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CHEMISTRY CURRICULUM COMPARISON IN SELECTED MICHIGAN HIGH SCHOOLS

By

Hyonam Kim

A DISSERTATION

Submitted to
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ABSTRACT

CHEMISTRY CURRICULUM COMPARISON IN SELECTED MICHIGAN HIGH SCHOOLS

By

Hyonam Kim

Data were collected in two regular and one advanced placement chemistry classes in two Michigan suburban high schools in order to analyze four research objectives such as (1) a description of the educational environment of the two high schools, (2) an analysis of educational objectives, (3) an analysis of topics and teaching methods, and (4) an analysis of student interest. A total of 40 class periods were observed, and 20 sets of student evaluation materials and three yearly teacher plannings were surveyed. Klopfer's categories were used for the analysis of educational objectives and chemistry topics. The developed categories were used for the analysis of teaching methods and student interest. Most data were analyzed by counting frequency, calculating percentages, and tabulating the results.

Educational objectives were instructed, which were knowledge and comprehension objectives, 46.3 percent to 68.2 percent; scientific inquiry I, 11.2 percent to 17.8 percent; application, 3.2 percent to 16.1 percent; and scientific inquiry II, III, and IV, 0.0 percent to 4.2 percent in the 40 classroom observations. In the student evaluation methods, educational objectives were emphasized, which were knowledge and comprehension, 39.5 percent to 48.0 percent; application, 43.7 percent to 45.4 percent; and scientific inquiry II, IV, and manual skills, 0.0 percent to .5 percent.

In the analysis of chemistry topics, the two regular programs planned to emphasize mostly chemical laws, energy relationships and equilibrium in chemical systems, and atomic and molecular structure. The advanced placement program planned to emphasize mostly chemical materials (15.3 percent), chemical laws (15.3 percent), energy relationships and equilibrium in chemical systems (24.7 percent), and atomic and molecular structure (16.9 percent) in the total instruction hours. All three programs rarely taught general topic categories (0.0 percent to 7.4 percent). In the analysis of teaching methods, the two regular programs planned to use mostly lecture, student experiment, problem solving, and test. The advanced placement program planned to use more student experiment methods (31.2 percent) than lecture method (29.2 percent) in the total instruction hours.

In the analysis of student interest, lecture, problem solving, and socratic method classes received less interest than experiment classes or lecture classes. Manual skills (60.3 percent to 85.5 percent) captured greater student interest than knowledge and comprehension (41.3 percent to 53.2 percent).

To my families and teachers

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CHAPTER 1

Introduction

This chapter describes a brief history of science curricula, the problems to be solved, and the purposes of this study. The history sketches ancient, modern, and U.S. science curricula development. Since the overall purpose includes developing a methodology for comparing chemistry curricula, with a long range intention of using it and helping develop science education in Korea, a brief background on Korean education is also presented here.

1.1. Background of the Study

This section includes background of origins of modern science, American science education, and Korean science education.

1.1.1. Ancient and European Origins of Modern Science

People study things which are presumed to be needed to live in this world. The contents of learning are inextricably interrelated to methods of learning, which for the purposes of this study, both will be embraced within the concept of curriculum. Curricula have shifted and changed throughout the flow of history. Curriculum is usually formulated in terms of perceived cultural need.[1] European culture, which influences American culture, was affected by ancient Greek culture. From the ancient Greek and Roman periods, throughout the medieval, Byzantine, and Renaissance periods and from the sixteenth through the eighteenth centuries, Europeans developed relatively more formal scientific curricula than those of other people in those time periods.

In times previous to the aforementioned periods, people studied what were assumed to be needed knowledges, skills, and attitudes by interpreting their surroundings, analyzing and classifying natural phenomenon, including animals, plants, the sky cosmic objects (such as moon, sun, and stars), and weather events.

Greeks pursued the study of categories and topics such as happiness, truth, the atom, and so on. They used a dialectic method to discuss those topics. "Education was based on following the example of adults and the gods, and on learning the poems and myths passed down from generation to generation. Historical knowledge, whether inscribed in poetry, or preserved by oral traditions in family and clan, was part of this early curriculum."[2]

In the Greek period, primary schools taught the "three R's" (reading, writing, arithmetic), music (vocal, instrument-lyres, flutes), gymnastics (individual, competitive exercises), and religion (through literature, and by participation in community religious events). Upper secondary schools offered further training in gymnastics and also in military matters.

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[1]Y. Shimasu, "Social and Economic Influences in Curriculum Change in Japan: Case History of Environmental Education," *Environmental Education and Information*, vol. 1, no. 2, (April-June, 1981).

[2]W.K. Medlin, *The History of Educational Ideas in the West*, (The Center for Applied Research in Education, Inc., 1964), pp. 11-12.

In the Roman period, primary schools taught the three R's and the Twelve Tables of Law; Secondary schools, Greek, Latin, literature, history, and some rhetoric; higher schools, rhetoric, law, and architecture.

In the medieval period, cathedral schools taught grammar, rhetoric, logic, arithmetic, geometry, astronomy, and music; universities, philosophy, law, and medicine. In the Byzantine culture, primary schools offered instruction in the basic skills and religion; secondary schools taught grammar, literature, and mathematics; institutions of higher education, rhetoric, logic, philosophy, science (astronomy), music, and mathematics.

In the Renaissance period, secondary schools provided Latin, Latin literature, Greek, Greek literature, grammar, rhetoric, logic, mathematics, astronomy, music, drawing, ancient history, philosophy, nature studies, and physical military exercises.

From the sixteenth through the seventeenth centuries in Europe, there emerged some new trends in curriculum, which were the results of some people's efforts to experiment and to develop general scientific rules. Copernicus (astronomy, heliocentrism), Vesalius (human anatomy), Galileo (telescopic magnifying lens, heliocentric theory), Kepler (planetary movements), Decartes (analytical geometry), Newton (gravitation, laws of motion, calculus), and Boyle (chemistry, laws of gases) were among the creative persons in that period, who greatly influenced curricula.

And so a scientific academic community emerged and began and to accumulate the vast and astonishing scientific knowledge which is so predominant in our times. This knowledge was organized firmly, taught in the various schools, and became the fundamental bases of modern scientific knowledge. In the seventeenth and eighteenth centuries, science and mathematics were emphasized. A modern curriculum formulated by John Milton offered instruction in mathematics, natural sciences, geography, anatomy, astronomy, navigation, and other practical and civic subjects.

1.1.2. Development of Science Education in the U.S.

Columbus was the first modern European to set foot in North America in 1492. Europeans began to immigrate to America in increasing numbers in the sixteenth through the seventeenth centuries and as they did so, they established European educational systems in their communities. On the basis of European traditions, and motivated by a pioneering frontier spirit, Americans have evolved their own educational system and curriculum, through the colonial period, and on into the twentieth century.

The secondary school curriculum in English colonial America consisted of Latin, Greek, some English, writing, and arithmetic.[3] By the end of the eighteenth century, academic secondary schools were established widely, where writing, drawing, arithmetic, accounting, geometry, astronomy, the English language, history, natural science, mechanics, commerce, and health were taught.[4] Academic secondary schools where classical languages were not necessarily taught, were urged to do so by such people as Benjamin Franklin.

By the end of the nineteenth century, more than 20,000 high schools were in operation in the United States, where there were a variety of courses such as commercial subjects, manual arts, agriculture, and home economics. In the period between 1920 and 1940, general mathematics, biology, general science, general business, social studies, and civics were included in the high school curricula.

In the early years of the eighteenth century, chemistry was introduced into the American secondary schools and was taught formally at Franklin's Philadelphia

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[3]W. Bechner and J.D. Cornett, *The Secondary School Curriculum-Content and Structure*, (Intext Educational Publishers, 1972), p. 36.

[4]Ibid, p. 37

Academy, founded in 1751, along with other science subjects: astronomy, geography, zoology, and geology.[5]

During World War II, military trainers were surprised at high school graduates' low level of scientific knowledge. After World War II, some science educators began to plan the revision of science curricula. At the end of 1957, the Soviet Union launched Sputnik, the first earth-orbiting satellite. In those times of turmoil and competition with the Soviet Union, some United States educators began to urge Americans to develop more scientific discipline, and more mathematical and higher-level scientific knowledge.

After 1957, many new science programs were developed. These programs, along with newly-published textbooks emphasized the processes of science: observing, measuring, inferring, abstracting, and experiencing. Educators, school teachers, and psychologists worked together to develop the proposed new science curricula. The challenging programs were evaluated in real school situations and revised.

As of 1983, the 1957-invented curricula and traditional curricula are used together in United States high school chemistry classes. Traditional curricula emphasized knowledge already established by previous scientists. Experiments in the traditional curricula were arranged in order to conform to already-established experimental procedures and results. There were a few inquiry types of experiments, but some traditional textbooks, such as *Chemistry and You* [6] included many life-related problems and principles. The authors tried to apply chemical knowledge to familiar life events.

The 1957-invented textbooks included more updated knowledge. The CHEM Study (Chemical Educational Material Study) was organized with emphasis on scientific experi-

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[5]Ibid, p. 202

[6]B.S. Hopkins et al., *Chemistry and You*, (Lyons & Carnahan, 1939).

ment and inference as the main structures. The CBA (Chemical Bonding Approach) program was based on emphasizing the chemical bond theory, which is the main theory of modern chemistry, especially of organic chemistry. Both programs tried to include basic concepts which had not yet been taught in high school classes. Those programs also used more mathematics than the older textbooks.

These two programs were supported by the NSF (National Science Foundation). They were designed for college bound students, especially for science-oriented students. Because of their emphasis on scientific conceptual knowledges in the high school curricula, universities and colleges had to enhance the level of their introductory science curriculum.

Some evaluations of the 1957-invented curricula indicated that they were useful for enhancing students' scientific attitudes but were not so useful for achieving scientific knowledge.[7] The courses are difficult, but these students are more motivated in inquiry types of classes.[8]

A common educational goal continues to be to sustain present life and to enhance future life. We strive to teach accumulated knowledge, study skills, attitudes, and creativity. Benjamin S. Bloom and other psychologists met to discuss achievement testing and to clarify educational objectives. As a result, they classified educational objectives into three domains: the cognitive domain, the affective domain, and the psychomotor domain. The cognitive domain included recall or recognition of knowledge and the

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[7]F. Lawrentz and A. Gullickson, *A Comparison of CHEM Study Classes and Traditional Curriculum Classes with Respect to Achievement and Attitudinal Measures*, Research Paper no. 4, (Minnesota University, College of Education).

[8]J.M. Armstrong, *A Comparative Evaluation of an Investigative and Traditional Biology Laboratory Curriculum at the Introductory College Level*, (Ph.D. dissertation, University of Colorado, 1974).

development of higher intellectual abilities and skills.[9] The affective domain included changes in interest, attitudes, and values, and the development of appreciations and adequate adjustment.[10] The third domain was the manipulative or motor-skill area. Bloom thought the cognitive domain dominated in the greatest part of test development and curriculum development. But the actual curriculum occurs in classrooms and these include considerable activity in the affective domain, such as students' interests and attitudes.

Klopfer specified science objectives into nine different categories and 48 subcategories[11] (see Appendix A). These nine different categories are knowledge and comprehension, processes of scientific inquiry I, II, III, IV, application of scientific knowledge and methods, manual skills, attitudes and interests, and orientation. Bloom's cognitive domain includes Klopfer's knowledge and comprehension, and his four processes of scientific inquiry and application. Bloom's psychomotor domain parallels Klopfer's manual skills.

These objectives are to be achieved by the curriculum. Curriculum is usually defined as the teaching contents and the teaching methods. It often also includes the objectives of teaching and the evaluation of learning. Teaching content, which is the core part of curriculum, usually is chosen from textbooks, and textbooks are written by people who have teaching experiences in the high schools or who are experts in those content areas. In the United States there are many different chemistry textbooks. Teaching methods vary: Some teachers use films, slides, pictures, models, and scientific

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[9] B.S. Bloom, ed, *Taxonomy of Educational Objectives; Cognitive Domain*, (Longman, 1981).

[10] D.R. Krathwohl, B.S. Bloom and B.B. Masia, *Taxonomy of Educational Objectives; Affective Domain*, (Longman, 1980).

[11] L.E. Klopfer, "Evaluation of Learning in Science," in B.S. Bloom et al. eds, *Handbook on Formative and Summative Evaluation of Student Learning*, chapter 18, (McGraw-Hill Book Company, 1971) pp. 559-642.

experimental equipment to give students better chances to understand and become motivated. Recently the teaching of inquiry skills, which the 1957-invented programs emphasized, has come to be regarded as an important objective in science education.

What kinds of topics in chemistry should be taught in high schools? And how should new knowledge in chemistry be taught?[12] Is chemistry really a useful subject for future adults?[13] Do high school students feel satisfaction in their learning of chemistry through the various teaching methods? Many researchers have tried to answer these questions. Most research has been based on such tests as achievement tests,[14] attitudes tests,[15] and inquiry skill tests.

It is probable that the educational budget in the United States is not sufficient at present to realize the goals of science education. The United States spends only .5 billion dollars on textbooks for grades kindergarten through 12, whereas 176 billion dollars are spent on 44 major weapons programs, 40 billion dollars are spent on federal paper work, and 20 billion dollars are spent on tobacco.

Budgets in local school districts vary widely. In 1982, the Detroit Public School District spent $1,400 per year per student, but Midland, Michigan, spent $2,350 per stu-

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[12] C.T. Bishop, "High school Chemistry, Relevance or Principles," *Journal of Chemical Education*, vol. 54, no. 3, (March 1977) pp. 169-170

[13] G.C. Britton, "A Challenge Answered? -- 1," *Education in Chemistry*, vol. 14, no. 2, (March 1977), p. 37

[14] E.A.P. Vanek, *Comparative Study of Science Teaching Materials (ESS) and a Textbook Approach on Classificatory Skills, Science Achievement, and Attitudes,* (Ph.D. dissertation, The University of Rochester, 1974); H.W. Heikkinen, *A Study of Factors Influencing Student Attitudes Toward the Study of High School Chemistry,* (Ph.D. dissertation, University of Maryland, 1973); R.E. Davies, *A Comparison of an Elective Mini-course science Curriculum and a Conventional Non-elective Science Curriculum at the Junior High School Level,* (Ph.D. dissertation, The Pennsylvania State University, 1977).

[15] J.Y. Dempsey III, *A Comparison of Selected Lousiana High Schools Having High Percentage Enrollments in Chemistry with Those Having Low Percentage Enrollments in Chemistry in terms of certain Identified Instructional Teacher, and Students Characteristics,* (Ph.D. dissertation, McNeese state University, 1975); M.F. Dobbins, IV, *the Use of Chromatography to improve the Attitudes of High School Chemistry Students Towards Science,* (Ph.D. dissertation, University of Pennsylvania, 1980); E.A.J. Hall, *The assessment of Parental Knowledge, Comprehension and Attitudes about the Science Curriculum in a Junior High School,*

dent. The Detroit public school district is poorer than Midland's school district, and therefore, the curricula in the two school districts may be different in terms of quality. They may have different quantities and kinds of laboratory equipments.[16] Due to such a difference in funding, some schools may not be able to conduct enough experiments because of a lack of supplies or limited classroom space.

There is no comprehensive examination in the United States for high school graduation as there is in the United Kingdom, but the SAT (Scholastic Aptitude Test) scores, which test verbal and mathematical abilities, are used as criteria for college admissions, and the PSAT includes 15 subject areas including science subjects such as physics, chemistry, and biology. Some universities require some subject scores of the PSAT for college admission review.

A given chemistry curriculum depends primarily on the chemistry teacher and the school. If a chemistry teacher likes organic chemistry, then organic chemistry will be stressed; teaching methods vary according to teachers' preferences. As a result, student learning varies. Some high school students can remember the names of elements, the periodic table, and the atomic numbers of elements; some can synthesize compounds such as soap or lotion. In this study, high school chemistry curricula will be studied in terms of educational environment, chemistry topics, teaching methods, and student interests.

(Ph.D. dissertation, University of Maryland, 1977).

[16]F. Fornoff, *Beginning an Advanced Placement Chemistry Course, Edition Y*, (Educational testing Service, Princeton, N.J., Test Collection, 1976).

1.1.3. Background of Science Education in Korea

Korean science educational background of high schools was described, in the following aspects: educational system, and science courses.

Educational System

The Korean educational system can be called as a semi-centralized system. The general structure is shown in Figure 1. In Korea, the educational headquarters come under the auspices of the Ministry of Education. Educational councils are established in each province. The educational councils act as administration bodies for the schools -- the elementary through high school. All colleges in Korea are administrated directly by Ministry of Education. The basic educational system is 6-3-3-4, as shown in Figure 2: which is six years for an elementary school, three years for a middle school, three years for a high school, and four years for a college. For one school year, the school days number 240 days for elementary, middle and high schools, and 210 days for colleges. With the exception of the colleges, students attend school 5.5 days per week. The general class size is 50-65 in grades kindergarten through twelve.

There are differences in size and future plans for students between the vocational and academic high schools. In 1981 there were 748 Korean academic high schools and 614 vocational schools -- 56 agricultural schools, 100 industrial schools, 232 business schools, 37 vocational schools, 180 integrated vocational schools, and nine fishing and marine schools.[17] There was a total of 1,006,313 academic high school students and 811,255 vocational high school students. Of the total of vocational high schools, 32.6 percent wished to attend college, but only 15.3 percent were able to do so. Graduates of

[17]Korean Educational Association and Saehan Newspaper, *Yearbook of Korean Education, 1981-1982,* (Seoul, Korea), pp. 112-122

