken, involving not only the Chemistry and Society class but two control groups as well. The other classes tested were a traditional, skills-oriented introductory chemistry class taught by the same instructor as the Chemistry and Society course, and a course in the Comparative History of Religion. The main hypothesis was that the change in attitude, as reflected by scores on the science attitude questionnaire, would be larger for the Chemistry and Society group than for the other two groups.

Analysis of the data supported this hypothesis. The change in attitude scores for the experimental group was larger (+15.5 points, or a 23.8% increase from the initial value) than for the other two groups (+8.2 points or 9.5% for the Chemistry 119 group and +3.5 or 5.3% for the

History 100 group).

A t-test for a difference between independent means was calculated for each of the groups. At the 0.10 confidence level, the change calculated for the Chemistry and Society (Chemistry 115) group was significant while the changes for the other two groups were not.

Table 33 summarizes the data obtained during the winter 1981 phase of this study.

TABLE 33  
SUMMARY OF SCIENCE ATTITUDE CHANGE DATA

| GROUP         | MEAN<br>(INITIAL) | MEAN<br>(FINAL) | CHANGE<br>(POINTS) | CHANGE<br>(PERCENT) | t    |
|---------------|-------------------|-----------------|--------------------|---------------------|------|
| CHEMISTRY 115 | 65.1              | 80.6            | +15.5              | 23.8%               | 1.89 |
| CHEMISTRY 119 | 86.6              | 94.8            | + 8.2              | 9.5%                | 1.20 |
| HISTORY 100   | 66.2              | 69.7            | + 3.5              | 5.3%                | 0.51 |

These data support the hypothesis that a significant change did take place in the students' attitudes toward science for the students enrolled in the Chemistry 115 Course. The attitude change measured for the other two groups was not statistically significant.

The qualitative discussion of student responses to

various items on the science attitude questionnaire also reveals patterns which clearly support that the goals of the course were met.

Other variables in addition to the course content and approach are very likely involved in these results. The change for the Chemistry 119 class, while smaller in magnitude than for the Chemistry 115 and not statistically significant, does suggest that this course might have had a positive effect on student attitudes toward science. The Chemistry 119 group did have a larger attrition rate and the students who withdraw from a course most likely would be those with the lower ability or motivation and would most likely have the lower initial attitudes toward science. These students' attitudes would have been measured in the initial questionnaire but not in the final one, making the overall change larger than might be expected if these students' final attitudes were also measured.

There is also an argument that students who receive the higher grades in a course will have a more positive attitude toward any quantities measured as part of that course. A look at students' final grades and their final attitude scores (Tables 31 and 32) does support this contention. However, such a relationship is not inconsistent with the purpose or perceived success of this study. If students have a successful experience in a

chemistry course (one of the goals set down for the Chemistry 115 course), their attitudes would be expected to improve. And this improved attitude may result in more enthusiastic participation in the course and a more sustained effort resulting in assured success in the course. It is perhaps difficult to separate cause and effect in such a discussion.

The fact that the course was essentially an elective for the students presents the valid consideration that these students would be more open to learning something about science and chemistry and therefore would be more likely from the onset to experience a change in attitude. While this argument certainly is plausible, it does not present any disproof of the success of the course or of the results relating to attitude change.

The third purpose of this study---to provide other chemical educators with information and support for similar endeavors---can be addressed by a series of recommendations based on this study.

The Chemistry and Society course, as has been described, accomplished the goals that had been outlined for it. The sequence of topics proved logical and timely. The incorporation of more traditional chemical skills, calculations, and theories is not recommended but some more precisely defined mechanism for offering this detail to students who might want to go into more depth might be

provided---by additional handouts or tutoring sessions, for example. Students who are interested in learning more, of course, should be encouraged to take additional courses which would provide them with the background theory and skills they seek.

The use of outside lecturers and films is recommended but these activities should not be disruptive to the topic sequence or presented as mere filler. The task of discussing the scheduled topics to the depth intended and addressing the interest level of the students in the lecture periods allocated was a challenge. There is more than enough of interest in the text, in outside readings, and in new developments and spontaneous discussions to fill up the more than forty lecture periods in the course.

The frequency and level of testing proved adequate for the goals of the course. The test items were easily written from the material presented in the study guides to the students. It is recommended that memorization of details (formulas and structures of compounds, lists of names, details of who discovered what and when) be avoided. Writing creative but fair questions is one of the largest challenges in a course of this type since the instructor cannot just ask the students to perform calculations or balance equations. The testing method used in the Chemistry 115 course worked well and provided relatively discriminating grade distributions consistent with the goals of

the course.

The use of some outside assignments as part of the course requirements is also recommended. This forced the students to get involved at a level beyond merely attending class. The articles they located were from surprisingly diverse sources and their analyses showed a level of appreciation and critical thinking that was gratifying. Other instructors might consider having a more extensive research/writing assignment that would further involve the students in the current topics they are encountering in lecture.

The success of the course depended on many factors---an instructor who had the time and commitment to develop a new course tailored to the departmental needs, the students' needs and her own interests, a departmental administration and faculty who supported the effort in many direct and indirect ways, and the cooperation of other departments and the office of student advising in directing students to enroll in the course.

The success demonstrated by the attitude measurement in this study should be a recurring phenomenon in any course of this type. The "exciting nature" of the course content, the readiness of the student audience who has been attracted to take this elective course, and the competence and enthusiasm of any instructor who would undertake such an assignment all combine to provide an

almost failproof experience for everyone involved to emerge feeling more positively about science, about chemistry, and about their own abilities.