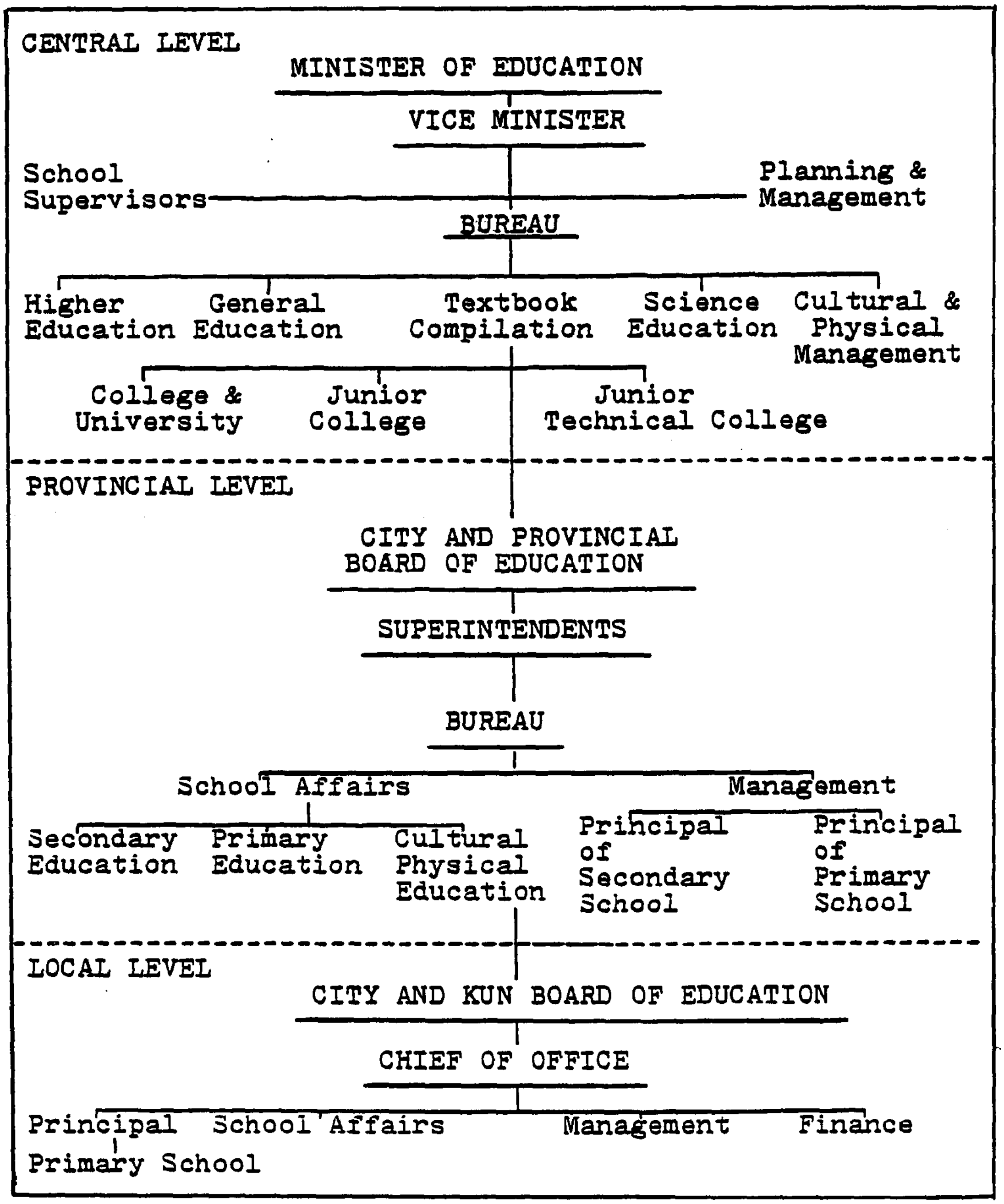

Figure 1. Educational Administration System of the Republic of Korea

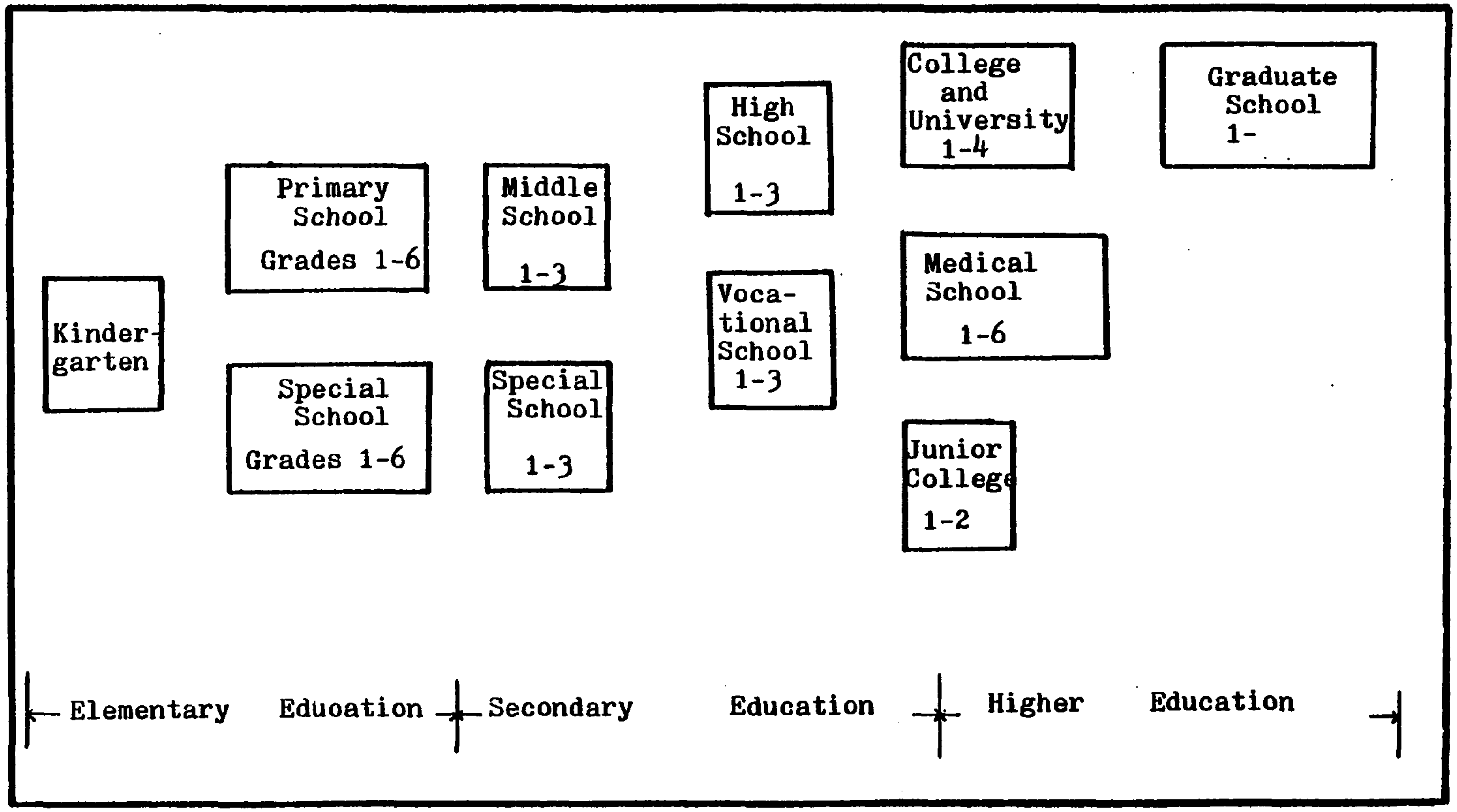

Figure 2. School System of the Republic of Korea

vocational high schools got jobs after high school graduation in the following portions: agricultural, 29.8 percent; industrial, 47.5 percent; business, 55.7 percent; fishing and marine, 38.3 percent; home economics, 85.9 percent; and academic tracks of vocational schools, eight percent. Of the total number of students in academic high schools, 79.9 percent wanted to go college, but only 51 percent of total academic high school students went to school beyond high school. Thirty-two percent of total academic high school students went to four-year colleges in 1981. Science curricula will be different in vocational and academic high schools, for the vocationally oriented students and academically oriented students in each school.

Science Courses

Science is emphasized and treated as an important subject in Korea. Science in high schools is divided into four subjects: physics, chemistry, biology, and earth science. Each subject is specialized into subject I and subject II. Subject I includes such basic knowledge as liberal art subjects. Subject II includes more advanced basic knowledge of modern sciences. Four to six units of all four subject Is are required for all academic high school students.[18] Vocational high school students are required to take two out of four science I subjects. Four science II subjects are required for all science track students and one or two of four science II subjects are required for vocational high school students.

Chemistry classes are divided into two levels: one is Chemistry I and the other is chemistry II. As shown in Table 1, Chemistry I is taught to all academic high school students for four to six units, but in vocational high schools, it is offered as an elective

[18]Ministry of Education of the Republic of Korea, *Outline of new Curriculum: High School, 1982*, pp. 89-91 and pp. 98-105

Table 1. Chemistry Course Units in Korean High School[1]

Schools	Academic High School		Vocational High School
Courses	Social-Human Science track	Science Track	
Chemistry I	4-6 units* (72-108 class period) compulsory	4-6 units (72-108 class period) compulsory	4-6 units (72-108 class period) elective
Chemistry II	0 unit	4 units (72 class period) compulsory	4 units (72 class period) elective
Total	4-6 units (72-108 class period)	8-10 units (144-180 class period)	0-10 units (0-180 class period)

* One unit means one class period per week for one semester. One semester is about 18 weeks. Thus, one unit is 18 class periods.

[1]Ministry of Education of the Republic of Korea, *Outline of New Curriculum: High School*, (1982)

course. One unit comprises one class period per week for one semester. Science track students in academic high schools are required to take Chemistry II for four units. All in all, in academic high schools, science track students take chemistry for eight to ten units, and social-human science track students, for four to six units. In vocational schools, students take Chemistry I and II as elective courses for zero to 10 units.

In 1982, education comprised 17.10 percent of total government expenditure. This was the second largest expenditure following 34.32 percent for defense.[19] However, there is great demand for additional money for the construction of laboratories, purchase of chemicals, glassware and equipment, and the hiring of laboratory assistants in high schools. Figure 3 and Figure 4 show the laboratory facilities of an common high school in Seoul, Korea. The laboratory has relatively sufficient glassware and chemicals, but facilities such as water supplies and comfortable space for experiments are needed.

1.1.4. Objectives and Topics of Korean High School Chemistry Teaching

Educational objectives and topics recommended by the Ministry of Education became effective in this 1984 school year. One school year starts on March 12 and ends on February 25. In this section, the recommended objectives and topics were analyzed using Klopfer's categories. Objective analysis by classroom observation and topic analysis by studying teaching plans will be attempted in the future.

Objectives of Chemistry Teaching

The new chemistry curricula, revised in 1984, emphasize the relationship between attitudes and the human culture. Chemistry teaching objectives are specified according

[19]International Monetary Fund, *Government Finance Statistics Yearbook, Vol. VI.*, (Washington D.C., U.S.A., 1982), p. 25

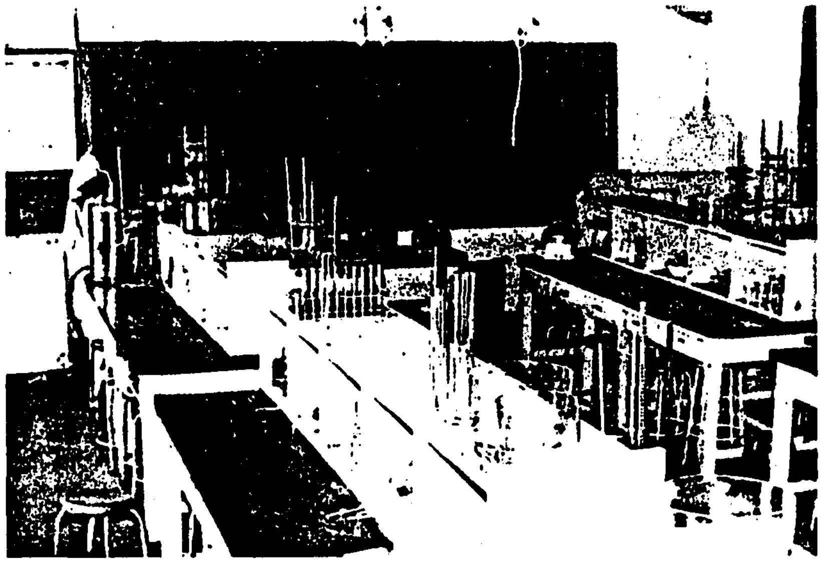

Figure 3. Lab Table in a Korean High School

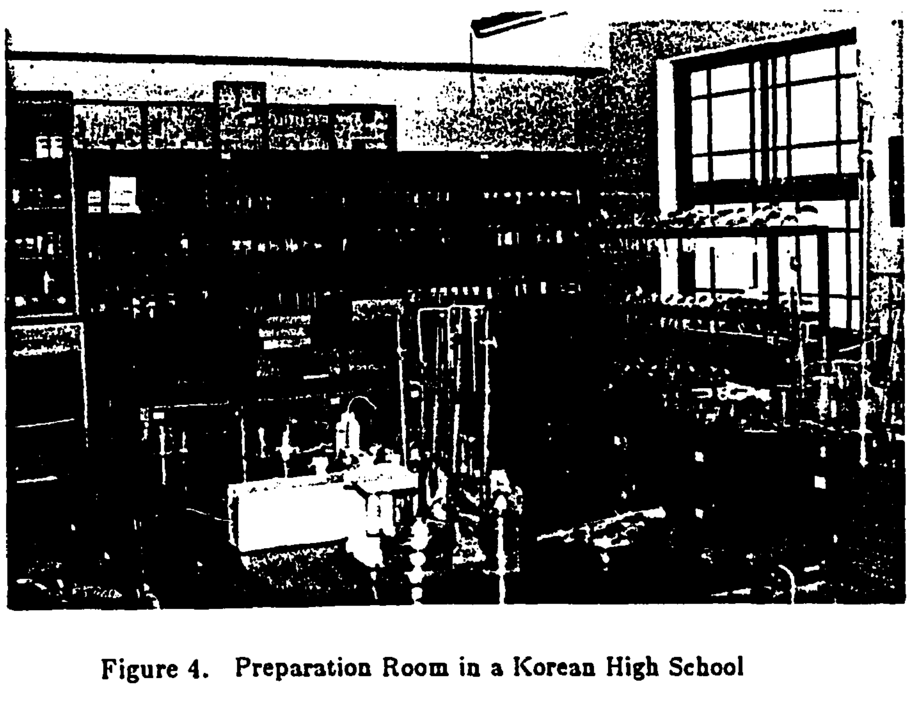

Figure 4. Preparation Room in a Korean High School

to Chemistry I and Chemistry II. In Chemistry I, five objectives are recommended: (1) systematic understanding of fundamental concepts of matters and chemical phenomena, (2) developing inquiry ability, (3) recognizing improvement and changeability of chemical concepts, (4) developing scientific life attitudes, and (5) recognizing the relationship between chemistry and human culture.

In Chemistry II, five objectives are also recommended: (1) obtaining fundamental knowledge needed for inquiry of regularity of nature, (2) improving inquiry ability, (3) recognizing improvement and changeability of chemical concepts, (4) developing scientific life attitude, and (5) developing attitudes for ongoing chemistry study. The objectives in Chemistry I have some of the same objectives to Chemistry II, such as recognizing improvement and changeability of chemical concepts and developing scientific life attitudes. Chemistry II aims at more advanced objectives because it is taught to students who will study about work in chemistry-related areas. The advanced objectives are to obtain the fundamental knowledge needed for inquiry into the inherent natural order of the physical world and developing attitudes of continued chemistry study.

As the five objectives are compared with Klopfer's educational objective categories in science education,[20] they include strongly Klopfer's educational objective categories. Klopfer's educational objectives are divided into nine major categories and 48 subcategories. The nine major categories are: (1) knowledge and comprehension, (2) scientific inquiry I: observing and measuring, (3) scientific inquiry II: seeking a problem and ways to solve it, (4) scientific inquiry III: interpreting data and generalization, (5) scientific inquiry IV: theoretical model, (6) application in science and outside of science, (7) manual skills in laboratory, (8) attitudes and interests in science and science-related

[20]Klopfer, "Evaluation of Learning in Science"

careers, and (9) relationship to other areas of knowledge.

The fundamental concepts objective in Chemistry I and II is similar to Klopfer's knowledge and comprehension objectives. The inquiry ability objective in Chemistry I and II corresponds to Klopfer's scientific inquiry I, II, III, and IV objectives. Changeability of chemical concepts objectives in Chemistry I and II correspond to Klopfer's orientation objectives. Relationship with the human culture in Chemistry I also corresponds to Klopfer's orientation objectives. Attitudes of the continuous chemistry study objective in Chemistry II also correspond to Klopfer's attitudes and interests objectives. Among Klopfer's major objective categories, the application and the manual skills objectives are not mentioned in Chemistry I and II in Korean high schools. The objectives of Chemistry I and II are specified in as much as detail in Klopfer's objective categories. However, Chemistry I and II include most of Klopfer's objective categories.

Chemistry I includes two objectives, which correspond to Klopfer's orientation objectives. They are the changeability of chemistry concepts and the relationship with the human culture objectives. Chemistry II includes two objectives, which are mapped to Klopfer's attitudes and interest objectives, the scientific life attitude and the attitude of continuous study objectives. Chemistry I emphasizes the orientation objective and Chemistry II emphasizes the attitudes and interest objectives. The objectives of Chemistry I and II are recommended by the Korean Ministry of Education. The actual objectives in the classroom may be different from the recommended objectives. Actual Korean chemistry teaching objectives will be studied in the future. Each school may have different educational background. Educational objectives may be pursued differently in each chemistry classroom even though the same educational objectives are recommended by the Korean Ministry of Education.

High School Chemistry Topics

The topics of Chemistry I and II, suggested by the Korean Ministry of Education, are analyzed by Klopfer's chemistry topic categories. Klopfer's chemistry topic categories are specified into the following ten categories: 2.11 chemical materials, 2.12 classification of chemical elements, 2.13 chemical change, 2.14 chemical laws, 2.15 energy relationships and equilibrium in chemical systems, 2.16 electrochemistry, 2,17 atomic and molecular structure, 2.18 introductory organic chemistry, 2.19 chemistry of life processes, and 2.10 nuclear chemistry.

Chemistry I has four parts: (1) chemistry-science of matter, (2) regularity of material world, (3) chemical bond and structure, and (4) chemical reaction. Chemistry I emphasizes the atomic and molecular structure, the energy relationships and equilibrium in chemical systems, and the chemical laws in Klopfer's topic categories. It does not include introductory organic chemistry, chemistry of life processes, or nuclear chemistry. Chemistry II has nine parts: (1) gas, liquid, and solid, (2) characteristics of solution, (3) modern models of atomic structure, (4) bonding and structure, (5) carbon compound and polymer, (6) thermochemistry, (7) reaction rate, (8) electrochemistry, and (9) transition elements and complex ions. Chemistry II emphasizes the energy relationships and equilibrium in chemical systems, electrochemistry, introductory organic chemistry topic categories, but it does not include classification of chemical elements, chemistry of life processes, and nuclear chemistry topic categories.

Three evaluation areas are suggested by the Ministry of Education: understanding fundamental knowledge, improvement of scientific inquiry, and development of scientific attitudes. The Ministry of Education also suggests the various application of evaluation methods, such as pencil and paper examination, conversation, experiment, observation, report, and opinion study.

The Korean educational background was described in terms of educational system, science courses--especially chemistry, and financial supports and facilities. The Korean education system needs greater financial support to allow high school students to attend colleges and job training centers, and to gain employment. As shown in Table 2, in Korea, science track students in academic high schools take eight to 10 units of chemistry, which amounts to 144-180 class periods. Chemistry is compulsory course for all of academic high school students, so social-human science track students can learn chemistry at least 72 class periods of during the high school years. In Michigan, chemistry is an elective course, and some students take no chemistry courses in high school. Some Michigan high school students take one year of chemistry courses--180 hours, and some take two years of chemistry courses-- 360 hours. In Korean high schools, science track students in academic high schools (144-180 class periods) have fewer classes than students in some Michigan high schools (360 hours).

1.2. Statement of the Problem

The aim of this study is to develop and implement a curriculum comparison methodology. The validity of comparison data depends on methods of collecting data. In this study, comparison data will be collected by field study in chemistry classroom, and from school personnel. Actual curricula may be different from the written curriculum materials because of the differences in individual classroom background, such as teacher's and student's background and school environment.[21]

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[21]M. Spencer, "The Future of School Chemistry," *Education in Chemistry*, vol. 5, no. 8, (November 1978) pp. 190-191; R.G. Barker and P.V. Gump, *Big School, Small School-High School Size and Student Behavior*, (Stanford University Press, 1972).

Table 2. Chemistry Class Periods in High Schools

Courses / Schools	Chemistry I		Chemistry II		Total
	Class periods	Compulsory or elective	Class periods	Compulsory or elective	Class periods
Social-Human Science Track in Academic High Schools, Korea	72-108	compulsory	0		72-108
Science Track in Academic High schools, Korea	72-108	compulsory	72	complusory	144-180
Vocational High Schools, Korea	72-108	elective	72	elective	0-180
Some High Schools, in Michigan, U.S.A.	180	elective	180	elective	0-360
Some High schools, in Michigan, U.S.A	180	elective	0		0-180

There are many chemistry topics, and there are many teaching methods, such as lecture, lecture-demonstration, student experiment, essay writing, field trips,[22] discussions, and film-slide showing. Among the wide range of topics and teaching methods, chemistry teachers select those within their particular circumstances, and this process of selection is influenced by their preferences, by students' future plans, and by the school's financial support. For curriculum comparison, both the examination of teaching plans and classroom observation would most likely provide data which is closer to actual curriculum than would other sources of data.

For purposes of curriculum comparison, educational objectives of chemistry teaching, chemistry topics, and teaching methods have been researched (objectives: Roadranka[23] and Wood;[24] and teaching method: Heikkinen[25] and Vanek[26]). Most researchers used standardized or nonstandardized tests to evaluate students' achievement, attitudes, and skills.

Some researchers have studied just one aspect of curriculum, such as the textbook, or only the teaching methods, or a particular skill or attitude. Curriculum comparison should be performed taking many variables into account and through direct classroom observation. A curriculum comparison methodology based on field study and including teaching plans will be applied to chemistry curricula of two Michigan suburban high schools.

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[22]M. Binns, "Chemistry for Life: A Mode III Course," *Education in Chemistry,* vol. 15, no. 5, (September 1978) p. 143 and 145

[23]V. Roadranka, *A Content Analysis of Texas and Thai High School Biology Textbooks,* (Ph. D. dissertation, North Texas State University, 1981).

[24]C.G. Wood, *An Examination of the Interrelationships between Societal Factors and the Development of the High School Chemistry Curriculum Form 1850 to 1939,* (Ph.D. dissertation, University of Maine at Orono, 1976), pp. 78-90

[25]Heikkinen, *Student Attitudes*

[26]Vanek, *ESS and a Textbook Approach*

1.3. Purposes of the Study

This study has four purposes: (1) to describe educational environment of two high schools in terms of communities, schools, teachers, students, and science courses, financial support, and facilities, (2) to analyze chemistry classes through observation and student evaluation methods in terms of educational objectives such as knowledge and comprehension, scientific inquiry skills, application, manual skills, scientific attitude, and orientation in the two high schools, (3) to analyze chemistry topics and teaching methods shown in one-year teaching plans, and (4) analysis of student interest shown in chemistry classes. This study proposes developing a curriculum evaluation methodology, which may be used in Korea.

This dissertation includes a literature review of objective research, teaching method research, and curriculum comparison methodology research in Chapter 2; methodology of the study in Chapter 3; description of educational environment of the two schools in Chapter 4; data analysis of educational objectives, chemistry topics, teaching methods, and student interest in Chapter 5; summary, conclusion, and further research plans in Chapter 6; Appendices; and References.

CHAPTER 2

Literature Review

A literature review concerns recent studies of educational objectives, teaching methods, and curriculum evaluation methodology.

2.1. Studies of Educational Objectives

Educational objectives are studied quantitatively by three researchers, Roadranka, Ogden, and Wood. Roadranka used Klopfer's categories to analyze five Texas high school biology texts and one Thai high school biology text.[1] In that study, the author analyzed the portions of knowledge and comprehension, application, scientific inquiry skills, orientation, scientific attitudes, and manual skills presented in the texts. She said that scientific attitudes could be analyzed by using student questionnaires. However, this study will use observation methods to locate a portion of scientific attitudes, as well as the other objectives, more realistically. The on-site observation is nearer to what happens in science instruction. Such results are expected to be more valid for the assessment of chemistry instruction.

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[1]V. Roadranka, *Content Analysis of Biology Textbooks*.

Roadranka's research showed 74 percent to 88 percent of contents of textbooks focus on cognitive objectives, 10 percent to 20 percent on inquiry skills objectives, two percent to five percent on manual skills objectives, and .5 percent to one percent on orientation objectives. She studied common topics covered in six texts for reference, such as structure of programs, and recorded the frequency of a certain objective shown in a topic. She found that cognitive objectives took high priority. However, these results will be different from the results of observation methods which will be used in this study. Roadranka chose just textbooks from among the various curriculum materials. Even though textbooks have been the most basic curriculum materials for selecting the contents of courses until now, the same contents can be taught with emphases on different objectives.

Ogden[2] studied objectives of secondary school chemistry teaching by searching professional periodicals of the 1918-1972 period. He categorized objective statements into four such as; knowledge, process, attitudes & interest, or cultural awareness. The categories were further divided into 18 sublevels. He also historically divided the 1918-1972 period into 6 sublevels. In the sixth subperiod, 1963-1972, objectives of secondary school chemistry teaching were found such as; the knowledge category, 41.3 percent; the process category, 13.7 percent; the attitude and interest category, 24.1 percent; and the cultural awareness category, 20.6 percent.

Wood also analyzed objectives collected from various articles published from 1918 to 1933. Knowledge objectives comprised 40 percent; process objectives, 20 percent; attitudes and interests objectives, 25 percent; cultural awareness objectives, 15 percent.[3]

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[2]W.R. Ogden, "Secondary School Chemistry Teaching, 1918-1972: Objectives as Stated in Periodical Literature," *Journal of Research in Science Teaching*, vol. 12, no. 3 (1975), pp. 235-246

[3]C.G. Wood, *High School Chemistry Curriculum*, p. 90

Wood's knowledge objectives included study skills and the application of chemistry to daily life, respectively, which belong to inquiry skills, and application objectives in Klopfer's objective categories. Wood's process objectives included the scientific method of thinking and the requisite skills needed to think analytically. His attitudes and interests objectives included an appreciation for science, an interest in scientific subjects, and career development in chemistry. Cultural awareness objectives dealt with esthetic, philosophical, and sociological aspects of chemistry. Klopfer analyzed objectives in more detail. The two researchers' objectives are differently classified, so the portion of objectives can not be compared each other, but Klopfer's orientation objectives are similar to Wood's cultural awareness objectives. In Roadranka's study, orientation objectives are .5 percent to one percent, which is much smaller than that in Wood's study, 15 percent. This study will use Klopfer's objective categories for analysis of educational objectives shown in chemistry classrooms and in student evaluation methods.

2.2. Studies of Teaching Methods

Certain teaching methods are believed to be more effective for some students than others. Student achievement and interest were studied with respect to different teaching methods. Student-centered classes seem to produce higher achievement and higher interest than CHEM Study or teacher-centered classes, but no significant difference in critical thinking ability has been observed (Heikkinen),[4] and there are several studies on the effectiveness of gaining certain skills in different programs. Most of them used standardized tests or self-developed tests to assess these differences.

Vanek studied the Elementary Science Study (ESS) as an activity-based curriculum and the Laidlaw Science Series as a textbook approach in the aspects of classificatory

[4]Heikkinen, *Student Attitudes*

skills, science achievement, and attitude. In order to assess the results, he used the Science Attitude Scale (Ralph), the Piagetian Classification Task, and the Science Test of the Stanford Achievement Primary Battery III for pre- and post-tests. He found that students in the ESS program liked science classes and scientists more than students using the textbook approach; teachers also liked the ESS program (activity-based curriculum) more than the textbook approach.[5]

Wood researched students' preferences for different teaching methods. In his research of New York student ratings with regard to various methods, students rated methods where they "gained greatest understanding". They were as follows: lecture-demonstration (33 percent), textbook method (22.6 percent), individual lab (16.8 percent), problem method (15.9 percent), and combination (11.7 percent).[6] One-third of the students indicated that the lecture-demonstration method was the best method for gaining greatest understanding. Their ratings for "gained greatest enjoyment" were: individual lab (44.4 percent), lecture-demonstration (26.2 percent), combination (15.2 percent), problem method (8.5 percent), and textbook method (5.7 percent).[7] Almost half of the students answered that "individual lab" was the best method to use for gaining the greatest enjoyment.

These results agree with other research. Vanek(1974) found that students and teachers liked more activity-based programs than a textbook approach. Heikkinen (1973) found that student-centered classes generated higher interest among students than teacher-centered classes. None of this research showed the reasons for students, preference for activity-based classes. In the present study, instruction will be analyzed

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[5]Vanek, *ESS and a Textbook Approach*

[6]Wood, *High School Chemistry Curriculum*, p. 119

[7]Ibid, p. 119

in terms of proportion of educational objectives and student interest. The student interest data will be collected by classroom observations and interviews with both students and teachers

Various teaching methods are classified. Slavison and Speer[8] classified teaching methods into 18 kinds, such as lecture method, socratic method, library, object-study, picture, observation, lecture- demonstration, individual lab, problem, Dalton plan, unit, historical biographical, concentric, heuristic, project, coordinated plan, integrative plan, club plan, trips and excursions, exhibits, and search-discovery.

Wood divided teaching methods into lecture-demonstration, individual lab, textbook method, problem method, and combination.[9] Downing classified teaching methods as lecture, question and answer, book method, text, assignment, recitation method, observation, experimental, lecture-demonstration, individual laboratory, problem method, project method, contract method, supervised study, and historical method. These three different kinds of classifications of teaching methods include lecture-demonstration, individual laboratory and problem method.[10] Downing, Slavison, and Speer dealt differently with observation and individual lab work.

Wood used a questionnaire method to study students' opinions of teaching methods. This study will apply different criteria to analyze student interest. The criteria will be classified into negative, neutral, and positive. If students talk with others about nonsubject-related topics, and do not pay attention to their work, student interest will be judged to be negative. If students do their work eagerly and joyfully, then their attitudes will be judged to be positive. Intermediate judgments between negative and

[8]Ibid., p.129
[9]Ibid., p. 119.
[10]Ibid, pp. 128-189

positive will be judged to be neutral.

2.3. Studies of Curriculum Evaluation Methodology

Many standardized tests are used for evaluation of student learning in curriculum comparison studies. There are achievement tests, attitude tests, classification skill tests, and inquiry skill tests, among others. But the classroom observation method is also used frequently to evaluate curriculum.

Achievement tests which have been used include the Science Test of the Stanford, the Achievement Primary Battery III,[11] the Test on Understanding Science, Form W (TOUS)[12] the ACS-NSTA Cooperative Chemistry Exam, 1965, 1971 ,[13] the Anderson-Fisk Chemistry Test, 1966,[14] the Testing of Science Knowledge, Part II,[15] the Cooperative Science Tests, Form A and B,[16] and the BSCS processes of Science Knowledge, Comprehension, Application, and Analysis.[17] Many attitude tests have been used, such as the Science Attitude Scale (Ralph),[18] the Student Opinion Survey in Chemistry (SOSC),[19] the Scientific Attitude Inventory (Davies and Dovinns), the Academic Interest Measure (Dempsey), the Learning Environment Inventory (Dempsey), and the Projective Tests of Attitudes (P.T.O.A.)-Lawrence, Lowery (Helenmarie). The Piagetian Classification Tasks (Vanek), Comprehension (Hall), and a modification of Science Inquiry

[11]Vanek, *ESS and a Textbook Approach.*

[12]Dempsey, *Enrollments in Chemistry;* Heikkinen, *Student Attitudes.*

[13]J.S. Bock Jr., *A Comparison of the Effects of an Inquiry-investigative and a traditional Laboratory Program in High School Chemistry on Students' Attitudes, Cognitive Abilities and Developmental Levels,* (Ph. D. dissertation, West Verginia University, 1979); R.L. Call, *A Comparison of Individualized and Traditional Methods for Teaching High School Chemistry,* (Ph.D. dissertation, Arizona State University, 1974)

[14]R.L. Call, *A Comparison of Individualized and Traditional Methods*

[15]Davies, *Elective and Non-elective Science Curricula*

[16]Ibid.

[17]Bock, *High School Chemistry.*

[18]Vanek, *ESS and a Testbook Approach.*

[19]Heikkinen, *Student Attitudes.*

Assessment Instrument (Hartford) have also been used for evaluation.

As a nonpaper-pencil type of evaluation, field study has been used often in educational research.[20] When using frequency counting in the field study, it is easy to omit description of details. The field study method is useful for studying problems which are difficult to quantify for testing.[21] Cusick said that the individual teacher's personal field is an important element in the construction of curricula. For several examples of personalized curricula there were war games in social studies classes, computer programming in mathematics classes, and music opera in English classes. Hollen developed observation modes[22] in science instruction. Brophy developed a table assessing student-teacher relations.[23]

Hollen developed classroom observation form, task description form, and lesson summary form. These consisted of coded and narrative records. These forms are very descriptive, and are analytically coded. These forms show materials used, class format (12 kinds: demonstration by teacher, student presentation, and so on), student task description, noise level, teacher location, teacher activity, and student activity on coded forms. Science tasks are also coded.[24] These forms are too detailed to be used appropriately for comparison studies. The frequency of a certain code will become smaller because of the detail of the code, which makes it hard to compare one with another.

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[20]H. Munson, " An American Observations on Science Education in the Federal Republic of Germany," *Science Education*, vol. 60, no. 2, (April-June 1976) pp. 263-268; D. Smetherham, "Curriculum Innovation: Another View," *CORE: Collected Original Resources in Education*, vol. 1, no. 3, (October 1977) pp. 3160-3198.

[21]D.A. Payne, *The Assessment of Learning-Cognitive and Affective*, (D.C.Heath and Company, 1974).

[22]R. Hollen et al., *A System for Observing and Analyzing Elementary School Science Teaching: A User's Manual*, (Institute for Research on Teaching, Michigan State University, 1980) Research Series no. 90.

[23]J. Brophy et al., *Relationships between Teacher's Presentations of Classroom Tasks and Students' Engagement in Those Tasks*, (Institute for Research on Teaching, Michigan State University, 1982) Research Series no. 116.

[24]Hollen, *A System for Observing and Analyzing*, p. 34.

Anang and Lanier studied the influence of social organization in the classroom on teaching by using field study for one year. They visited ninth-grade classrooms once or twice a week. They observed mathematics and social studies classes taught by different teachers. The researchers used field notes and informal and formal interviews with students and teachers. A mathematics teacher introduced new concepts and explained problems for 10 to 20 minutes, and let students work their worksheets or workbooks independently for the last 30 minutes. In almost every class during this independent period, the teacher talked about the problems with individual students. In the meantime, the social studies teacher tried to lead the class in every class event: questioning, answering, and writing. Researchers interviewed the teachers and students who participated in both of the classes.

They found that students liked the mathematics class better, and felt they learned something in that class.[25] Students remembered the social studies teacher's scolding of other students for making noise, and many concepts and facts in the various social studies area were without connection to earlier learning. In the math class including individual work period, students felt stable and could take close concern of the teacher. The research showed that social organizations in the classroom, such as the whole group recitation or individual work groups, interacted with the teaching of subject matter. Close concern of the teacher can be interpreted differently in terms of educational objectives. The math teacher may explain problems with inquiry skills, orientation, or application educational objectives. He probably did not just give students factual knowledge. Teachers' individual teaching needs to be analyzed in terms of educational objectives to determine effectiveness.

[25]A. Anang and P. Lanier, *Where is the Subject matter ?: How the Social Organization of the Classroom Affects Teaching,* (Institute for Research on Teaching, Michigan State University, 1982) Research Series no. 114."

Anang and Lanier found one of the math teacher's class goals was application of math to the real world. When students learn applications of subject matter, they feel stable and interested. Klopfer's specifications for science education include application of scientific knowledge and methods into application to new problems in the same field of science, to new problems in different fields of science, and to problems outside of science (including technology). Application of subject matter to the real world involves application to problems outside of science. How much we should teach application, which is related to and useful in the real world, is a controversy.[26] Before 1957, science textbooks included many kinds of application to the real world (everyday life). Teaching applications can be achieved by mentioning examples of application[27] and letting students search subject matter- related magazine articles with corresponding discussion.

Generally, students' positive attitudes toward learning in school decreases as grade level increases. If students learn that which is interesting to them, they are motivated and do not become bored. Intrinsically, students try to be useful and want to receive praise from their teachers, parents and friends. Choosing topics[28] is another crucial factor in the quest to teach interestingly; teaching methods and students' interest are closely related. Some comparative research on laboratory and recitation teaching showed that laboratory teaching was more effective in increasing students' interest in chemistry.

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[26]W. Worthy, "Education: Applied Chemistry Getting Bigger Role," *Chemical Engineering News*, vol. 60, no. 35, (August, 1982) pp. 25-27.

[27]P.J. Gaskell, "Science Education for Citizens: for Perspectives and Issues, I. Science, Technology and Society: Issues for Science Teachers," *Studies in Science Education*, vol. 9, (1982) pp. 33-46; U. Zoller, "Smoking and Cigarette Smoke: An Innovative, Interdisciplinary, Chemically-oriented Curriculum," *Journal of Chemical Education*, vol. 56, no. 8, (August 1979) pp. 518-519

[28]New York State Education Department, Albany, Bureau of Secondary Curriculum Department, *Chemistry, A Syllabus for Secondary Schools*, (1979).

Cusick researched the effects of professional staff networks on curriculum by using participant observation[29] and interview in two comprehensive secondary schools. There were two kinds of network: support systems for teacher's activity and informal interactions for personal pleasure. One school had strong network, and another school, a weaker one, because there was no lunch hour and school closed early. Teachers working for the yearbook and the newspaper in the strong network school, established networks supporting their jobs. A science teacher who was a newcomer in the strong network school, liked to teach physical science, and organized four physical science classes and one chemistry class. The strong network school had had one chemistry class, one physical science class, and one ninth-grade science class. For a while he tried to persuade the principal and to make a new network, and created more physical science classes. This teacher thus changed the science curriculum of the school.

Brophy studied relationships between teachers' statements in the process of presenting classroom tasks and students' engagement in those tasks. They coded 18 categories of teachers' presentation statements and counted the frequencies of each happening. Students' engagements after these teachers' presentation statements were coded as positive, neutral, and negative. Teachers' extrinsic reward, recognition, self-actualization value, survival value, and personal reference statements received positive students' engagement. Self-fulfilling prophecy effects occurred in accordance with teacher expectations. Similarly, giving obvious objectives to students may have effects on the achievement of those objectives.

[29]P.A. Cusick, *A Study of Networks among professional Staffs in Secondary Schools*, (Institute for research on Teaching, Michigan state University, 1982) Research Series no. 112.

2.4. Summary

In Chapter 2, the recent studies of educational objectives, teaching methods, and curriculum evaluation methodology are reviewed. The educational objectives were studied quantitatively by two researchers. Klopfer's specification was used for the evaluation of high school biology textbooks by Roadranka. Over 70 percent of contents of textbooks concentrate strongly on cognitive objectives.

Student-centered classes, such as experiment classes, show higher student interest than teacher-centered classes, such as lecture classes. As curriculum evaluation methods, paper-pencil types of methods are used usually, but the classroom observation method is used frequently. Field study is also based on classroom observation method.

CHAPTER 3

Methodology of Data Collection and Data Analysis Procedures

Most of the data for this paper were collected via classroom observations in two Michigan high schools. In addition, this study used several other data collection methods: tape recording, photographing, interviewing, and surveying. The data collected to answer several research questions have been analyzed using qualitative and quantitative methods. However, educational environment of selected schools is described primarily using qualitative methods. In this study, classroom indicates lecture room and/or laboratory for chemistry teaching. The term "program" refers to two chemistry courses in School S and one chemistry course in School D.

This chapter includes:

- Research questions
- Selection of schools
- Preparation of categories and data collection forms
- Data collection activities performed
- Data analysis procedures

3.1. Research Questions

This study tried to develop a curriculum comparison methodology, and at the same time, to get a picture of Michigan high school chemistry curricula. Class observation and surveys of teacher planning were most often used to collect data. Specifically, four research questions are proposed.

The first question is concerned with the educational environment of the schools selected for study. The environment was described and analyzed, which was performed with respect to such aspects as school and community characteristics, student and chemistry teacher backgrounds, science courses, financial support, and facilities.

The second research question is concerned with educational objectives. The actual curricula practices observed in Schools S and D were analyzed using Klopfer's student behavior categories, which are shown in Appendix A, and which are considered as educational objectives in this study. Educational objectives were examined as they were manifested in high school chemistry instruction and in student evaluation methods used in the selected schools.

The third research question is concerned with topics and teaching methods. The topics selected for teaching and methods employed by Teacher S and Teacher D are analyzed using Klopfer's content categories (shown in Appendix B), which are considered as topic categories, and teaching method categories (shown in Appendix C). The proportion of teaching methods shown in one-year teaching plans was analyzed in each one-year chemistry program. Topics shown in one-year teaching plans were analyzed quantitatively and qualitatively.

The fourth research question is concerned with student interest as displayed in student behavior and student comment in response to each educational objective and each teaching method. Analysis of student interest employed classroom observation data and student interview data.

3.2. Selection of Schools

For the various reasons, the selection of school presented some difficulties. Two high schools in Michigan were selected for study, using particular criteria for selection.

3.2.1. Criteria used in Selection of Schools

Some schools offered chemistry classes every other year, and did not offer chemistry classes in the 1983-1984 school year. Some schools had no well-qualified chemistry teachers, and some school districts were not willing to participate in this kind of research. Therefore, two schools were selected using the following criteria:

- Willingness on the part of the schools participate in this research project and to allow access to chemistry classes

- Comparable educational background of teachers and students, such that the teacher would both be (a) professionally well-qualified, (b) experienced in the classroom; and that the students would come from small, stable communities situated close to centers of communication, higher education, and scientific endeavor.

3.2.2. Negotiation with Principals, Chemistry Teachers, and School Districts

Permission to observe classes was granted by different authorities from one school to another. Six Michigan high schools were contacted; finally, two schools gave permission, and four schools refused to participate. Principals in Schools S and D, located in towns S and D, respectively, were contacted by telephone. The principal in School D gave permission to observe chemistry classes after consulting with the chemistry teacher. The principal in School S gave the researcher permission to talk with the chemistry teacher by telephone, saying that permission for classroom observation depended on the approval of classroom teachers. The chemistry teacher in School S gave permission willingly.

Two other city school districts were contacted by submitting application forms which indicated research goals and methodology, and attendance at a research review committee of one school district. Both schools, however, denied permission for this study to be performed in their school districts. The reason for one school district's denial was that the school district planned to perform an overall academic achievement evaluation during the early spring semester and they did not want to generate further noncurricula disturbance to students and teachers. The reason the other school district gave denial was that this study asked too many research questions. These school districts were located in university towns, and they regularly have visitors and observers, so they have research review committees to screen and to limit research in their school districts.