## **APPENDICES**

**APPENDIX A**  
**SCIENCE ATTITUDE QUESTIONNAIRES**

## CHEMISTRY 115 CHEMISTRY AND SOCIETY COURSE EVALUATION

Please answer each of these questions as accurately and as honestly as possible. This will be of great help in planning for this class in the future and for helping this course serve the needs and interests of students taking it.

1. At this time, what grade do you think you will receive in this course? \_\_\_\_\_

2. When you started this course, what grade did you think you would earn? \_\_\_\_\_

3. Now that the course is over, did you find it more interesting than you had initially expected, less interesting than you had expected, or about the same as you had expected?

MORE \_\_\_\_\_ LESS \_\_\_\_\_ SAME \_\_\_\_\_

4. Do you feel that this course was more difficult than you had expected, less difficult than you had expected, or about the same as what you had expected?

MORE \_\_\_\_\_ LESS \_\_\_\_\_ SAME \_\_\_\_\_

5. Do you feel that you were adequately prepared to do well in this course?

YES \_\_\_\_\_ NO \_\_\_\_\_

If not, please explain your answer.

6. Do you feel that the instructor made assumptions about knowledge that were not realistic?

YES \_\_\_\_\_ NO \_\_\_\_\_

If your answer was yes, please explain.

7. Do you think that more of the lectures should have been given by outside speakers?

MORE \_\_\_\_\_ LESS \_\_\_\_\_ SAME \_\_\_\_\_

8. Do you think that there should have been more exams, fewer exams, or the same number of exams?

MORE \_\_\_\_\_ FEWER \_\_\_\_\_ SAME \_\_\_\_\_

9. Do you think that the outside projects should count a larger part of the final grade, a smaller part of the final grade, the same as they did this semester, or should be eliminated entirely?

LARGER \_\_\_\_\_ SMALLER \_\_\_\_\_ SAME \_\_\_\_\_ NONE \_\_\_\_\_

10. Do you think that there should be more films, fewer films, or about the same number?

MORE \_\_\_\_\_ FEWER \_\_\_\_\_ SAME \_\_\_\_\_

11. Do you think that the textbook was helpful in this course?

YES \_\_\_\_\_ NO \_\_\_\_\_ NO OPINION \_\_\_\_\_

12. Do you think that the exams were too difficult, too easy, or just about right?

TOO DIFFICULT \_\_\_\_\_ TOO EASY \_\_\_\_\_ JUST RIGHT \_\_\_\_\_

13. Did you find the study guides given before each test to be helpful?

YES \_\_\_\_\_ NO \_\_\_\_\_ NO OPINION \_\_\_\_\_

14. Please list any topics which were not discussed in class which you think should be included in a course of this type.

15. Please answer honestly whether BEING IN THIS COURSE has changed you attitudes in any way about the following subjects:

YES NO

- |                                                                                                               |       |       |
|---------------------------------------------------------------------------------------------------------------|-------|-------|
| a. Do you have a better understanding of what science is?                                                     | _____ | _____ |
| b. Do you have a better understanding of what chemistry is?                                                   | _____ | _____ |
| c. Do you have a better understanding of how scientific problems are or can be solved?                        | _____ | _____ |
| d. Do you have a better understanding of what it is possible for scientists to know?                          | _____ | _____ |
| e. Do you have a better understanding of some of the philosophical and ethical questions relating to science? | _____ | _____ |
| f. Do you have a better understanding of how chemistry relates to other areas of science?                     | _____ | _____ |
| g. Do you have a better understanding of how chemistry relates to YOUR everyday life?                         | _____ | _____ |

16. For these next questions, indicate whether your attitude is MORE POSITIVE, LESS POSITIVE, or ABOUT THE SAME as when you started this course:

|                                                                                                                                                                  | MORE  | LESS  | SAME  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|
| a. How has your attitude changed about your own ability to understand science and to do well in a science course?                                                | _____ | _____ | _____ |
| b. How has your attitude changed about the benefits of chemistry to the quality of life in our society?                                                          | _____ | _____ | _____ |
| c. How has your attitude changed about the need for laws to regulate science and the chemical industries?                                                        | _____ | _____ | _____ |
| d. How has your attitude changed about the requirement that all college students should take several courses in science?                                         | _____ | _____ | _____ |
| e. How has your attitude changed about your ability to make intelligent decisions on some important scientific issues (such as energy, medications, food, etc.)? | _____ | _____ | _____ |

## SCIENCE ATTITUDE QUESTIONNAIRE (FORM I: FALL 1980)

NAME \_\_\_\_\_

For each of the following statements, indicate whether you strongly agree, agree, have no opinion, disagree, or strongly disagree.