In yet another case, a contact letter (Appendix D) was sent to a high school which sent back a denial letter. The reason for denial was that the school planned to have a substitute teacher for chemistry classes during the planned data collection period. One school principal was contacted by telephone and visited, but it did not offer chemistry classes in the 1983-1984 school year. The school offers chemistry classes and physics classes alternatively every year. The principal said that chemistry classes would be offered in the next school year and could then be observed for the research; however, this was not possible in view of this project's time schedule.

3.2.3. Selection of Appropriate Schools

Six schools in all were contacted before two schools (School S and School D) were found which would permit the study and met the criteria for selection. These schools satisfied all the criteria for selection. That is, both schools offered chemistry classes in the 1983-1984 school year. The chemistry curricula of the two schools were comparable with curricula of other schools in terms of subject matter content, teacher qualification, and adequacy of facilities. Both schools agreed to allow this study, and teachers in both schools cooperated fully in the project.

3.3. Preparation of Categories and Data Collection Forms

Klopfer's educational objective categories and topic categories were used. Class information forms and field note forms were developed as well.

3.3.1. Educational Objectives

Klopfer's educational objectives (student behaviors) categories[1] were used in this study; they are recognized as a comprehensive classification of educational objectives (Appendix A). The categories have nine major categories and 48 subcategories. The major categories include four categories of scientific inquiry skills which are defined as actual activities performed by students themselves. They also include 11 subcategories in knowledge and comprehension objectives. Historical and philosophical aspects are included in orientation objectives. Career concerns which are emphasized in the recent science teaching, are also included in attitudes and interests objectives. Klopfer's categories have been used by other researchers.[2]

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[1]Klopfer, " Education of learning in Science."

[2]Ibid; Roadranka, *Content Analysis of Biology Testbooks;* B.J. Fraser, "Use of Content Analysis in Examining Changes in Science Education Aims over Time," *Science Education*, vol. 62, no. 2, (1978), pp. 135-141.

3.3.2. Topics and Teaching Methods

Klopfer's content categories[3] were also used in this study. Chemistry content categories and general content categories (Appendix B) were used specifically; the former categories have been coded as 2.11 through 2.110 and the latter categories, as 3.1 through 3.5. Topics shown in popular chemistry textbooks are included satisfactorily in Klopfer's content categories.

Teaching method categories were developed from Wood's categories and Slavison's and Speer's categories.[4] The categories used in this study included nine different teaching methods (Appendix C), which are numbered as 1 through 9. Teaching Method 2, demonstration, included teacher demonstration and student demonstration. Teaching Method 5, discussion, is defined as student-student conversation with chemistry problems in chemistry classes. Teacher-student conversation, including a question-answer process, is assigned to the Socratic method, Teaching Method 8.

3.3.3. Student Interest

Student interest is categorized by student interest phenomena, and data of student interest is collected by classroom observation. Student interest is graded positive, neutral, and negative. Student interest points are assigned, positive, +1; neutral, 0; and negative, -1. Continuous variables such as interest are hard to categorize, so representative positive and negative interest phenomena are described. All other student interest classroom phenomena which could not clearly be scored as positive or negative are regarded as neutral interest.

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[3]Klopfer, "Evaluation of Learning in Science."

[4]Wood, *High School Chemistry Curriculum.*

Positive interest phenomena include:

- Students ask questions within a given five-minute observation period in lecture-room sessions

- Over 90 percent of students watch, listen to teacher, write, and are quiet in lecture class period

- Over 50 percent of students express their surprise at new information in experiment or lecture class periods

Negative phenomena include:

- Over 60 percent of students do not look at teacher, and do not write notes during lecture session
- Over 60 percent of students talk about non-class-related topics

3.3.4. Preparation of Data Collection Forms

Three kinds of data collection forms were used in this study: class information form, field note form, and interview questionaires. Class information forms (Appendix E) were made for indication of general class information such as school, teacher, number of students, topics, and teaching methods. The forms were used to give information of educational background, and general information of a chemistry classroom such as topics and teaching methods. This information could be used for comparison of chemistry curricula with curricula in different educational backgrounds.

Field note forms (Appendix F) were developed including some variables such as time, educational objectives, student interest, student and teacher behavior, and instructional contents. The forms were used for analysis of educational objective and student interest.

Interview questionaires (Appendix G) were developed to get information of teachers' and students' opinion about student interest as related to different teaching methods. The interview questions are about students' preference of experiment class to lecture class, preference of lecture class to demonstration class, and the reasons of the preference. The questionaire includes a question about teachers' opinion of financial support.

3.4. Data Collection Activities Performed

Data were collected from 40 high school chemistry class periods, from December 1983 through March 1984, observing classes, taking photographs, drawing maps, tape recording, interviewing, and surveying.

3.4.1. Selection of Chemistry Classes

In this study, the two one-year chemistry programs were selected for observation in School S and only a one-year chemistry program in School D was observed. School S has two one-year chemistry programs and a one-semester chemistry program. The one-semester chemistry program is offered for twelfth-grade students who already have taken a one-year chemistry program. The semester chemistry program is organic chemistry. The teaching methods are the socratic method and student experiment. Only a few students take this and some of them work as lab assistants. This advanced class was not observed for this study. One of the one-year chemistry programs at School S is the regular chemistry program. The chemistry teacher at School S teaches four regular chemistry class periods a day. The first class meets from 8:00 a.m to 8:50 a.m. The second class meets from 11:40 a.m to 12:30 a.m. The third class meets from 12:40 a.m to 1:30 p.m and the fourth class, from 1:40 p.m to 2:30 p.m. All class periods have the same teacher and the same chemistry curriculum. First class had 22 students and the other classes had 28-30 students. On the assumption that the four chemistry classes are similar, one of them was selected randomly on any given day for observation from December through March. Thus, fourteen regular chemistry class periods were selected in School S, the same number as in School D. Another one-year chemistry program is advanced placement chemistry, designed to expose students to college chemistry and to prepare them for the chemistry placement examination that some college-bound students take to satisfy college admission requirements. This program has been taught for only one class period a day, 10:05-10:55 a.m. This class was also observed from December through March. Twelve advanced placement chemistry class periods were selected for observation in School S.

School D has only one regular one-year chemistry program. This program was observed in School D without selection. The chemistry teacher at School D teaches three classes a day. The first class is from 11:10 a.m to 12:00 a.m. The second class is from 12:10 a.m to 1:00 p.m. The third class is from 1:50 p.m to 2:40 p.m. All the classes have the same teacher and the same chemistry curriculum. Fourteen of these regular chemistry class periods were observed in School D. A random selection among the three classes a day was made for each of the fourteen days randomly selected from December through March. Hence, a total of 40 class sessions were used for observation in this study. Finally, two programs in School S and one program in School D were selected and observed.

3.4.2. Data Collection Period

Data collection was done for 20 days (60 hours) in School S and 18 days (40 hours) in School D. The data collection period included 40 classroom observations, as shown in Table 3, a two-day science fair visit, and several visits without classroom observation. Data were mainly collected from December through March. There was classroom observation for five days in December, seven days in February, and three days in March at School S. on each day, three to four hours were spent at School S. Nine days in December, four days in February, and one day in March were spent at School D. Two to three hours were spent in School D. Each day, the field notes were taken in all 40 class observations. Tape recordings were made in 22 class sessions.

The visits corresponded to weather conditions. The data collection period was carried on in the winter of 1984. During the data collection period, schools were closed occasionally for several days. School S closed more than School D. Although the two schools are located within 30 minutes driving distance of each other, the weather conditions differed. School personnel were of differing opinions about the safety of road condition for driving school buses, so the two schools did not close on the same snow days.

3.4.3. Observation of Chemistry Classes

Both lecture room and laboratory classes were observed for a total of 40 class periods. In each class period three to four field note forms and a class information form were filled out. During classroom observation, recordings of educational objectives and of student interest were entered every five minutes. Students' and teachers' behaviors and teaching contents were also recorded.

In the lecture room sessions, the observation locations were unchanged during observation. In School S, the observation location was in the middle of the farthest row

Table 3. Chemistry Classroom Observation Schedule

Programs	School S, Regular Chemistry			School S, AP Chemistry*			School D, Regular Chemistry**		
Date	Field Note	Tape	Teaching Methods	Field Note	Tape	Teaching Methods	Field Note	Tape	Teaching Methods
12/2							√	√	7,8
12/5							√		4,8
12/8	√	√	1,8	√		1,7,8	√		3,8
12/12	√		3,8				√		3,8
12/13		√	3,8	√		1,7,8	√	√	1,8
12/14	√		1,7,8	√		2,3,8	√		1,7,8
12/15	√		3,8	√		3,7,8	√	√	7,8
12/19							√		3,8
12/20							√		3,8
2/13							√	√	1,2,8
2/14	√	√	1,7,8	√	√	1,8			
2/15	√		3,8	√	√	1,7,8	√	√	1,2,8
2/16	√	√	3,8,	√	√	3,8			
2/17				√	√	3,8			
2/21	√	√	1,7,8	√	√	1,7,8			
2/22	√		3,8	√		3,8			
2/24	√		1,7,8				√		3,8
3/1	√		3,8				√	√	1,7,8
3/6	√	√	1,8	√	√	1,4,8			
3/7	√	√	1,2,4,7	√	√	1,4,8			
Total Days	14	7		12	8		14	7	

*"AP chemistry" means "Advanced placement chemistry."

** School D offered only a regular chemistry course.

from the teacher's table. In the regular classes, students sat close beside the observer because of the large number of students. The observation locations were in the right corner and the middle of the back of the lecture room in School D. The chemistry teacher brought a table and a chair to that location for the observer. The location of observation made it easier to hear students' words in the regular class of School S than in School D.

In laboratory sessions the observation locations were changed during the classroom observation. The observer walked around the classroom to observe students' behavior and words.

3.4.4. Audio-Visual Recording of Chemistry Classes

Two kinds of recording were done such as audio tape recording and visual recording. The visual recording was done by taking photographs and drawing maps. Eleven class photographs and 10 major facility photographs of chemistry teaching were taken during the observation periods. Before taking photographs permission of the chemistry teachers was obtained. Some students did not care whether they were being photographed, but others indicated that they did not want to be photographed, and no pictures were taken of these students. Maps of classrooms were drawn, including information such as the location of facilities of classrooms.

Over 1,000 minutes of chemistry class time were recorded by an audio tape recorder; twenty lecture class periods and two experiment class periods were recorded. Tape recording locations are indicated in the figures of Chapter 4. The tape recorder was located on the laboratory table, which was placed at the back of the chemistry classroom of School D. In the chemistry lecture room of School S, it was located at the center of the back row of chair-table-combinations. In the laboratory of School S, it was located near a hood, which was placed at the back of the laboratory.

3.4.5. Interviews of Personnel in the Two Schools

The interviews were done with two chemistry teachers, six students in the three programs, a principal, and a counselor in the two schools. Both chemistry teachers were interviewed with questions about student interest with respect to different teaching methods. The chemistry teacher of School D was asked several times about his educational background, science curriculum, chemistry curriculum, financial support, and facilities. Before these informal interviews began, questions that would be asked were written out and shown to the chemistry teacher; his answers were recorded. The chemistry teacher of School S preferred to answer questions in written form, so written questions about science curriculum and student interest with respect to different teaching methods were submitted and answered in written form a few days after asking. Information about the teacher's educational background and about financial support for the school were asked and answered orally.

Two students in the chemistry classes at School D, two students in the regular chemistry classes at School S, and two students in the advanced placement chemistry class at School S were selected randomly and interviewed with predeveloped interview questions. Each interview took five to 10 minutes and was scheduled before or after classes. The principal at School S, the secretary at School district D, and a counselor at School D were asked about student family jobs, student future plans, and financial support. The interviews gave useful information of educational background of teachers and students, and student interest in teaching methods.

3.4.6. Survey of the Written Materials

The survey of written materials included the teaching plans of three programs and the evaluation materials used by teachers to evaluate students. Three sets of one-year teaching plans were copied from Schools S and D. They showed daily teaching topics and teaching methods during one school year. The 1983-1984 teaching plans at School D represented a complete set with the chemistry teacher's early planning of March through June, 1984. The 1982-1983 teaching plans for the regular and advanced placement chemistry programs of School S were obtained, but the March 28-May 13, 1983 plans were not available. The missing plans could nevertheless be compensated for by using the teacher's estimated figures and students' notes. The teacher's estimated figures concerned number of periods of each teaching method that was supposed to have been spent for Chapters 18, 19 and 20 of the textbook, which were taught during the periods between March 16 through May 16. Students' recorded lecture class notes and students' notebooks, lab reports, textbook problems, and worksheets, all of which indicated the dates of instruction and completion.

Over ten sets of tests, most of the worksheets used, and lab questions and textbook problems solved by students in each program were collected as evidence of evaluation methods in both schools.

3.5. Plan for Description of Educational Background

Educational background was described with regard to such aspects as community and school, teacher and student, science curricula, financial support, and facilities. The histories of schools, minimum credit requirements, and courses offered were described and tabulated for both schools. Populations of school districts, information concerning schools, museums, science centers, and observatories in both communities were tabulated and described.

The number of students in each grade, family jobs, and quantitative figures of college-bound students are described and tabulated in both communities. The two chemistry teachers' backgrounds are described and tabulated in terms of sex, past teaching experience, teaching experience in the present schools, educational background, teaching certification in chemistry, and preference for teaching jobs.

Science curricula in both schools was tabulated in terms of course names, number of students in attendance, grade levels, and whether they were elective or compulsory courses. Chemistry curricula in both schools were described and tabulated in terms of course names, number of students in attendance, grade levels, whether they are elective or compulsory courses, names of textbook and laboratory manuals, and information for lab assistants and for science fairs.

Financial support in both schools was analyzed in terms of annual support per student for general and for chemistry teaching and revenue. Facilities in both schools were analyzed in terms of chemistry classroom size, equipment in lecture rooms and laboratories, exhibits on walls, and number of and sufficiency of chemicals and glasswares. Photographs and maps of classrooms were descriptively explained. Most analyses of facilities used descriptive methods.

3.6. Data Analysis Procedures

This section describes the procedures of analysis plan of educational objectives, topics, teaching methods, and student interests.

3.6.1. Educational Objectives

Educational objectives were analyzed through classroom observation and the evaluation methods. From the audio tapes, two to three minute representative parts exemplifying various educational objectives were selected and transcripted. Some representative transcripts were analyzed in terms of their educational objectives.

Forty class periods in both schools were analyzed in terms of educational objective subcategories. Among the various teaching methods, more than one teaching method was used in one class period. One class period is 50 minutes in School D and 55 minutes in School S. Nine to eleven five-minute periods were available for educational objectives and student interest assignment. During the class period, five to ten minutes were spent: (1) to move to another type of instruction, for example, from lecture class to student experiment class; (2) to explain the tests; (3) to hand out and hand in worksheets or experimental reports; and (4) for chatting with other students or the teacher.

However, in this study, if some part of the five minute-period, which included the above (1), (2), (3), or (4) was used for certain educational objectives, the period was considered to be spent on the certain educational objectives. The beginning of the class period was usually not assignable to any educational objective. At the end of some class periods, students in both schools who had already finished and whose tasks were given no more tasks to do, chatted with others. The regular chemistry class in School S had personal homework check cards for every student, which are sometimes checked at the beginning of class. Goodlad reported that 76 percent of a class period is spent for instruction in the American high school.[5] The last part of a class period is spent on behavioral disciplines, and so on. In this study, 82 percent to 90 percent of the class

[5]J.I. Goodlad, *A Place called School*, McGraw-Hill Book Co., 1984.

period is considered to be spent for instruction.

For educational objective analysis, the observed days were classified with respect to six groups of teaching methods, such as the lecture, problem solving and socratic method; the lecture and socratic method; the demonstration method; the student experiment, discussion, socratic method; the film-slide showing method; and the field trip or guest speaker invitation method.

The lecture, problem solving, and socratic method are grouped together because lecture and problem solving methods are usually used in one class period. In one class period, the teacher of School S sometimes changed teaching method three or four times. The teacher in School S asked students to identify the procedural steps for solving problems by calling students' names following their orders to sit down. Students asked questions frequently when they did not clearly understand and/or had specific questions. Sometimes when there were too many questions, the teacher of School S just ignored the questions and delivered the lecture.

The teacher in School D gave lecture first and let students solve problems at the end of the period, but he did arrange some class periods just for problem solving. In the problem solving session, students solved problems, usually textbook problems, and the teacher walked around the classroom to answer questions, to give some clues to solutions, and to encourage students in their work.

Student experiment was grouped with discussion and socratic method because these methods appeared together in the class period. In experiment classes, students discussed matters frequently with the teacher and their laboratory partners or other groups of students. Students asked questions about procedures or expected results.

Field trip and guest speaker classes were considered to be equal to class types. Field trip or guest speaker classes may have the same affects on students because a guest speaker is invited from a specialized area, such as certain industrial areas or research areas. The frequency of educational objectives was counted and the percentages were tabulated and analyzed with respect to each teaching method in each program. Five sets of each evaluation method employed were randomly selected and the frequencies and percentages of educational objective subcategories were recorded. Evaluation methods used in both schools were tests, textbook problems, experiment questions, and worksheet questions. The percentage of educational objective subcategories was compared in each evaluation method and in each program.

3.6.2. Topics and Teaching Methods.

Using Klopfer's content categories, chemistry topics to be taught each day were classified. The percentage of each topic category was counted and described in each program. The frequency and the percentage of each teaching method shown in yearly teacher plannings were counted and tabulated in each program. And percentage for each method of teaching each topic category was tabulated with each program and analyzed.

3.6.3. Student Interest

Student interest was analyzed with respect to different teaching methods and different educational objectives. The categories of teaching methods were the lecture, problem solving, and socratic method; the lecture and socratic method; the demonstration method; the student experiment, discussion and socratic method; the film-slide showing; and the field trip or guest speaker method. The analysis of educational objectives was done in terms of Klopfer's educational objective major categories.

From the field notes, student interest points were counted by adding points, which were recorded for every five minutes of instruction during the classroom observation. First the point of student interest was counted from the field notes of each class period. Positive student interest was considered as 1 point; negative student interest, -1 point; and neutral student interest, 0 point. The points of student interest were classified with respect to six types of teaching methods. The points of student interest were added according to different types of teaching methods. The points of student interest were divided by the number of five-minute periods for each teaching method to obtain the percentage of student interest in each type of teaching method. The percentages of student interest were tabulated, compared, and contrasted with respect to six types of teaching methods.

The points of student interest were counted, according to each Klopfer's educational objective major category. The percentages of student interest were calculated by dividing the student interest points by the number of five-minute periods. The percentages of student interest were tabulated, compared, and contrasted with respect to educational objectives. The student interest points were classified according to teaching methods and educational objectives. The percentages of student interest were also calculated by dividing student interest points by the number of five-minute periods. The percentages of student interest were tabulated according to nine major categories of educational objective in each type of teaching method. In each type of teaching method, student interest was compared and contrasted with respect to educational objective major categories in the three programs.

The findings of interview with teachers and students regarding student interest were analyzed descriptively. Photographs of classes were described in terms of student interest.

3.7. Summary

In Chapter 3, data collection methods and data analysis procedures are included. Two Michigan high schools were selected in order to analyze four research objectives: (1) a description of the educational background of the schools visited, (2) an analysis of the educational objectives, (3) an analysis of the topics and teaching and (4) an analysis of student interest. Two regular chemistry classes and one advanced placement chemistry class were observed for a total of 40 class periods and recorded for 20 class periods in order to analyze educational objectives and student interest. The one-year teaching plans were surveyed for the analysis of chemistry topics and teaching methods in the three programs. Data about the educational background of the two schools were collected by interviews with school personnel and students, and surveys of written materials such as curriculum guides, which included information about communities, schools, teachers, students, and financial supports, and facilities.

Educational objectives were analyzed by counting the frequency of each of Klopfer's objective subcategories indicated in every five minute of classroom observation and shown in five sets of each evaluation method. The percentages of educational objectives in classroom observation and the evaluation methods were tabulated with respect to six types of class periods. Chemistry topics and teaching methods were analyzed by counting the hours spent on each of Klopfer's 15 topic categories and on each of his seven teaching methods. Student interest was analyzed by counting the student interest points (positive, +1; neutral, 0; and negative, -1) in each five minute period of classroom observation with respect to the six types of class periods and each of Klopfer's objective major categories.

CHAPTER 4

Educational Environment of Two Schools Studied

This chapter includes a description of the educational environment in two Michigan high schools. The data concerning the educational environment of the two schools, including aspects of the background of the communities, schools, teachers, students, science courses, financial support, and facilities, were described both qualitatively and quantitatively.

4.1. Communities and Schools

The two schools studied were located in communities within 20 minutes driving distance from a big university city and within one hour driving distance from two big industrial cities. The big university had a well-known science museum. A town within 30 minutes driving, had a science observatory and Village D had its own museum. Near these two communities, various industries including automobile, vacuum cleaner, and pharmaceutical products are flourishing. The background of the two schools and communities were tabulated in Table 4. Two high schools (Schools S and D) were located in small towns (City S and Village D), located near big cities and classified as rural suburban towns. School S was established in 1874 as a result of people's willingness to

Table 4. Communities and Schools

	Community S and School S	Community D and School D
School District population	17,000 (City S: 7,000)	10,000 (Village D: 1,400)
Schools	3 elementary schools: K-4 grades, 552 students; K-4 grades, 508 students; 5-6 grades, 540 students 1 junior high school: 7-8grades, 549 students 1 high school: 9-12 grades, 1050 students	1 primary school: K-1 grades, 278 students 1 elementary school: 2-4 grades, 447 students 1 middle school: 5-8grades, 671 students 1 high school: 9-12 grades, 750 students
History of schools	Established in 1874	Established in 1883
Minimum credits for graduation	21 English (3) Social Studies(3) Science (2) Math (1) Physical education (1)	22 Language arts (3) Social studies(3) Science (2) Math (1) Physical education (1) Consumer Economics (1/2)
Transportation	Less than 80 % of students are transported by school bus	More than 80 % of students are transported by school bus

support a high school. School D was also established in 1883.

Michigan had about 529 school districts[1] serving Michigan's eight million population, of which 1.8 million were students in grades kindergarten through twelve.[2] The two schools were administrated by the individual school districts. Both school districts included are near rural areas as well as the towns. The school district population of Village D, which was 10,000, was less than that of City S, which was 17,000. Both school districts included each of their elementary, junior high, and high schools.

Both high schools required minimum credits for graduation in each subject: English (3), Social studies (3), Science (2), Math (1) and Physical education (1) in both schools, and Consumer economics (1/2) in School D. Total credits for graduation are 21 credits in School S and 22 credits in School D. In both schools, one credit was received by attending five days a week for one year. The two schools offered various courses in academic and vocational areas. School S offered the following courses: 28 courses in English Department, 16 courses in Math Department, 16 courses in Foreign Language Department, 27 courses in Science Department, 22 courses in Social Studies Department, 16 courses in Business Department, 17 courses in Art-physical Education Department, 6 courses in Music Department, 6 courses in Home Economics Department, 21 courses in Industrial Education Department, 10 courses in Special Programs, and 23 courses in Consortium classes. School D offered the following courses: 16 courses in English Department, 8 courses in Math Department, 6 courses in Foreign Language Department, 11 courses in Science Department, 11 courses in Social Studies Department, 9 courses in Business Department, 4 courses in Physical Education Department, 3 courses in Art

[1]Michigan State Board of Education, *Michigan K-12 Public School Districts Ranked by Selected Financial Data*, Bulletin 1014, 1980-1981

[2]Valena W. Plisko (Editor), *The Condition of Education, 1983 Edition--A Statistical Report*, (National Center for Education Statistics)

Department, 4 courses in Music Department, 6 courses in Home Economics Department, 16 courses in Auto mechanics, Drafting, and Shared Vocational Programs, 7 Special classes. The individual course names are in Appendix E. School S offered more various courses than School D.

4.2. Chemistry Teachers and Students

This section includes the backgrounds of both chemistry teachers and students. Backgrounds of students and teachers were tabulated in Table 5. Each chemistry teacher in Schools S and D had long teaching experience and high educational backgrounds. The teacher in School S had 15 years of teaching experience; the teacher in School D, 23 years. The teacher of School S had BS in chemistry and MS in organic chemistry, and attended the special program for chemistry teaching certificate; the teacher in School D, BS in chemical engineering and MA in education. Both teachers had teaching certificates in chemistry. Students were mostly from families of managerial and professional employees in university and industrial company, and working in technical, sales and administration areas. School S had more students from families of the semiprofessional or professional job than in School D. Over 60 percent students of the two high schools had continued their education beyond high school. In the 1982-1983 school year, 75 percent of graduates from School S have gone to college more than 60 percent of graduates from School D.

The teacher's educational background influences curriculum orientation. The chemistry teacher in School D had background in chemical engineering. When he invited a guest speaker, he chose a researcher from a local pharmaceutical company. and let the guest lecture about the company product and spectrometer. The chemistry teacher in School S had MS degree in organic chemistry. She offered organic chemistry

Table 5. Chemistry Teachers and Students

	School S	School D
Teachers		
. teaching experience	15 years	23 years
. periods at the present school	9 years	23 years
. educational background	BS in Chemistry, MS in Organic Chemistry, Program for teaching certification	BS in Chemical Engineering, MA in Education
. teaching certification in chemistry	yes	yes
. preference in teaching job	very energetic in teaching and preparing of teaching materials	very positive (He changed his job from engineering job 23 years ago.)
Number of students	9th grade (281), 10th (271) 11th (273), 12th (222)	9th (154), 10th (189) 11th (154), 12th (146)
Family jobs of students		
. successful farms	5%	3%
. managerial and professional employees in industry and university	45-50%	28.5%
. others	40-45%	technical and sales, 30.5%; laborers, 14%; crafts,14.1%; service, 10%
Education beyond high school of student (1983 graduates)		
. 4 years college	55%	45%
. 2 years college	20%	15%
. work and job training	25%	40%

course as a semester course. Both teachers liked teaching. The teacher in School S said that she worked at school all day long and at home too. She had two student assistants, who helped her in the preparation of classes, and in scoring and correcting worksheets and lab reports. The teacher in School D had also student assistants who helped one hour a day. School D and S offered student assistantship courses as semester courses. The two chemistry teachers were highly educated and experienced teachers.

4.3. Science Courses

This section is about science courses including chemistry offered in two high schools. School S offered 27 science courses and School D offered 11 science courses. In the 1983-1984 school year, some of them were offered in both schools, which were shown in Table 6-1 and Table 6-2. Some are one-year courses and some are one-semester courses. Some of the courses were elective and offered to certain grade students.

School S offered five chemistry courses (Appendix H), but two yearly chemistry courses and one semester course were taken by students in the 1983-1984 school year. In the second semester of the 1983-1984 school year, a few students took organic chemistry, which was one of three semester courses; 15 students, the advanced placement chemistry; and 135 students, the regular chemistry in School S. School D had only one chemistry course, which was taken by 85 students. They used certain textbooks and lab manuals, which were tabulated in Table 7. The textbooks and lab manuals were purchased by schools about every five years. However, the two regular programs used 1975 editions of textbooks although 1983 editions of the textbooks were published and the teacher in School D had the 1983 edition. The teacher in School D said that the 1983 edition was not much different from the 1975 edition, so they decided to use the 1975 edition. The advanced placement chemistry course in School S used the 1979 edition

Table 6-1. Science Courses in School S in the 1983-1984 School Year

Names of Courses	Semester or Year	Grade Level	Elective or Compulsory	Number of Students
Chemistry				
Advanced placement	Year	11-12th	Elective	15
Regular	Year	10-12th	Elective	135
Physics	Year	11-12th	Elective	75
Biology	Year	9th	Compulsory	275
Physical Geology	Year	10th	Elective	58
Space Science	Semester	10th	Elective	27
Physical Science	Year	10th	Elective	25

Table 6-2. Science Courses in School D in the 1983-1984 School Year

Name of courses	Semester or Year	Grade Levels	Elective or Compulsory	Number of Students
Chemistry, Regular	Year	11-12th	Elective	75 (11th); 10 (12th)
Physics	Year	11-12th	Elective	51
Biology	Year	10-12th	Elective	122
Advanced Biology	Year	11-12th	Elective	21
Practical Biology	Semester	10-12th	Elective	27
ESS*	Semester	9-12th	Elective	98
IPS*	Semester	9-12th	Elective	98
Environment	Semester	9-12th	Elective	14
Health	Semester	9-12th	Elective	30
ES*	Semester	9-12th	Elective	21

* In the 9th grade students must choose ESS/IPS or IIS/ES. In the 10th grade, elective courses should be taken for obtaining one more required credit. And in the 11th-12th grade, students may choose any elective courses. ESS: Earth Space Science, IIS: Ideas and Investigation in Science, IPS: Introduction to Physical Science, ES: Earth Science

Table 7. Chemistry Courses Observed in Schools S and D

Schools and Programs	School S, Regular Chemistry	School S, Advanced Placement Chemistry	School D, Regular Chemistry
Number of Students	135	15	85
Elective or Compulsory	Elective	Elective	Elective
Grade levels	10-12th	11-12th	11-12th
Textbooks	Chemistry: A modern course[1]	Chemistry: A conceptual approach[1]	Chemistry: An experimental foundation[1]
Lab manuals	Laboratory chemistry[1]	Experimental chemistry[1]	Lab Manual[1]
Lab Assistants	Student Assistant	Student Assistant	Student Assistant
Science Fair	Participation	Participation	No

[1]R.C. Smoot and J. Price, *Chemistry: A Modern Course*, (Charles E. Merrill Publishing Co., 1975); [1]C.E. Mortimer, *Chemistry: A Conceptual Approach*, 4th Edition, (D. Van Nostrand Co., 1979); [1]M. Dietz, R.L. Tellefson, R.W. Parry, and L.E. Steiner, *Chemistry Experimental Foundations*, 2nd Edition, (Prentice-Hall, Inc., 1975); [1]L.N. Carmichael, D.F. Haines, and R.C. Smoot, *Laboratory Chemistry*, (Charles E. Merrill Publishing Co., 1983); [1]M.J. Sienko, R.A. Plane, and S.T. Marcus, *Experimental Chemistry*, (McGraw-Hill Book Co., 1976); [1]R.W. Merrill, Parry, R.L. Tellefson, and H. Bassow, *Laboratory Manual-Chemistry: Experimental Foundations*, 2nd Edition, (Prentice-Hall, Inc., 1975)

textbook and lab manual in college general chemistry. Those textbooks were borrowed by students while taking the courses.

School S participates in the Southeastern Michigan Science Fair every year. Before attending the Southeastern Michigan Science Fair, School S had a science fair in its cafeteria, where the students' work during the winter break and special works of the students were exhibited. The exhibitions were periodic tables, a comparison of D_2O and H_2O, a comparison of cold medicines, a changing role of zoo, and many others. School S exhibited a comparison of cold medicines, a changing role of zoo, and the other work in the Southeastern Michigan Science Fair of 1984. The Southeastern Michigan Science Fair was supported by a university, a community college, a local newspaper and industrial companies including automobile companies. Judges of the fair were researchers in industrial companies, professors in universities, and military personnel. Special awards were given from: University of Michigan Women in Science Program, Air Pollution Control Association, Huron Hills Lapidary, Mineral Society, American Society for Microbiology, Washtenaw Council on Alcoholism, U.S. Navy, U.S. Air Force, and U.S. Army. Over 300 students' works were exhibited in the afternoon of March 31, 1984. Exhibitions were classified by: (1) levels of school, and (2) the contents of the exhibitions. They were also separately exhibited in senior and junior high schools. In the senior division, the exhibitions were classified into biology, chemistry, and physics-mathematics. In the junior division, the exhibitions were classified into experiment category, and models and collections category.

Good exhibition skill is based on three major points: (1) displaying information in organized and systematic ways, (2) properly emphasizing important points, and (3) providing sufficient evidence for each claims made. Based on these three criteria, students' works could be evaluated. An example of a good exhibition is in Figure 5, and an example of a sloppy exhibition is in Figure 6. Well-arranged and clear exhibition can give more useful information to observers. The observers were from various age groups, ranging in age from one to 80. There were long lines to get into the fair in a community college. The science fair is a big event in the southeastern Michigan area as shown in Figure 7. Figure 8 showed a challenging idea that hydrogen gas was produced by a simple experiment and used as a fuel. Science curricula, including the science fair, showed the geographical characteristics of the two schools.

4.4. Financial Support and Facilities

Financial support and facilities were described in this section. The financial support was described in terms of annual expenses per student, annual expenses per student for chemistry teaching, and revenue. The facilities of the two schools were described in terms of number of classrooms, size of classrooms, equipment in lecture room, exhibits, exhibition board, teaching materials, equipment in laboratories, chemicals, glassware, and other equipment.

The two schools had similar revenue as shown in Table 8. Both schools were supported financially by local property tax. In School S, $2,986 is spent per student annually. For chemistry teaching, $4.40 is spent per student in the regular course, $28.50 in the advanced placement course, and $50-70 in the organic chemistry course. In revenue, 91 percent was supported by the local school district, which was actually from local property taxes, three percent from the state, three percent from the federal government and three percent from other sources.

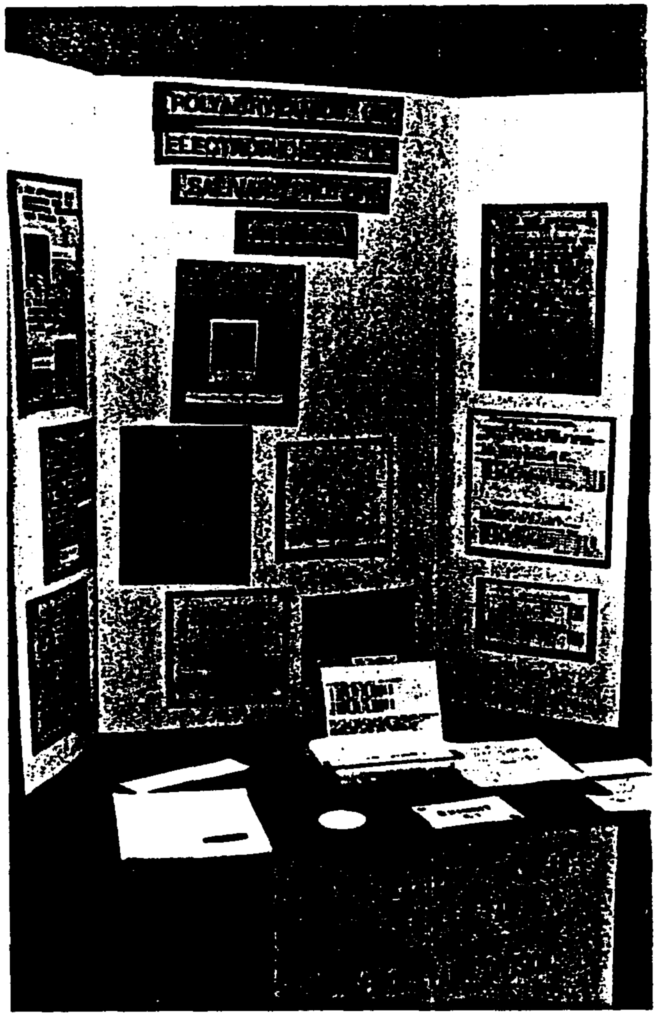

Figure 5. An Example of a Good Exhibition

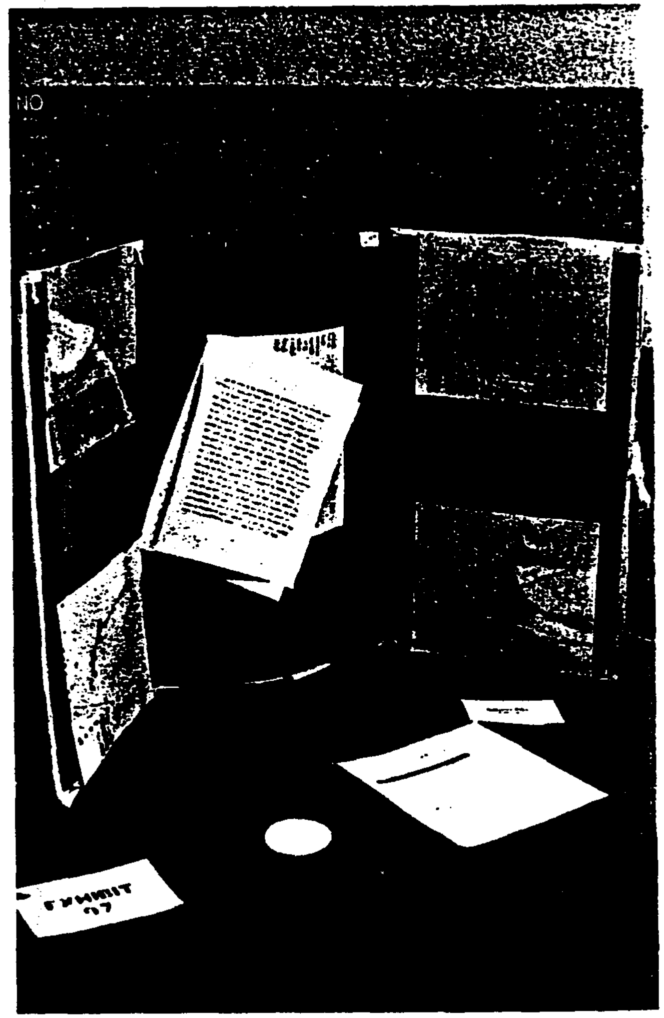

Figure 6. An Example of a Sloppy Exhibition

Figure 7. Science Fair as a Big Community Event

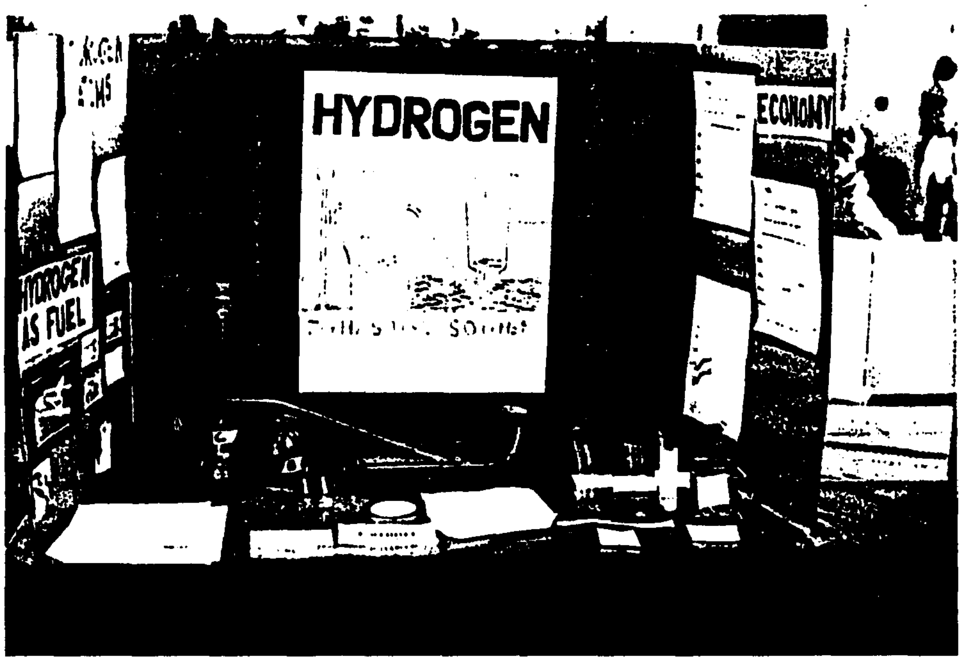

Figure 8. A Chemistry-related Exhibition

Table 8. Financial Support of Schools S and D in the 1983-1984 School Year

	School S	School D
Annual Expenses per Student	$2,986	$2,790
Annual Expenses per student for chemistry teaching	$4.40 (Regular program) $28.50 (Advanced placement program) $50-70 (Organic Chemistry)	$6.60 (Regular program)
Revenue[2]		
local school district (property taxes)	91 (%)	94
state	3	1
federal	3	3
other sources	3	2

[2] Michigan State Board of Education, *Michigan K-12 Public School Districts Ranked by Selected Financial Data*, (Bulletin 1014, 1980-1981), p. 34.

In School D, \$2,790 is spent per student annually. For chemistry teaching, \$6.60 is spent annually. In revenue, 95 percent was supported by the local school district, one percent from the state, three percent from the federal government, and two percent from other sources. Annual expenses in the two schools were higher than other Michigan high schools.[3] School S was supported better financially than School D.