SA   A   N   D   SD

For me, the education and training needed to prepare me to work in a scientific field would:

|                                                           |   |   |   |   |   |
|-----------------------------------------------------------|---|---|---|---|---|
| cost too much money                                       | — | — | — | — | — |
| be worth it in the long run                               | — | — | — | — | — |
| open many job opportunities                               | — | — | — | — | — |
| be worthwhile, even if I don't go into a scientific field | — | — | — | — | — |

Which of these words best describe your general reaction to science and technology?

|                                        |
|----------------------------------------|
| _____ fear or alarm                    |
| _____ satisfaction or hope             |
| _____ excitement or wonder             |
| _____ indifference or lack of interest |

When you are in a science class, how do you feel?

|                  |                  |
|------------------|------------------|
| _____ happy      | _____ successful |
| _____ interested | _____ dumb       |
| _____ excited    |                  |

|                                                                                   | YES   | NO    | NO OPINION |
|-----------------------------------------------------------------------------------|-------|-------|------------|
| Do you plan to stop taking science courses as soon as your requirements are met?  | _____ | _____ | _____      |
| Would you like to work at some job that lets you use what you know about science? | _____ | _____ | _____      |
| Do you want to work with scientists in an effort to solve problems?               | _____ | _____ | _____      |
| Would you like to visit a scientist at work?                                      | _____ | _____ | _____      |
| Do you think that there are science-related jobs which you could do?              | _____ | _____ | _____      |
| Do you think that scientists should be given more money to study.....             |       |       |            |

|                                                       | YES   | NO    | NO OPINION |
|-------------------------------------------------------|-------|-------|------------|
| how X-rays change living cells                        | _____ | _____ | _____      |
| small parts of the atom                               | _____ | _____ | _____      |
| how animals communicate                               | _____ | _____ | _____      |
| how gases condense around crystals                    | _____ | _____ | _____      |
| how genes control characteristics                     | _____ | _____ | _____      |
| storms on the surface of the sun                      | _____ | _____ | _____      |
| how continents move around                            | _____ | _____ | _____      |
| how to reduce air pollution                           | _____ | _____ | _____      |
| ways to produce more food                             | _____ | _____ | _____      |
| how to prevent earthquakes                            | _____ | _____ | _____      |
| habits of fish in the ocean                           | _____ | _____ | _____      |
| new ways to build smokestacks                         | _____ | _____ | _____      |
| how mice react to drugs at different times of the day | _____ | _____ | _____      |

State whether you strongly agree, agree, have no opinion, disagree, or strongly disagree with each of these statements:

|                                                                                            | SA | A | NO | D | SD |
|--------------------------------------------------------------------------------------------|----|---|----|---|----|
| To be a successful scientist,<br>you cannot have a normal<br>family life                   | —  | — | —  | — | —  |
| you have to sacrifice the<br>welfare of others                                             | —  | — | —  | — | —  |
| you have to be a genius                                                                    | —  | — | —  | — | —  |
| you have to be a little bit "odd"                                                          | —  | — | —  | — | —  |
| you have no time to enjoy life                                                             | —  | — | —  | — | —  |
| Scientists believe that the universe<br>will be completely understood in a<br>few years.   | —  | — | —  | — | —  |
| Science is a self-correcting<br>enterprise.                                                | —  | — | —  | — | —  |
| Scientific conclusions are<br>statements that something is<br>highly probable.             | —  | — | —  | — | —  |
| Laws in science are statements<br>which are not subject to change.                         | —  | — | —  | — | —  |
| Theories in science never go<br>beyond the observed facts on<br>which they are based.      | —  | — | —  | — | —  |
| The usefulness of a theory is in<br>its application in explaining<br>natural events.       | —  | — | —  | — | —  |
| The more complex a theory is, the<br>more satisfied scientists will be<br>with it.         | —  | — | —  | — | —  |
| There may be different methods of<br>solving a single scientific problem.                  | —  | — | —  | — | —  |
| Observations of natural events are<br>very important sources of<br>scientific information. | —  | — | —  | — | —  |

|                                                                                                                     | SA | A | NO | D | SD |
|---------------------------------------------------------------------------------------------------------------------|----|---|----|---|----|
| Unexpected observations have played an important role in increasing scientific knowledge.                           | —  | — | —  | — | —  |
| Scientists always find answers to their questions.                                                                  | —  | — | —  | — | —  |
| Scientists believe that some mysterious events do not have causes which can be explained.                           | —  | — | —  | — | —  |
| YOU can help solve the problems of:                                                                                 |    |   |    |   |    |
| pollution                                                                                                           | —  | — | —  | — | —  |
| energy wastes                                                                                                       | —  | — | —  | — | —  |
| food shortages                                                                                                      | —  | — | —  | — | —  |
| disease                                                                                                             | —  | — | —  | — | —  |
| overpopulation                                                                                                      | —  | — | —  | — | —  |
| crime                                                                                                               | —  | — | —  | — | —  |
| One very important job of scientists is to report only what they observe.                                           | —  | — | —  | — | —  |
| Scientists must be willing to change their ideas when new information becomes known.                                | —  | — | —  | — | —  |
| Different scientists may give different explanations about the same observations.                                   | —  | — | —  | — | —  |
| Once scientists have developed a good theory, they should stick together to prevent others from saying it is wrong. | —  | — | —  | — | —  |
| Scientists should not criticize each others' work.                                                                  | —  | — | —  | — | —  |
| Science classes are useful for everyone.                                                                            | —  | — | —  | — | —  |

|                                                                         | SA  | A   | NO  | D   | SD  |
|-------------------------------------------------------------------------|-----|-----|-----|-----|-----|
| Science classes should be required of all college students.             | ___ | ___ | ___ | ___ | ___ |
| Much of what you learn in science classes is useful in everyday life.   | ___ | ___ | ___ | ___ | ___ |
| Much of what you learn in science classes will be useful in the future. | ___ | ___ | ___ | ___ | ___ |
| Do you think that scientists should be allowed to try...                |     |     |     |     |     |

|                                                  | YES | NO  | NO OPINION |
|--------------------------------------------------|-----|-----|------------|
| to grow frogs from test-tube beginnings          | ___ | ___ | ___        |
| to grow human babies from test-tube beginnings   | ___ | ___ | ___        |
| to make bigger bombs                             | ___ | ___ | ___        |
| to do any kind of research they want             | ___ | ___ | ___        |
| to seek other forms of life in space             | ___ | ___ | ___        |
| to experiment with people without their approval | ___ | ___ | ___        |
| to create new diseases for warfare               | ___ | ___ | ___        |
| to work on secret projects                       | ___ | ___ | ___        |
| to control the way people act                    | ___ | ___ | ___        |

Do you feel that the degree of control that society has over science and technology should be increased, decreased, or remain the same?

INCREASED \_\_\_\_\_ DECREASED \_\_\_\_\_ REMAIN \_\_\_\_\_

For the most part, do you feel that science and technology will eventually solve most, some, few, or none of the problems such as pollution, disease, drug abuse, etc.?

MOST \_\_\_\_\_ SOME \_\_\_\_\_ FEW \_\_\_\_\_ NONE \_\_\_\_\_

How much do you think the application of science can help:

|                                | much  | some  | a little | none  |
|--------------------------------|-------|-------|----------|-------|
| prevent worldwide starvation   | _____ | _____ | _____    | _____ |
| save us from energy shortages  | _____ | _____ | _____    | _____ |
| find cures for diseases        | _____ | _____ | _____    | _____ |
| control weather                | _____ | _____ | _____    | _____ |
| prevent wars                   | _____ | _____ | _____    | _____ |
| prevent birth defects          | _____ | _____ | _____    | _____ |
| save natural resources         | _____ | _____ | _____    | _____ |
| reduce air and water pollution | _____ | _____ | _____    | _____ |
| reduce world over-population   | _____ | _____ | _____    | _____ |

Do you feel that science and technology have caused most, some, few, or none of these problems?

|                  | MOST  | SOME  | FEW   | NONE  | NO OPINION |
|------------------|-------|-------|-------|-------|------------|
| pollution        | _____ | _____ | _____ | _____ | _____      |
| disease          | _____ | _____ | _____ | _____ | _____      |
| drug abuse       | _____ | _____ | _____ | _____ | _____      |
| inflation        | _____ | _____ | _____ | _____ | _____      |
| energy shortages | _____ | _____ | _____ | _____ | _____      |

Which of the following would you be willing to do to help solve world problems, even if it is inconvenient?

|                                                                     | YES   | NO    |
|---------------------------------------------------------------------|-------|-------|
| use less electricity                                                | _____ | _____ |
| spend a day helping clean up litter from a street, a park or a road | _____ | _____ |
| use returnable bottles rather than the "throw away" kind            | _____ | _____ |
| walk and ride bikes more often                                      | _____ | _____ |
| separate trash for recycling                                        | _____ | _____ |
| use less heat in the winter to save fuel                            | _____ | _____ |
| drive or ride in a smaller car                                      | _____ | _____ |
| decide to have two or fewer children                                | _____ | _____ |

## SCIENCE ATTITUDE QUESTIONNAIRE (FORM II: WINTER 1981)

NAME \_\_\_\_\_ STUDENT NUMBER \_\_\_\_\_

Please answer the following questions as honestly as possible. Record your answers on the computer answer sheet which is attached. Be sure that your name and student number are correctly recorded on the computer answer sheet.

Do not answer these questions in terms of how you think the instructor might want you to answer them.

Thank you for taking the time to answer this questionnaire.

1. For you, how often are the things you studied in science class interesting?  
A. Always      B. Often      C. Sometimes      D. Seldom      E. Never
2. For you, how often are the things you studied in science class too difficult?  
A. Always      B. Often      C. Sometimes      D. Seldom      E. Never
3. How often have science classes made you feel uncomfortable?  
A. Always      B. Often      C. Sometimes      D. Seldom      E. Never
4. How often have science classes made you feel curious?  
A. Always      B. Often      C. Sometimes      D. Seldom      E. Never
5. How often have science classes made you feel stupid?  
A. Always      B. Often      C. Sometimes      D. Seldom      E. Never
6. How often have science classes made you feel confident?  
A. Always      B. Often      C. Sometimes      D. Seldom      E. Never
7. How often have science classes made you feel successful?  
A. Always      B. Often      C. Sometimes      D. Seldom      E. Never

For questions 8 through 11, tell how much you agree or disagree with each of the following statements regarding science classes in general.

8. Science classes are useful.  
A. Strongly agree      B. Agree      C. No opinion      D. Disagree      E. Strongly disagree
9. The things which are learned in science classes have nothing to do with the real world.  
A. Strongly agree      B. Agree      C. No opinion      D. Disagree      E. Strongly disagree
10. Science should be required for all getting a college degree.  
A. Strongly agree      B. Agree      C. No opinion      D. Disagree      E. Strongly disagree
11. Much of what is learned in science classes is useful in everyday life.  
A. Strongly agree      B. Agree      C. No opinion      D. Disagree      E. Strongly disagree

For questions 12 through 19, indicate how often you have done the following activities when NOT REQUIRED to do them.