The two schools had different quality and quantity of facilities as shown in Table 9. The differences lay in room capacity, chemicals, and experiment equipments such as glassware. Figure 9 was a map of School S; Figure 10, of School D. School S had more room for chemistry teaching than School D as shown in Figure 11 and Figure 12. Chemistry lecture rooms and labs in both schools were described in Figure 13, Figure 14, Figure 15, and Figure 16. School S had one lecture room and two labs; School D had one lecture-lab room. Chemistry preparation room and storage in both schools were shown in Figure 17 and Figure 18. School S had one storage room and one preparation room; School D had one preparation-storage room. School S had six rooms for chemistry teaching, where 150 students took chemistry courses, whereas School D had only two rooms, where 85 students took the chemistry course in the 1983-1984 school year. The total area for chemistry teaching was 319.8 m^2 in School S; 147.6 m^2 in School D. The area per student was 2.1 m^2 in School S; 1.7 m^2 in School D. School S had a comfortable preparation room, as shown in Figure 17 but School D had a small space for preparation, as shown in Figure 18. However, actual classroom situation in School D does not seem to depend on this room area. Figure 19 showed the lecture room in School S and Figure 20 showed lecture class in the lecture-lab room in School D. The advanced placement chemistry class in School S, as shown in Figure 21, had an extra room for 15 students in

[3]Michigan State Board of Education, *Michigan School Districts*

Table 9. Chemistry Classroom Facilities of Schools S and D.

Facilities	School S	School D
School Building	Built in 1969: Figure 9	Built in 1958, Addition in 1974: Figure 10
Chemistry Classrooms	Figure 11	Figure 12
lecture rooms	1: Figure 13, Figure 19	1 lecture-lab room: Figure 16, Figure 20, Figure 22
laboratories	2: Figure 14, Figure 15 Figure21	
preparation rooms	1: Figure 17	1 preparation-storage room: Figure 17
storage rooms	1: Figure 17	
teacher rooms	1: Figure 14	0: in lecture-lab room
Size of Classrooms (m × m)		
lecture rooms	57.4	111.6 (lecture-lab room)
lab 1	76.7	
lab 2	76.7	
preparation rooms	61.1	36 (preparation-storage room)
storage rooms	35.9	
teacher room	12.0	
Equipments in Lecture room	Figure 13	Figure 16
overhead projectors	1	1
screens	1	1
blackboards	1	3
Desks and chairs	Desk-chair combination	Long desk and individual chair
Worksheet stand	1	
Exhibits	Periodic table (one in lecture room and one in Lab 1)	Periodic Table; Size of elements and ions; Names, formula, and ionic charges of common ions; Energy level of electrons
Exhibition Boards	3 in lecture-room (2 for student work, and 1 for news) 1 in lab 1 (for worksheets) 1 in lab 2 (for safety posters) 1 in hall way (for news)	1 in lecture room (for news) 1 in hallway (for news)
Teaching Materials	textbook, lab manual, worksheets, diagrams:	textbook, lab manual worksheets, diagrams

Table 9 (cont'd.).

Facilities	School S	School D
Equipments in Laboratory		
safety	2 eye and body washing stands (one in each lab), 2 fire blankets (one in each lab)	1 eye washing stand 1 fire blanket
oven	1	0
sterilizers	2 (for goggles)	0
hood	2 (one in each laboratory)	1
tables	black coating (new)	black coating (worn out)
drawers	for individual student's apparatus	
blackboards	1 in lab 1 and 1 in lab 2	
Chemicals	over 1,000	over 500
Glassware (numbers)		
Erlenmeyer flasks	50	15
round-bottomed flasks	20	
measuring flasks	50	
beakers	30	40
washing bottles	20	40
plastic bottles		
small	50	150
medium	20	30
large	20	30
small glass bottles	100	
cylinders	20	30
funnels	20	15
medicine droppers	100	
Stoppers	20 sizes	
Spatulas	10	
Thermometers	4	
Thermostirs	4	
Hot plates		1
PH paper	10	
Molecular model	20 lattice models	1
22.4 l box		1
Other equipments		
computers in other classrooms	use them	use them
video projectors		use them
film projector	use it	