12. Read science articles in magazines.  
A. Often      B. Sometimes      C. Seldom      D. Never
13. Read science articles in newspapers.  
A. Often      B. Sometimes      C. Seldom      D. Never
14. Watched science programs on TV.  
A. Often      B. Sometimes      C. Seldom      D. Never
15. Gone to hear people give talks on science.  
A. Often      B. Sometimes      C. Seldom      D. Never
16. Read books about science or scientists.  
A. Often      B. Sometimes      C. Seldom      D. Never
17. Talked about science topics with your friends.  
A. Often      B. Sometimes      C. Seldom      D. Never
18. Done science projects.  
A. Often      B. Sometimes      C. Seldom      D. Never
19. Worked with science-related hobbies.  
A. Often      B. Sometimes      C. Seldom      D. Never
20. Do you plan to stop taking science courses after you have completed those which are required?  
A. Definitely yes    B. Probably yes    C. Not sure    D. Probably not    E. Definitely not
21. Would you like to work at some job that lets you use what you know about science?  
A. Definitely yes    B. Probably yes    C. Not sure    D. Probably not    E. Definitely not
22. Do you want to work with scientists in an effort to solve problems?  
A. Definitely yes    B. Probably yes    C. Not sure    D. Probably not    E. Definitely not
23. Do you think that there are science-related jobs which you could do?  
A. Definitely yes    B. Probably yes    C. Not sure    D. Probably not    E. Definitely not
24. Would you like to know more about jobs in science fields?  
A. Definitely yes    B. Probably yes    C. Not sure    D. Probably not    E. Definitely not

Questions 25 through 30 deal with science-related tasks. For each one, tell if you would be interested in doing it.

25. Working in a laboratory.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
26. Making field studies.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
27. Reading science articles.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
28. Sharing ideas with others.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
29. Writing reports about your findings.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
30. Designing and building things.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
31. For me, working in a science-related field would be fun.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
32. For me, working in a science-related field would be too much work.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
33. For me, working in a science-related field would be something I could do.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
34. For me, working in a science-related field would be boring.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
35. For me, working in a science-related field would make me important.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
36. For me, working in a science-related field would take too much education.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
37. For me, working in a science-related field would be lonely.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
38. For me, the education and training needed to prepare me to work in a scientific field would cost too much money.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not

39. For me, the education and training needed to prepare me to work in a scientific field would be worth it in the long run.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
40. For me, the education and training needed to prepare me to work in a scientific field would open many job opportunities for me.  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
41. Do you think that there are things you can do to help solve the problem of pollution?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
42. Do you think that there are things you can do to help solve the problem of energy waste?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
43. Do you think that there are things you can do to help solve the problem of food shortages?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
44. Do you think that there are things you can do to help solve the problem of overpopulation?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
45. Do you think that there are things you can do to help solve the problem of disease?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
46. Do you think that there are things you can do to help solve the problem of accidents?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
47. Do you think that there are things you can do to help solve the problem of running out of natural resources?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not

Questions 48 through 55 deal with things that you might or might not be willing to do to help solve some of the world problems. Indicate whether you would be willing to do these, even if it is inconvenient.

48. Use less electricity?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
49. Walk and ride bikes more often?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
50. Spend a day helping clean up litter from a street, park, or road?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
51. Separate trash (bottles, cans, paper, etc.) for recycling?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not

52. Drive or ride in a small economy car?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
53. Use less heat in the winter to save fuel?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
54. Use returnable bottles rather than "throw away" bottles?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not
55. Stay home from a party when you have a bad cold?  
A. Definitely yes B. Probably yes C. Not sure D. Probably not E. Definitely not

Questions 56 through 64 describe problems the world is facing. How much do you think that the application of science can help solve these problems?

- |                                         |         |         |              |
|-----------------------------------------|---------|---------|--------------|
| 56. to prevent world-wide starvation?   | A. None | B. Some | C. Very much |
| 57. to save us from an energy shortage? | A. None | B. Some | C. Very much |
| 58. to find cures for diseases?         | A. None | B. Some | C. Very much |
| 59. to control weather?                 | A. None | B. Some | C. Very much |
| 60. to prevent wars?                    | A. None | B. Some | C. Very much |
| 61. to prevent birth defects?           | A. None | B. Some | C. Very much |
| 62. to save our natural resources?      | A. None | B. Some | C. Very much |
| 63. to reduce air and water pollution?  | A. None | B. Some | C. Very much |
| 64. to reduce world overpopulation?     | A. None | B. Some | C. Very much |

65. For the most part, do you feel that science and technology will eventually solve most problems, such as pollution, diseases, drug abuse, and crime, some of these problems, or few if any of these problems?  
A. Most problems B. Some of these problems C. Few, if any D. No opinion
66. Which of these terms best describes your general reaction to science and technology?  
A. Fear or alarm B. Satisfaction or hope C. Excitement or wonder D. Indifference
67. Do you feel that science and technology change things too fast, too slowly, or just about right?  
A. Too fast B. Too slowly C. Just about right D. No opinion

68. Do you feel that science and technology have changed life for the better or for the worse?  
 A. Better      B. Worse      C. Both      D. Neither/no effect      E. No opinion
69. Do you feel that science and technology have caused most of our problems, some of our problems, a few of our problems, or none of our problems?  
 A. Most      B. Some      C. Few      D. None      E. No opinion
70. Do you feel that the degree of control that society has over science and technology should be increased, decreased, or remain as it is now?  
 A. Increased      B. Decreased      C. Remain as is      D. No opinion

The questions which follow list areas of research in science. Indicate whether you feel scientists should be given money to study each of these areas.