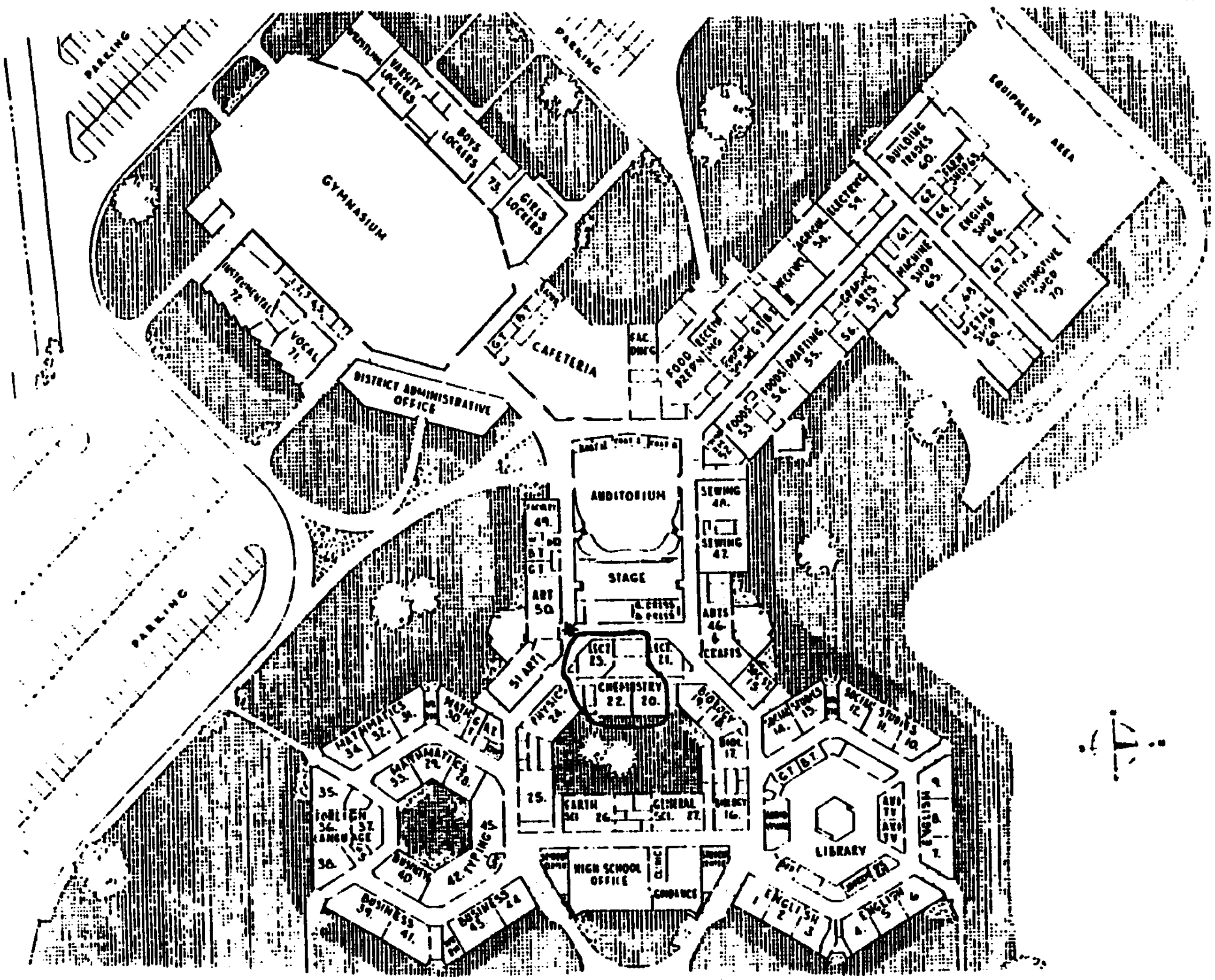

Figure 9. A Map of School S

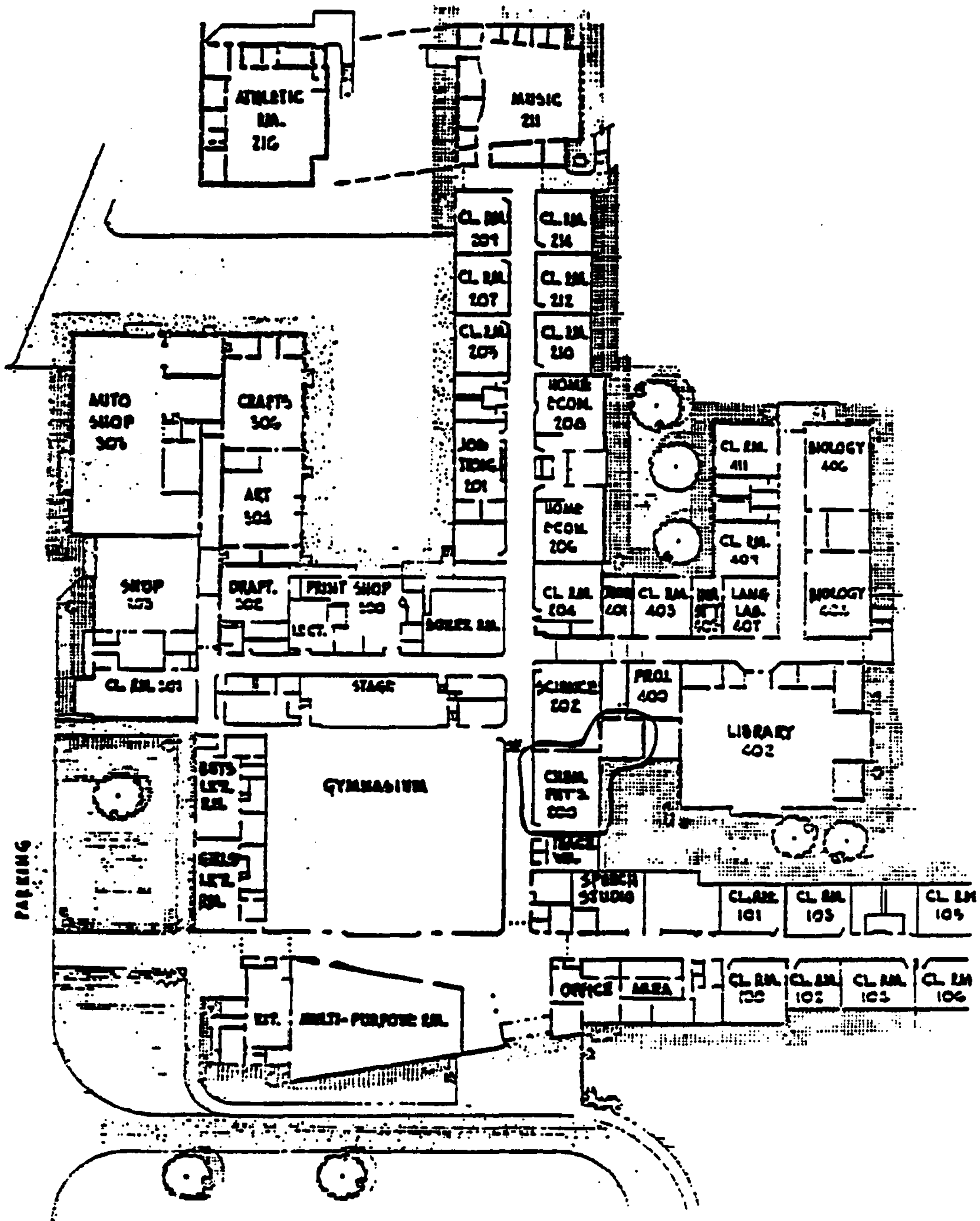

Figure 10. A Map of School D

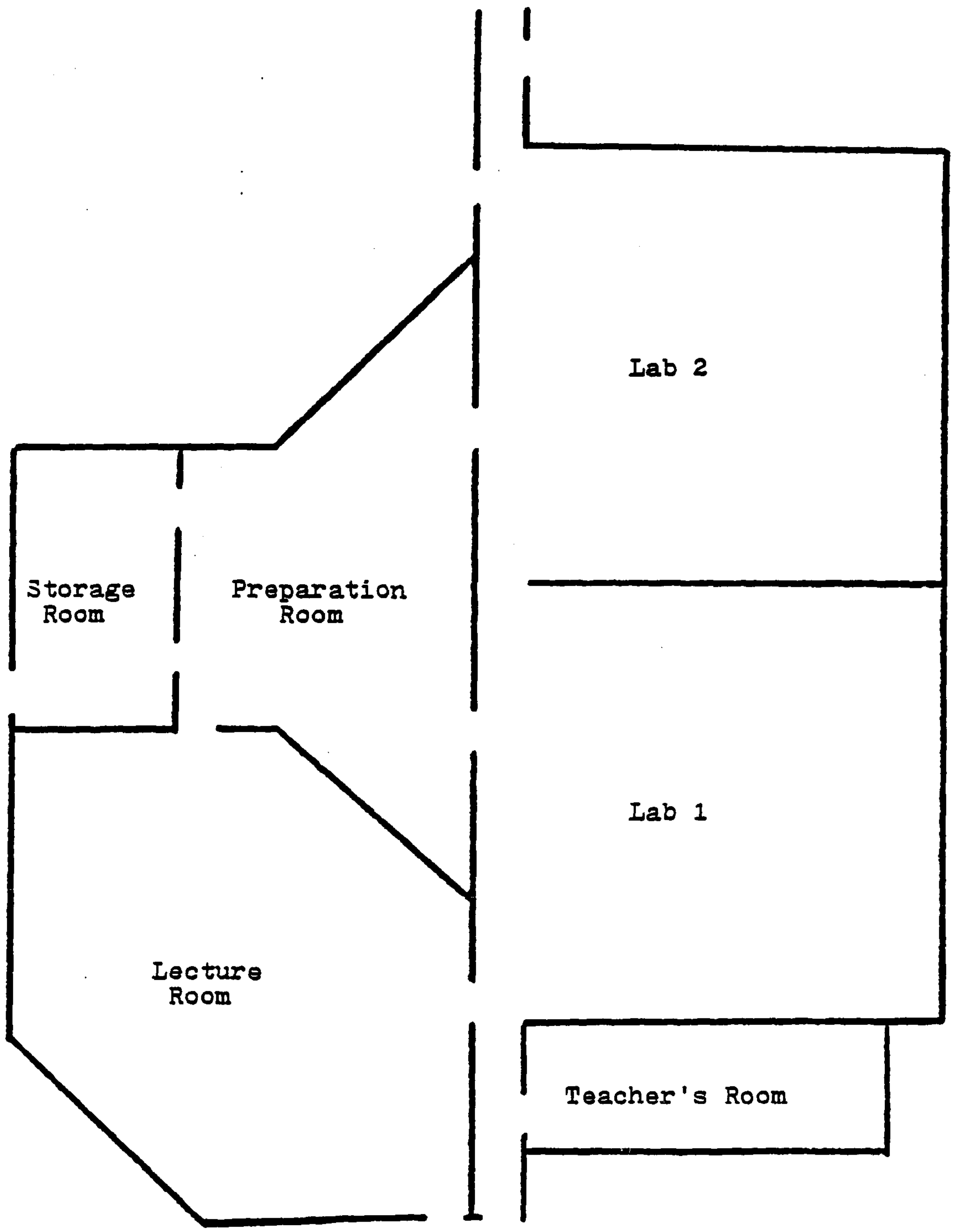

Figure 11. Chemistry Classrooms in School S

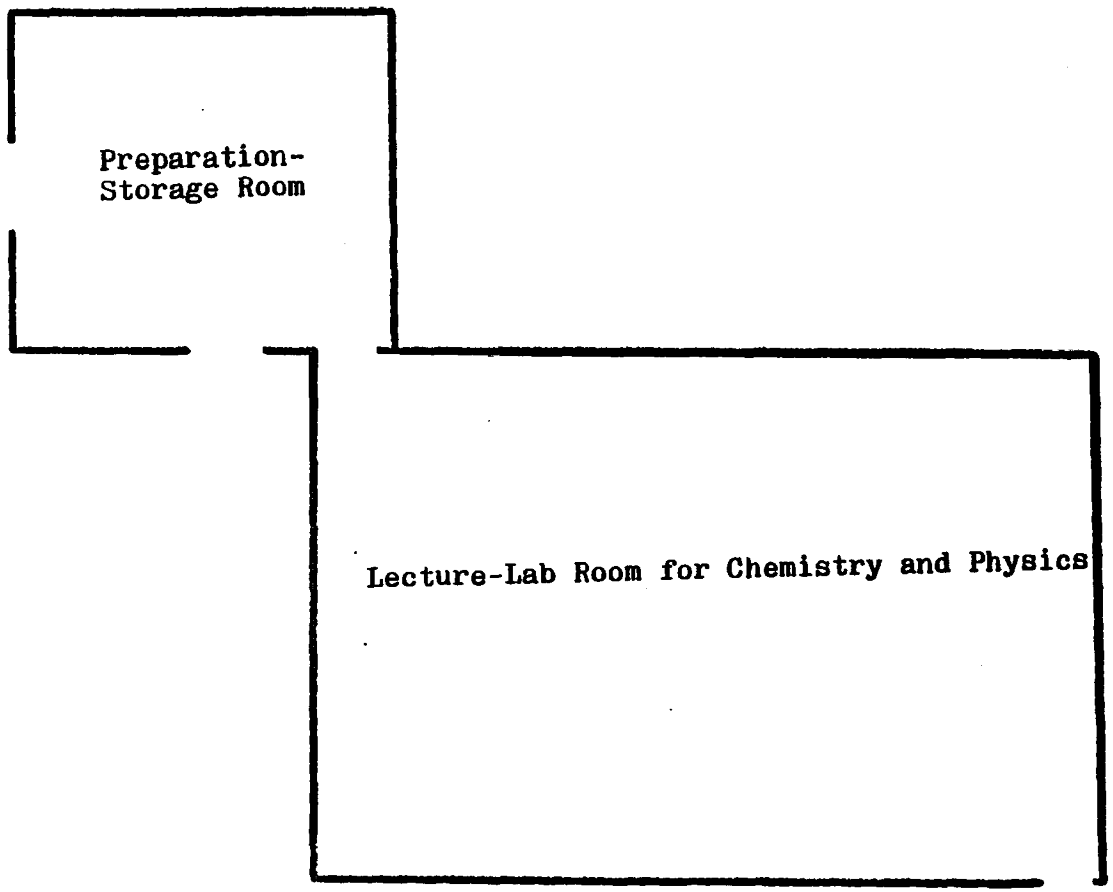

Figure 12. Chemistry Classrooms in School D

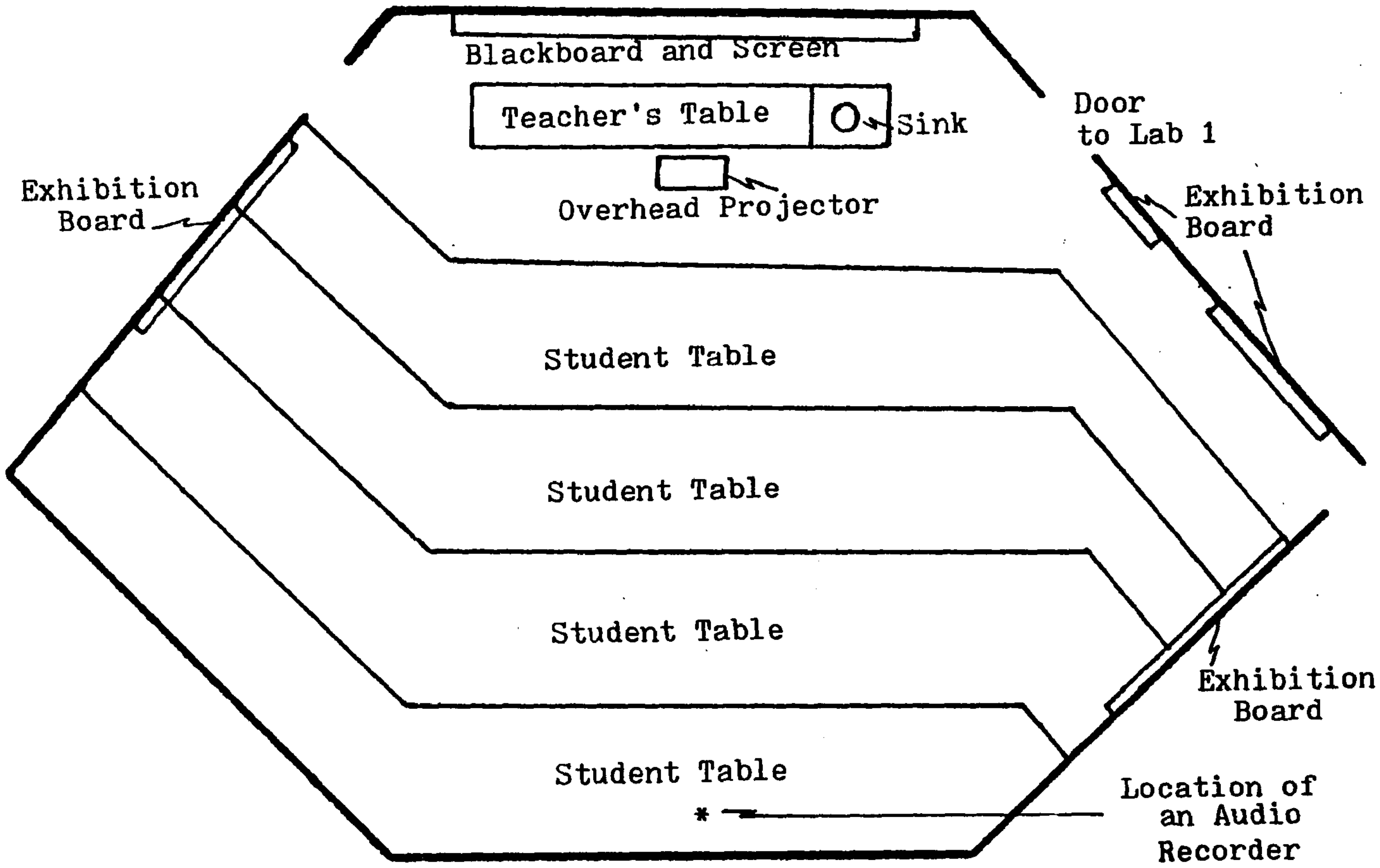

Figure 13. Chemistry Lecture Room in School S

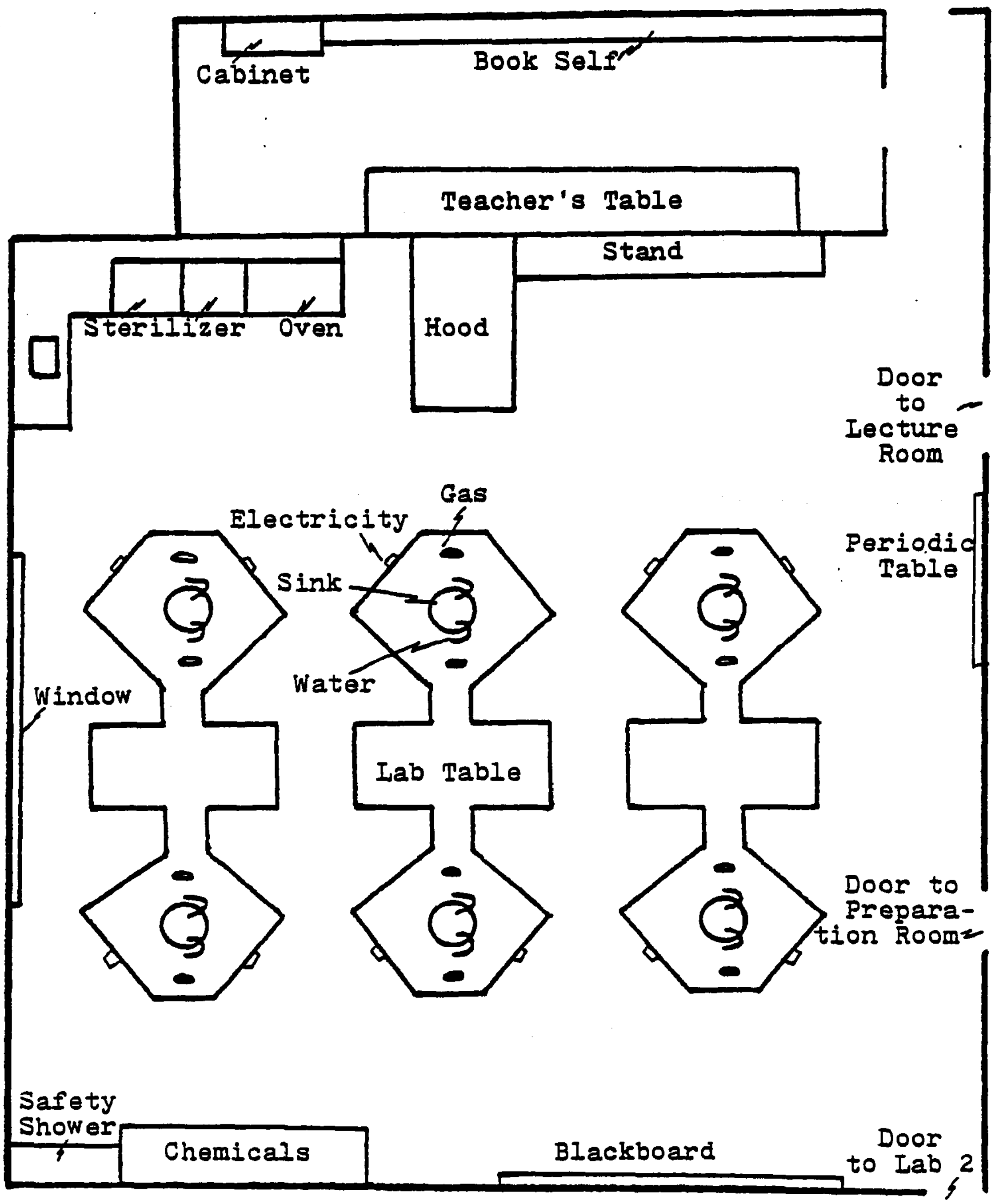

Figure 14. Chemistry Teacher Room and Lab 1 in School S

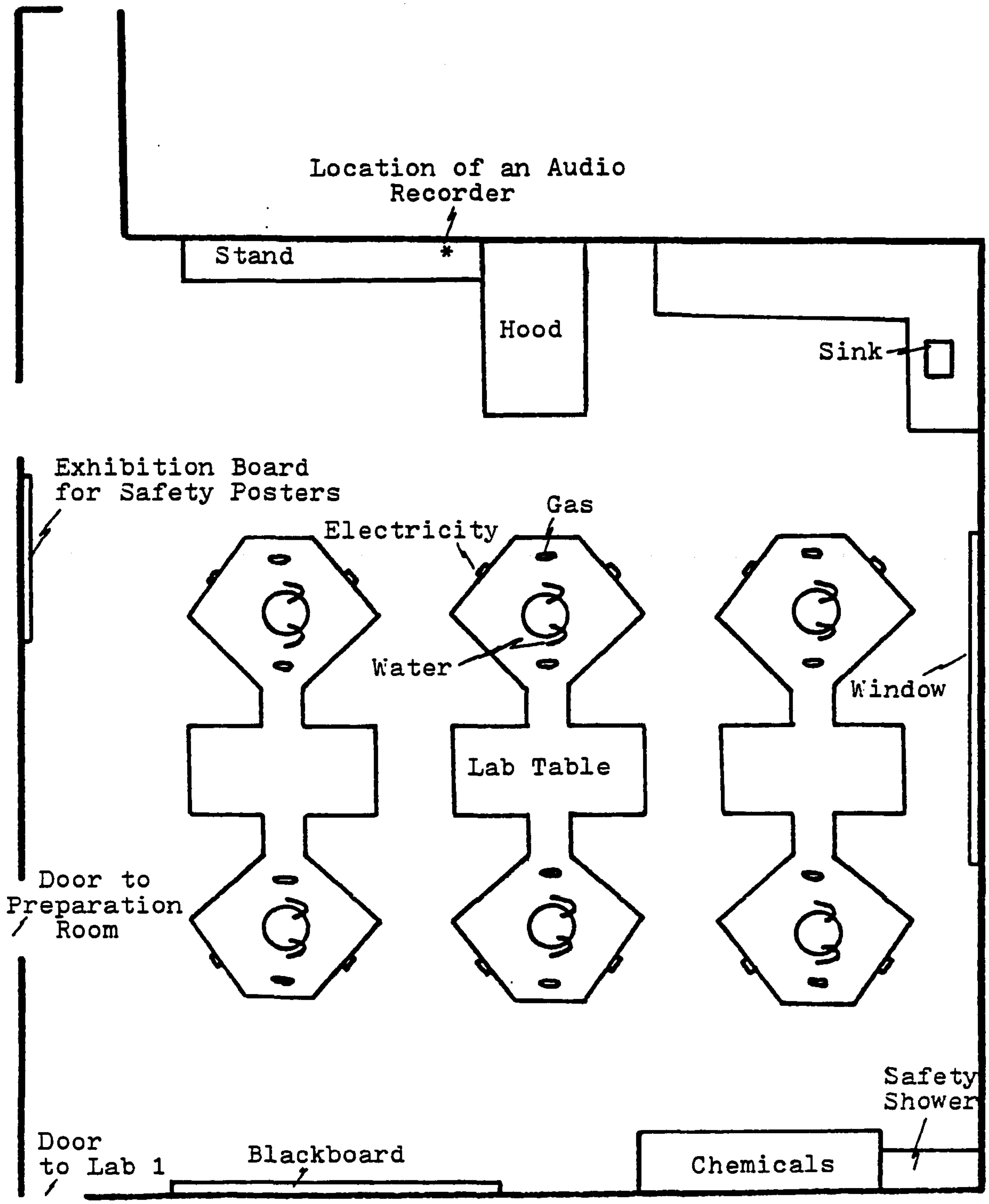

Figure 15. Chemistry Lab 2 in School S

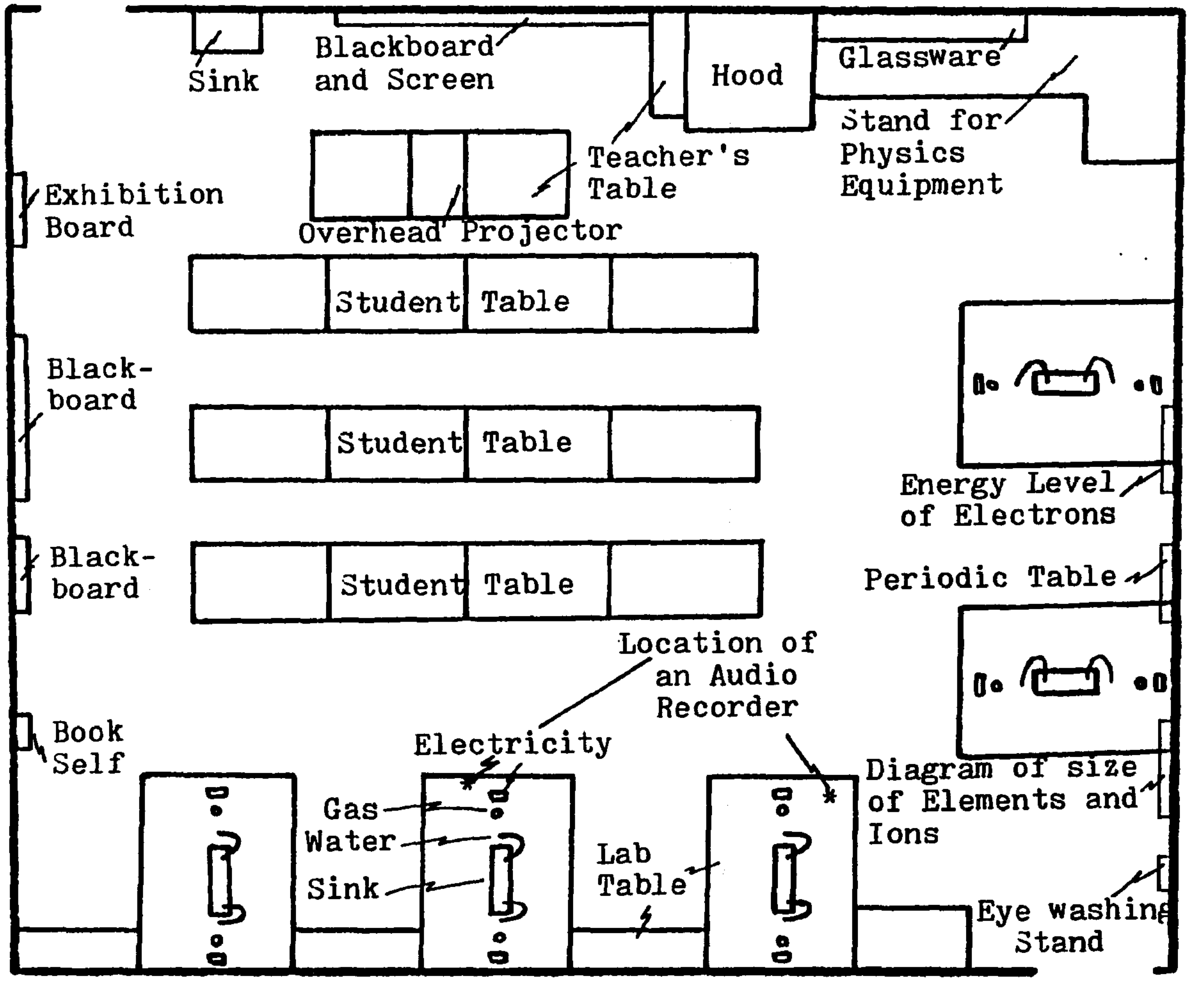

Figure 16. Chemistry Lecture-Lab Room in School D

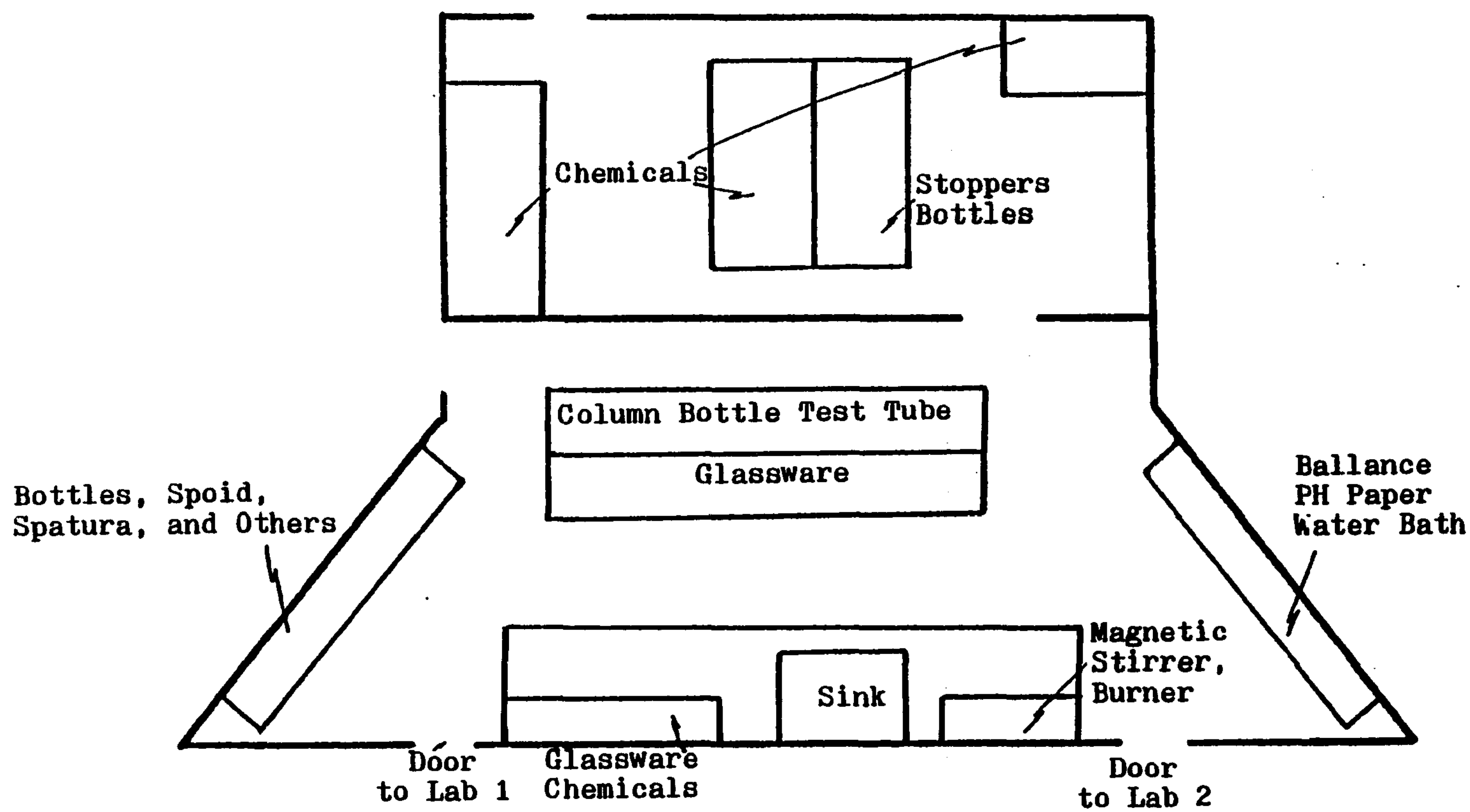

Figure 17. Chemistry Preparation Room and Storage Room in School S

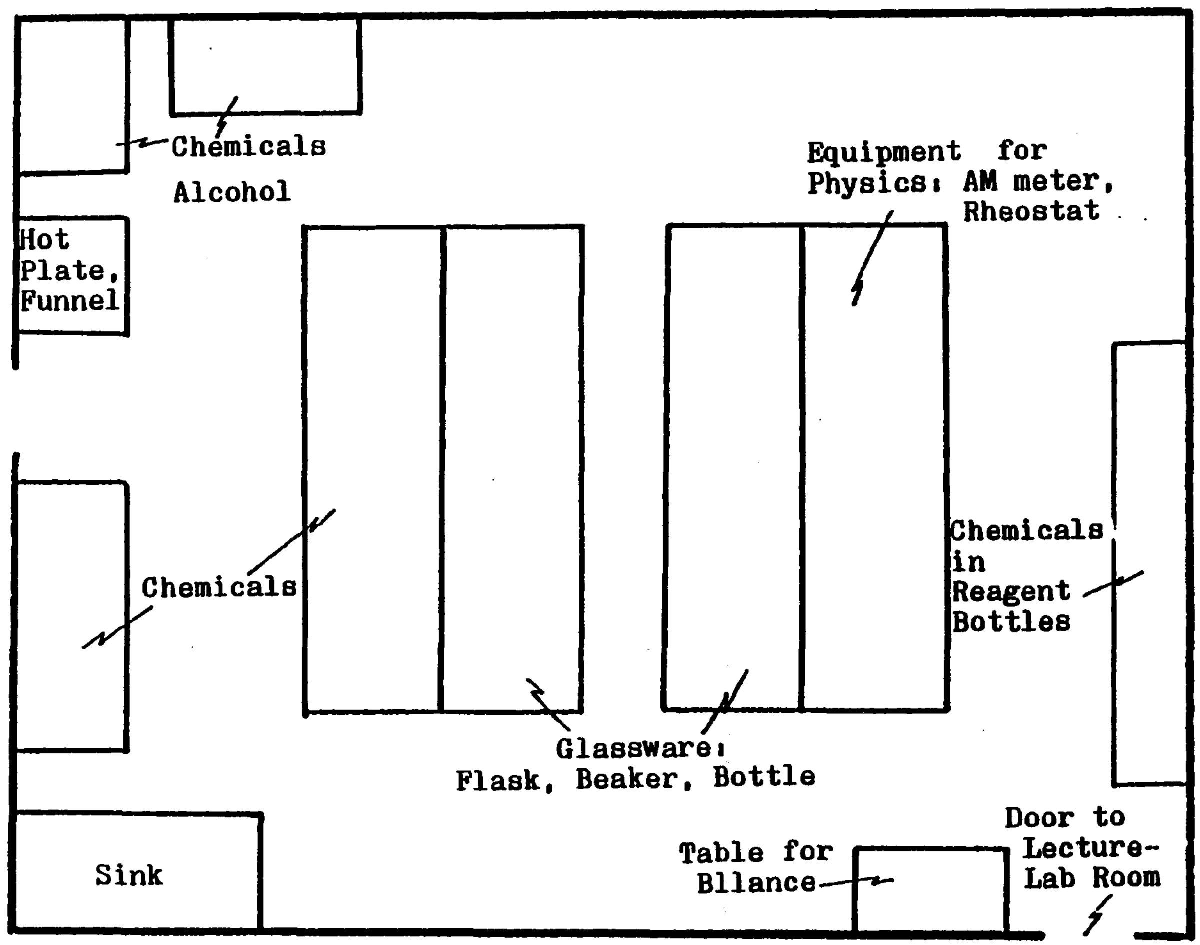

Figure 18. Chemistry Preparation-Storage Room in School D

Figure 19. A Regular Chemistry Lecture Class in School S

Figure 20. A Regular Chemistry Lecture Class in School D

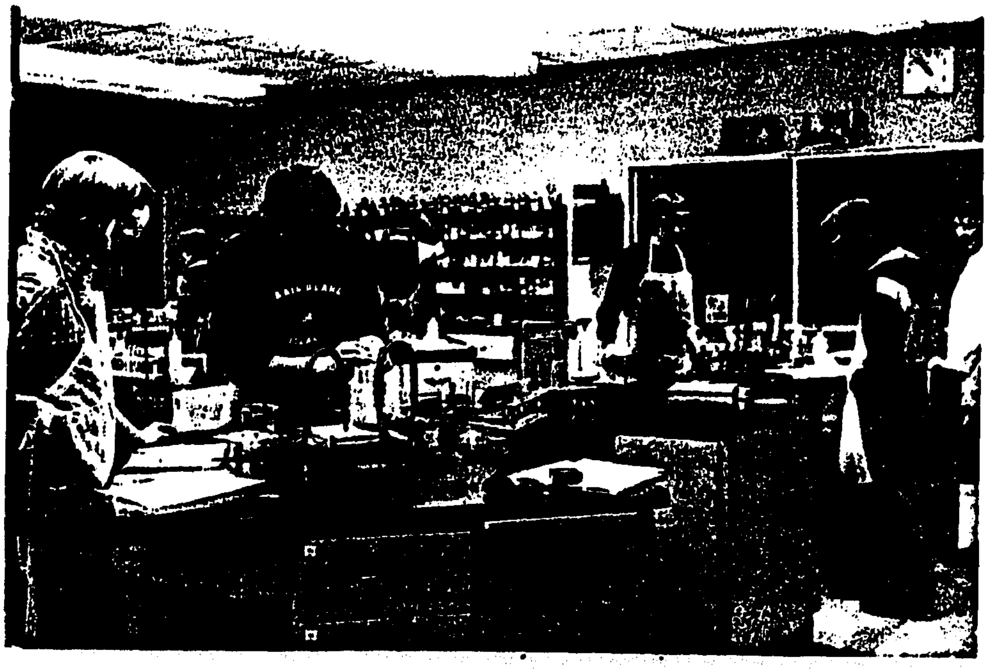

Figure 21. A AP Chemistry Experiment Class in School S

Figure 22. A Regular Chemistry Experiment Class in School D

their experiment class, whereas the regular chemistry class looked a little bit crowded with 30 students in their experiment class. Figure 22 showed the experiment class in the lecture-lab room in School D. School S had more glassware and chemicals than in School D. In School D, they did not use a lot of glassware and equipment in experiment classes. In this school, some small plastic bottles were used to distribute chemical solutions to students in the experiment.