71. earthquake predictions  
 A. Definitely yes    B. Probably yes    C. Probably not    D. Definitely not
72. how to make rain fall on farm land  
 A. Definitely yes    B. Probably yes    C. Probably not    D. Definitely not
73. methods of reducing air pollution  
 A. Definitely yes    B. Probably yes    C. Probably not    D. Definitely not
74. cures for cancer  
 A. Definitely yes    B. Probably yes    C. Probably not    D. Definitely not
75. ways to produce more food  
 A. Definitely yes    B. Probably yes    C. Probably not    D. Definitely not
76. way to cure a very rare disease  
 A. Definitely yes    B. Probably yes    C. Probably not    D. Definitely not
77. how people behave when they live in very crowded cities  
 A. Definitely yes    B. Probably yes    C. Probably not    D. Definitely not
78. methods of farming the oceans  
 A. Definitely yes    B. Probably yes    C. Probably not    D. Definitely not
79. ways to control insects  
 A. Definitely yes    B. Probably yes    C. Probably not    D. Definitely not
80. new ways to build smoke stacks  
 A. Definitely yes    B. Probably yes    C. Probably not    D. Definitely not

Do you think scientists should be given money to study

- 81. things that will probably never be useful  
A. Definitely yes B. Probably yes C. Probably not D. Definitely not
- 82. how the continents move around  
A. Definitely yes B. Probably yes C. Probably not D. Definitely not
- 82. storms on the surface of the sun  
A. Definitely yes B. Probably yes C. Probably not D. Definitely not
- 83. how animals communicate  
A. Definitely yes B. Probably yes C. Probably not D. Definitely not
- 84. distant stars  
A. Definitely yes B. Probably yes C. Probably not D. Definitely not
- 85. how mice react to drugs at different times of the day  
A. Definitely yes B. Probably yes C. Probably not D. Definitely not
- 86. small parts of the atom  
A. Definitely yes B. Probably yes C. Probably not D. Definitely not
- 87. how gases condense around crystals  
A. Definitely yes B. Probably yes C. Probably not D. Definitely not
- 88. how X-rays change living cells  
A. Definitely yes B. Probably yes C. Probably not D. Definitely not
- 89. how to create life  
A. Definitely yes B. Probably yes C. Probably not D. Definitely not

For each of the following statements, choose the one response which best expresses your degree of agreement or disagreement with the statement.

- 90. Unexpected observations have played an important role in increasing scientific knowledge.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
- 91. Scientists always find answers to their questions.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
- 92. Scientists believe that some mysterious events do not have causes.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
- 93. There may be many different methods of solving a single scientific problem.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree

94. Science is extremely valuable to society.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
95. Science makes out lives better.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
96. Science causes society to be confused about what is right and what is wrong.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
97. The growth of science means that a few people can control all of the rest.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
98. Science should be limited to those studies which will produce practical results.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
99. It is likely that some theories which scientists believe today will be shown to be inadequate someday.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
100. Theories are useful even though they might be incomplete.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
101. One important use of scientific theories is to predict future events.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
102. One very important job of a scientist is to report exactly what he/she sees.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
103. Scientists should not criticize each other's work.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
104. Once scientists have developed a good theory, they should stick together to prevent others from saying it is wrong.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
105. Scientists must be willing to change their ideas when new information becomes known.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
106. The scientists who are making decisions about the way science affects our everyday life are trustworthy and honest people.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
107. Scientific research must be closely controlled by regulations and laws.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree
108. Two well-trained scientists observing the same event in nature will see the same things and come to the same correct conclusion.  
A. Strongly agree B. Agree C. No opinion D. Disagree E. Strongly disagree

APPENDIX B  
INDIVIDUAL ATTITUDE SCORES  
WINTER 1981

TABLE 34  
ATTITUDE SCORES:  
CHEMISTRY 115  
(INITIAL)

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---

|     |
|-----|
| 119 |
| 108 |
| 98  |
| 95  |
| 90  |
| 86  |
| 77  |
| 75  |
| 70  |
| 68  |
| 64  |
| 57  |
| 49  |
| 49  |
| 42  |
| 41  |
| 38  |
| 38  |
| 38  |
| 33  |
| 33  |

---

N = 21  
MEAN = 65.1  
MEDIAN = 68  
RANGE = 33 - 119

---

TABLE 35  
ATTITUDE SCORES:  
CHEMISTRY 115  
(FINAL)

---

---

|     |
|-----|
| 125 |
| 114 |
| 112 |
| 109 |
| 103 |
| 103 |
| 99  |
| 89  |
| 87  |
| 86  |
| 77  |
| 72  |
| 68  |
| 65  |
| 62  |
| 57  |
| 56  |
| 51  |
| 44  |
| 33  |

---

N = 20  
MEAN = 80.6  
MEDIAN = 81.5  
RANGE = 33 - 125

---

TABLE 36  
ATTITUDE SCORES:  
CHEMISTRY 119  
(INITIAL)

---

---

|     |    |    |
|-----|----|----|
| 155 | 90 | 59 |
| 151 | 90 | 58 |
| 149 | 89 | 54 |
| 141 | 86 | 51 |
| 140 | 86 | 43 |
| 134 | 85 | 43 |
| 128 | 85 | 39 |
| 120 | 84 | 35 |
| 119 | 81 | 27 |
| 117 | 80 | 19 |
| 112 | 79 |    |
| 109 | 78 |    |
| 108 | 75 |    |
| 108 | 72 |    |
| 107 | 69 |    |
| 106 | 67 |    |
| 106 | 67 |    |
| 98  | 65 |    |
| 97  | 63 |    |
| 97  | 63 |    |
| 96  | 62 |    |
| 94  | 60 |    |
| 94  | 59 |    |

---

N = 56  
MEAN = 86.6  
MEDIAN = 86  
RANGE = 19 - 155

---

TABLE 37  
ATTITUDE SCORES:  
CHEMISTRY 119  
(FINAL)

---

---

|     |    |
|-----|----|
| 148 | 89 |
| 141 | 89 |
| 137 | 88 |
| 133 | 88 |
| 124 | 86 |
| 121 | 86 |
| 119 | 80 |
| 119 | 79 |
| 118 | 76 |
| 115 | 75 |
| 114 | 72 |
| 113 | 72 |
| 112 | 72 |
| 104 | 70 |
| 102 | 70 |
| 98  | 66 |
| 96  | 61 |
| 93  | 61 |
| 93  | 44 |
| 91  |    |

---

N = 41  
MEAN = 94.8  
MEDIAN = 93  
RANGE = 44 - 148

---

TABLE 38  
ATTITUDE SCORES:  
HISTORY 100  
(INITIAL)

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---

|     |    |     |
|-----|----|-----|
| 123 | 83 | 54  |
| 118 | 83 | 53  |
| 118 | 83 | 52  |
| 117 | 81 | 49  |
| 113 | 80 | 46  |
| 107 | 80 | 44  |
| 102 | 77 | 44  |
| 102 | 75 | 41  |
| 101 | 71 | 38  |
| 101 | 69 | 37  |
| 98  | 69 | 37  |
| 98  | 67 | 37  |
| 96  | 64 | 33  |
| 96  | 63 | 31  |
| 92  | 63 | 31  |
| 91  | 61 | 29  |
| 88  | 60 | 26  |
| 87  | 60 | 21  |
| 85  | 59 | 20  |
| 84  | 58 | 17  |
| 84  | 58 | 15  |
|     | 55 | 7   |
|     |    | -13 |

---

N = 66  
MEAN = 66.2  
MEDIAN = 67  
RANGE = -13 - 123

---

TABLE 39  
ATTITUDE SCORES:  
HISTORY 100  
(FINAL)

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---

|     |    |
|-----|----|
| 141 | 68 |
| 124 | 64 |
| 123 | 63 |
| 120 | 60 |
| 112 | 57 |
| 108 | 53 |
| 105 | 53 |
| 100 | 52 |
| 95  | 39 |
| 91  | 35 |
| 90  | 35 |
| 85  | 32 |
| 82  | 26 |
| 80  | 21 |
| 79  | 17 |
| 77  | 6  |
| 75  | 0  |
| 73  |    |

---

N = 35  
MEAN = 69.7  
MEDIAN = 73  
RANGE = 0 - 141

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APPENDIX C  
ITEM RESPONSE DATA  
SCIENCE ATTITUDE QUESTIONNAIRE  
CHEMISTRY 115: WINTER 1981

## APPENDIX C

## ITEM RESPONSE DATA

SCIENCE ATTITUDE QUESTIONNAIRE  
CHEMISTRY 115: WINTER 1981

Item responses on the Science Attitude Questionnaire administered during the winter 1981 semester were analyzed on a five-point scale:

Response "A" of the possible choices was valued at 0.

Response "B" of the possible choices was valued at 1.

Response "C" of the possible choices was valued at 2.

Response "D" of the possible choices was valued at 3.

Response "E" of the possible choices was valued at 4.

The table on the following pages lists the mean of the responses, based on these values, for each item. Values are listed both for the initial and final questionnaires. The table also includes the change in mean response for each item.

For most items on the questionnaire, where response "A" was the most favorable, a shift to a lower mean score reflects a shift to a more positive attitude. For those questions marked with "\*" in the table, response "A" was the least favorable response, so a shift to a higher mean indicates a shift toward a more positive attitude.

Questions marked with "#" do not have responses which correlate with either of these formats.

TABLE 40

ITEM RESPONSE DATA: CHEMISTRY 115, WINTER 1981

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| QUESTION | MEAN <sub>1</sub> | MEAN <sub>2</sub> | CHANGE |
|----------|-------------------|-------------------|--------|
| 1        | 1.52              | 0.95              | -.57   |
| *2       | 1.86              | 2.45              | +.59   |
| *3       | 2.05              | 2.55              | +.50   |
| 4        | 1.24              | 1.15              | -.09   |
| *5       | 2.38              | 2.60              | +.22   |
| 6        | 2.29              | 1.80              | -.49   |
| 7        | 2.10              | 2.05              | -.05   |
| 8        | 0.90              | 0.70              | -.20   |
| 9        | 2.95              | 3.25              | +.30   |
| 10       | 1.76              | 1.25              | -.51   |
| 11       | 1.62              | 0.85              | -.77   |
| 12       | 1.05              | 1.10              | +.05   |
| 13       | 1.24              | 0.95              | -.29   |
| 14       | 1.14              | 1.30              | +.16   |
| 15       | 2.67              | 2.60              | -.07   |
| 16       | 2.24              | 2.15              | -.09   |
| 17       | 1.43              | 1.50              | +.07   |
| 18       | 2.00              | 1.90              | -.10   |
| 19       | 2.00              | 1.90              | -.10   |
| 20       | 1.48              | 1.70              | +.22   |
| 21       | 2.00              | 2.00              | 0.00   |
| 22       | 2.43              | 2.25              | -.18   |
| 23       | 1.76              | 1.60              | -.16   |
| 24       | 1.67              | 1.25              | -.42   |
| 25       | 1.90              | 1.80              | -.10   |
| 26       | 2.10              | 1.95              | -.15   |

TABLE 40 (continued)

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| QUESTION | MEAN <sub>1</sub> | MEAN <sub>2</sub> | CHANGE |
|----------|-------------------|-------------------|--------|
| 27       | 1.57              | 1.70              | +.13   |
| 28       | 1.00              | 1.05              | +.05   |
| 29       | 2.10              | 2.00              | -.10   |
| 30       | 2.05              | 1.60              | -.45   |
| *31      | 1.95              | 1.60              | -.35   |
| 32       | 1.90              | 2.40              | +.50   |
| 33       | 1.86              | 1.60              | -.26   |
| *34      | 2.38              | 2.65              | +.27   |
| 35       | 2.33              | 1.80              | -.53   |
| *36      | 1.52              | 1.65              | +.13   |
| *37      | 2.43              | 2.30              | -.13   |
| *38      | 1.43              | 1.65              | +.22   |
| 39       | 1.67              | 1.70              | +.03   |
| 40       | 1.57              | 1.40              | -.17   |
| 41       | 1.62              | 1.35              | -.27   |
| 42       | 1.43              | 1.10              | -.33   |
| 43       | 1.62              | 1.25              | -.37   |
| 44       | 1.19              | 1.45              | +.26   |
| 45       | 1.86              | 1.90              | +.04   |
| 46       | 1.52              | 1.50              | -.02   |
| 47       | 1.67              | 1.55              | -.12   |
| 48       | 0.48              | 0.55              | +.07   |
| 49       | 0.76              | 0.65              | -.11   |
| 50       | 1.19              | 1.15              | -.04   |
| 51       | 1.24              | 1.00              | -.24   |
| 52       | 0.43              | 0.45              | +.02   |
| 53       | 1.24              | 1.00              | -.24   |
| 54       | 0.24              | 0.20              | -.04   |

TABLE 40 (continued)

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| QUESTION | MEAN <sub>1</sub> | MEAN <sub>2</sub> | CHANGE |
|----------|-------------------|-------------------|--------|
| 55       | 1.05              | 1.40              | +.35   |
| *56      | 1.67              | 1.55              | -.12   |
| *57      | 1.81              | 1.70              | -.11   |
| *58      | 1.90              | 1.90              | 0.00   |
| *59      | 0.90              | 0.95              | +.05   |
| *60      | 0.43              | 0.80              | +.37   |
| *61      | 1.62              | 1.40              | -.22   |
| *62      | 1.33              | 1.45              | +.12   |
| *63      | 1.52              | 1.55              | +.03   |
| *64      | 1.10              | 1.20              | +.10   |
| 65       | 1.00              | 0.85              | -.15   |
| #66      | 1.52              | 1.30              | -.22   |
| #67      | 1.48              | 1.55              | +.07   |
| #68      | 1.19              | 1.50              | +.31   |
| *69      | 1.33              | 1.45              | +.12   |
| #70      | 1.62              | 1.58              | -.04   |
| 71       | 0.62              | 0.65              | +.03   |
| 72       | 0.71              | 0.75              | +.04   |
| 73       | 0.24              | 0.30              | +.06   |
| 74       | 0.05              | 0.15              | +.10   |
| 75       | 0.19              | 0.35              | +.16   |
| 76       | 0.48              | 0.70              | +.22   |
| 77       | 1.33              | 1.40              | +.07   |
| 78       | 0.90              | 1.00              | +.10   |
| 79       | 1.05              | 0.85              | -.20   |
| 80       | 1.62              | 1.30              | -.32   |
| 81       | 2.50              | 2.15              | -.35   |
| 82       | 1.60              | 1.55              | -.05   |

TABLE 40 (continued)

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| QUESTION | MEAN <sub>1</sub> | MEAN <sub>2</sub> | CHANGE |
|----------|-------------------|-------------------|--------|
| 83       | 1.35              | 1.50              | +.15   |
| 84       | 1.30              | 1.40              | +.10   |
| 85       | 1.40              | 1.50              | +.10   |
| 86       | 1.20              | 1.30              | +.10   |
| 87       | 1.10              | 1.20              | +.10   |
| 88       | 0.70              | 0.75              | +.05   |
| 89       | 1.05              | 1.30              | +.25   |
| 90       | 1.05              | 0.75              | -.30   |
| 91       | 2.60              | 2.20              | -.40   |
| 92       | 2.60              | 2.75              | +.15   |
| 93       | 1.05              | 1.20              | +.15   |
| 94       | 0.65              | 0.75              | +.10   |
| 95       | 0.95              | 0.90              | -.05   |
| 96       | 1.90              | 1.45              | -.45   |
| 97       | 2.40              | 2.45              | +.05   |
| 98       | 2.05              | 1.95              | -.10   |
| 99       | 1.20              | 1.05              | -.15   |
| 100      | 1.10              | 1.15              | +.05   |
| 101      | 1.55              | 1.20              | -.35   |
| 102      | 0.85              | 1.00              | +.15   |
| 103      | 2.30              | 2.10              | -.20   |
| 104      | 2.90              | 2.45              | -.45   |
| 105      | 1.30              | 1.15              | -.15   |
| 106      | 1.85              | 1.90              | -.05   |
| 107      | 1.65              | 1.50              | -.15   |
| 108      | 2.60              | 2.50              | -.10   |

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