The similarities of both schools appear in utilities, audio-visual equipments, and class room facilities. Both schools had water, gas, and electricity supplies in lab tables. Both schools used overhead projectors in lecture classes as shown in Figure 19 and Figure 20. Using overhead projector gives more teacher-student contact.

The chemistry teacher in School D was satisfied with his chemicals and glassware even though he could not buy silver nitrate because of its high cost and, therefore, used other cheaper chemicals to do similar experiments.. The chemistry teacher in School S said that she needed a full time lab assistant even though student assistants were helpful. Both chemistry teachers wanted to have more financial supports to buy expensive equipments like pH meter, thermometer, fractional distillation equipment, and column chromatography equipment. All in all, School S had better facilities than School D in terms of laboratories and lecture rooms.

4.5. Summary

In Chapter 4, the educational environment of the schools was described in the aspects of communities, schools, teachers, students, science curricula, financial support, and facilities. The two communities were located in suburban towns near university cities and business industrial cities. The two high schools were well organized in the aspects of general curriculum. School S offered 27 science courses; School D, 11 science courses. The two chemistry teachers had master's degrees, teaching certificates in chemistry, and over 15 years of teaching experience. Over 60 percent of students had continued their education beyond high school. School S offered one-year regular and one-year advanced placement chemistry programs as elective courses; School D, one-year regular chemistry program. Financially, the two schools were supported by the local school districts --over 90 percent of the total revenue. That support was better than other high schools in Michigan.[4] School S spent $2,986 per student per year; School D, $2,790. School S spent $4.40 in the regular chemistry program, $28.50 in the advanced placement chemistry program, and $50-70 in the organic chemistry program per student per year; and School D, $6.60 in the regular chemistry program. School S had better facilities than School D, such as, more chemicals (School S had 1,000 chemicals; School D, 500) and more room (School S had 2.1 m^2 space in chemistry classrooms per student; School D, 1.7 m^2 space.).

[4]Michigan State Board of Education, *Michigan School Districts*

CHAPTER 5

Data Analysis

This chapter includes an analysis of data collected at two Michigan high schools. The data were analyzed qualitatively and quantitatively in order to answer research topics such as: analysis of educational objectives, analysis of topics and teaching methods, and analysis of student interest.

5.1. Educational Objectives

This section includes a description of the representative transcripts of the educational objectives, an analysis of educational objectives used in different teaching methods, and an analysis of educational objectives used in different evaluation methods. The analysis of educational objectives showed what was instructed in chemistry classroom in terms of educational objectives.

5.1.1. Representative Educational Objective Transcripts

Klopfer's educational objective categories were used in this study to analyze chemistry educational objectives in schools S and D, which were a comprehensive instrument used to study educational objectives in science education. Klopfer's objective categories had usually been used to analyze contents of science textbooks. But this study attempted to use Klopfer's categories to find the proportions of educational objective by classroom observation. The following transcripts are from audio recordings of class instructions. Here, three representative transcripts were explained by showing why they were assigned to certain educational objectives.

One transcript showed the interpretation of experimental data (D3) objective and the generalization (D6) objective in Klopfer's categories, which was from the regular class in School S and was instructed on December 14, 1984. Topic was "Properties of periodic table", and teaching methods were socratic method and lecture.

Teacher: Atomic radii, going to the cross? (It means that atomic radii are going to increase or decrease as going to cross the periodic table.) (Teacher indicated Periodic Table.)
Student: Um um.
Teacher: What is it, going cross the chart?
Student: Smaller.
Teacher: Smaller? To what group?
Student: Smaller.
Teacher: I don't think so. Keeps going down to get to?
Student 1: Six, seven (Name of group of elements).
Student 2: Seven.
Student 3: Seven, eight.
Teacher: To seven, eight. And then as approaching noble gases, they have completely filled shell. We gonna say, decreases to seven, eight ("seven" or "eight" means atomic number.). And then increase. So increases. Excuse me, decrease toward the nonmetals. And noble gases try to increase, some of them are larger than the beginning of the period.

Teacher tried to explain trends of atomic radii in elements of periodic chart. Before this class period, students made periodic charts themselves by cutting and gluing little pieces of paper, where alphabets were written. The purpose of which were to give information about density, atomic radii and phases on a different sheet of paper. In the following class of the experiment class, the teacher led students to interpret the periodic chart which they made, and to generalize the trends. This instruction was for interpretation of experimental data (D3) and generalization (D6) objectives in Klopfer's categories.

The other transcript showed the application in the same field of science (F1) in Klopfer's categories, which was from the advanced placement class in School S, and was instructed on February 21, 1984. The topic was Nernst Equation. Teaching methods were: lecture, problem solving, and socratic method.

Teacher: 10.5 (Problem number) is on page 360.

(Teacher writes it on overhead projector roll with the following explanation $E = E^0 - .05916/2 \times \log\{1/.1\}$)

What is electropotential of a zinc, ions of zinc electrode, which concentration of zinc ion is zero point one molar. OK, you write the partial reaction first to see how electrons move. So you look at the partial equation first. So in this case we can read, that is, n equals two. The symbol, the concentration of, you use the symbol inside the bracket, that's always bracketing. Molarity, mole per liter. And that tells us the zinc ion, in this case, is zero point one molar. The ... oh, the first go back to the chart and the, look at the electropotential for this reaction would be zinc ion is going to zinc, rather than zinc is going to zinc ion.

Teacher: OK, That's your easier standard conditions (indicating E^0), minus zero point five nine or five nine two. Divide by n, which is two, times log, what? He always wants the product, here in the right hand side you have zinc, that's solid, right? The activity of zinc is one. You got the log of the product, the activity of solid is one. You see what it is?

Student: Um.

Teacher: Concentration of the zinc, concentration of the zinc is point one. Let's calculate, make sure your calculators still work.

The teacher in School S showed how to find E value of Zn^{+2} to Zn, using Nernst equation, which students had learned just before solving this problem. In this instructional process, students learned how to apply Nernst Equation. Application in the same field of science educational objective, F1 was assigned in this period.

The third transcript showed the historical orientation objective (I3) in Klopfer's categories, which was from chemistry class in School D, and was instructed on December 2, 1983. Topic was "Model of atom" and the teaching method was lecture.

> Teacher: .... Also all that time, came up with the idea that the matter was particular. And he came up with the name, "atom". The matter was made of particle. Atom was supposed to be described, particle, very tiny particle. And it is indestructible, OK, atom was thought to be indestructible particle. And this idea had lasted at least a couple of thousand years. And then, in the very late, eighteen hundred to nearly nineteen hundred, finally started, making a little bit of progress for understanding of the atom.
> .....

The chemistry teacher in School D explained the change of idea about the atomic theories historically. This part was assigned to historical orientation educational objective, I3.

The twelve transcripts including the above three transcripts are in Appendix I to show the procedures of entering Klopfer's subcategories in each five minute period of instruction. The twelve transcripts are:

1. for the terminology (A2) objective and the conventional knowledge (A4) in Klopfer's categories, and the topic was "measurement of pressure".

2. for the conceptual knowledge (A3) and the principle knowledge (A8) objectives, and "net ionic equation" as a topic.

3. for the trend and sequence (A5), the interpretation of experimental knowledge (D3) and the generalization (D6) objectives, and " properties of periodic table" as a topic.

4. for the technique and procedure (A7), the description of observation (B2) and common laboratory performance (G2) objectives, and " activities of I A, II A, VII A elements"

as a topic.

5. for the principle knowledge (A8), the observing (B1), the interpretation of experimental data (D3) objectives, and Le Chartelier's principle as a topic.

6. for the theory knowledge (A9) objective and "kinetic theory" as a topic.

7. for the observing (B1), the measurement (B3) and the common laboratory performance (G2) objectives, and "diffusion of gases" as a topic.

8. for the application in the same field of science (F1) objective and " Nernst equation" as a topic.

9. for the development of vocational interest (H6) objective and " Women in chemistry" as a topic.

10. for the evolutionary character of science (I3) objective and "model of atom" as a topic.

11. for the observing (B1), the description of observation (B2) and the development skills in using equipment (G1) objectives, and "hydrogen peroxide" as a topic.

12. for the observing (B1), the description of observation (B2) and the development skills in using equipment (G1) objectives, and "ion and precipitation" as a experiment topic.

Forty classes observed were assigned in the same method by using Klopfer's educational objective subcategories. Some five minute periods had been assigned with two to five objective categories.

5.1.2. Educational Objectives with respect to Different Teaching Methods.

Educational objectives were analyzed with respect to different teaching methods. Among the various teaching methods, more than one teaching method was used. Teaching methods were classified into six categories: (1) the lecture, problem solving, and socratic method; (2) the lecture and socratic method; (3) the demonstration method; (4) the student experiment, discussion, and socratic method; (5) the film-slide showing method; and (6) the field trips or guest speaker method.

As shown in Table 10, three class periods were observed in the regular program in School S for the lecture, problem solving, and socratic method; four class periods for the advanced placement class in School S; and four class periods in four days during the observation period for the regular program in School D. For the lecture and socratic method, the regular program in School S was observed three class periods; the advanced placement program in School S, one class period; and the regular program in School D, three class periods. For the demonstration method, the regular program in School S was observed for five minute in a class period; the advanced placement program in School S, five minutes in a class period; and the regular program in School D, 25 minutes of a class period. For the student experiment, discussion, and socratic method, the regular program in School S was observed for six class periods; the advanced placement program in School S, three class periods; and the regular program in School D, four class periods. For the film-slide showing method, the regular program in School S was observed for five minutes in a class period; the advanced placement program in School S, 15 minutes in two class periods, which were five minutes in a period and 10 minutes in another class period; and the regular program in School D, 40 minutes in a class period. For the field trip or guest speaker method, two programs in School S did not have any class period of

Table 10. Observation Days According to Teaching Methods

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Methods	Days	Periods	Days	Periods	Days	Periods
Lecture, Problem Solving, and Socratic Method	12/14 2/14 2/21	10 11 9	12/8 12/13 2/15 2/21	10 10 10 9	12/2 12/14 12/15 3/1	10 10 10 9
Lecture and Socratic Method	12/8 2/24 3/6	9 9 9	2/14	10	12/12 12/13 2/27	9 9 9
Demonstration	3/7	1	12/14	1	2/27	5
Student Experiment, Discussion, and Socratic Method	12/12 12/13 2/15 2/16 2/22 3/1	9 9 9 10 10 10	2/16 2/17 2/22	10 10 10	12/8 12/19 12/20 2/24	10 8 9 8
Film-Slide Showing	3/7	1	3/6 3/7	1 2	12/5	8
Field Trip or Guest Speaker					2/13	10
Total	14	116	12	83	14	124

* Periods means the number of five-minute periods

this type of teaching method but the regular program in School D was observed for one class period during the classroom observation period. All together, 40 class periods were observed during the observation period.

An analysis of the educational objectives was tabulated in Tables 11, 12, 13, 14, 15, and 16. In the lecture, problem solving, and socratic method classes, as shown in Table 11, knowledge and comprehension objectives were 62 percent to 88 percent, which was the largest portion of educational objectives in the three programs. Among the eleven knowledge and comprehension objectives, terminology, concepts, and principle objectives are mainly taught in the three programs. In the advanced placement class in School S, the application objectives were 34 percent. In the problem solving session, the advanced placement class spent a lot of time on application in the same field of science objective. But no application outside of science and in a different field of science appeared in any of the three programs. The classes using this method did not include any scientific inquiry skills II, III and IV, manual skills, or orientation objectives.

In the lecture and socratic teaching method, as shown in Table 12, knowledge and comprehension objectives were 87 percent to 100 percent, which was emphasized more than in the lecture, problem solving, and socratic method (61.9 percent to 88.3 percent). Most knowledge and comprehension subcategories were pursued except trend and sequence, and demonstration in a new context of objectives. Among other objectives, 3.7 percent of the interpreting data objective in the regular class in School S and 3.7 percent of orientation to evolutionary character of science objective in School D appeared in the regular classes in School D.

In the demonstration classes, as shown in Table 13, scientific inquiry I objectives were found in a large portion of them. In School D, 32.7 percent of the knowledge and

Table 11. Educational Objectives in Lecture, Problem Solving, and Socratic Method

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
KNOWLEDGE AND COMPREHENSION	26.5	88.3	24.0	61.9	32.5	84.0
1: facts	0.0		.8	2.1	.5	1.3
2: terminology	4.0	13.3	.8	2.1	6.3	16.3
3: concept	2.0	6.7	5.3	13.7	11.8	30.5
4: convention	3.0	10.0	0.0		0.0	
5: trend and sequence	2.0	6.7	0.0		0.0	
6: classification, categories, criteria	1.5	5.0	0.0		0.0	
7: technique, procedures	5.0	16.5	4.0	10.3	0.0	
8: principle or law	4.5	15.0	10.8	27.8	9.3	24.0
9: theory or conceptual schemes	3.5	11.7	2.3	5.9	4.6	11.9
10: demonstration in a new context	0.0		0.0		0.0	
11: translation to other symbolic forms	1.0	3.3	0.0		0.0	
SCIENTIFIC INQUIRY I: observing and measuring	0.0		0.0		.3	.8
1: observing	0.0		0.0		.3	.8
2: description of observation	0.0		0.0		0.0	
3: measurement	0.0		0.0		0.0i	
4: selecting instrument	0.0		0.0		0.0	
5: calibration markings of instrument	0.0		0.0		0.0	
SCIENTIFIC INQUIRY II: seeking a problem and ways to solve it.	0.0		0.0		0.0	
1: recognition of problem	0.0		0.0		0.0	
2: formulation of hypothesis	0.0		0.0		0.0	
3: choosing a series of experiments	0.0		0.0		0.0	
4: design of procedure	0.0		0.0		0.0	
SCIENTIFIC INQUIRY III: interpreting data and generalization	0.0		0.0		0.0	
1: processing data	0.0		0.0		0.0	
2: making functional relationship	0.0		0.0		0.0	
3: interpretation of data	0.0		0.0		0.0	
4: extrapolation and interpolation	0.0		0.0		0.0	
5: evaluation of a hypothesis by data	0.0		0.0		0.0	
6: generalization	0.0		0.0		0.0	
SCIENTIFIC INQUIRY IV: theoretical model	0.0		0.0		0.0	
1: recognition of the need of a model	0.0		0.0		0.0	
2: formulation of a theoretical model	0.0		0.0		0.0	

Table 11 (cont'd.).

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
3: specification of phenomena explained by a model	0.0		0.0		0.0	
4: deduction of new hypothesis from a theoretical model	0.0		0.0		0.0	
5: interpretation and evaluation of the results of experiments to test a theoretical model	0.0		0.0		0.0	
6: revision and extension of a theoretical model	0.0		0.0		0.0	
APPLICATION	2.5	8.3	13.3	34.3	4.0	10.3
1: in the same field	2.5	8.3	13.3	34.3	4.0	10.3
2: in the different field of science	0.0		0.0		0.0	
3: outside of science	0.0		0.0		0.0	
MANUAL SKILLS	0.0		0.0		0.0	
1: development of skills in using equipment	0.0		0.0		0.0	
2: common laboratory performance	0.0		0.0		0.0	
ATTITUDES AND INTERESTS	1.0	3.3	1.5	3.9	1.9	4.9
1: favorite attitude toward science	.5	1.7	1.5	3.9	1.3	3.4
2: acceptance of scientific inquiry	0.0		0.0		.6	1.6
3: adoption of scientific attitude	.5	1.7	0.0		0.0	
4: enjoyment of scientific learning	0.0		0.0		0.0	
5: development of interest in science	0.0		0.0		0.0	
6: development of vocational interests	0.0		0.0		0.0	
ORIENTATION	0.0		0.0		0.0	
1: relationships among various scientific statements	0.0		0.0		0.0	
2: influence of science on philosophy	0.0		0.0		0.0	
3: to the evolutionary character	0.0		0.0		0.0	
4: relationship among scientific progress, technical achievements, and economic development	0.0		0.0		0.0	
5: social and moral implications	0.0		0.0		0.0	
Total	30.0	99.9	38.8	100.1	38.7	100.0

Table 12. Educational Objectives in Lecture and Socratic Method Classes

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
KNOWLEDGE AND COMPREHENSION	25.9	96.3	10.0	100.0	23.5	87.0
1: facts	3.0	11.2	1.0	10.0	1.0	3.7
2: terminology	.5	1.9	0.0		5.0	18.5
3: concept	6.3	23.4	0.0		.5	1.9
4: convention	3.5	13.0	1.0	10.0	0.0	
5: trend and sequence	0.0		0.0		0.0	
6: classification, categories, criteria	4.3	16.0	0.0		0.0	
7: technique, procedures	1.3	4.8	8.0	80.0	2.0	7.4
8: principle or law	2.0	7.4	0.0		10.5	38.9
9: theory or conceptual schemes	1.0	3.7	0.0		4.5	16.7
10: demonstration in a new context	0.0		0.0		0.0	
11: translation to other symbolic forms	4.0	14.8	0.0		0.0	
SCIENTIFIC INQUIRY I: observing and measuring	0.0		0.0		0.0	
1: observing	0.0		0.0		0.0	
2: description of observation	0.0		0.0		0.0	
3: measurement	0.0		0.0		0.0	
4: selecting instrument	0.0		0.0		0.0	
5: calibration markings of instrument	0.0		0.0		0.0	
SCIENTIFIC INQUIRY II: seeking a problem and ways to solve it	0.0		0.0		0.0	
1: recognition of problem	0.0		0.0		0.0	
2: formulation of hypothesis	0.0		0.0		0.0	
3: choosing a series of experiments	0.0		0.0		0.0	
4: design of procedure	0.0		0.0		0.0	
SCIENTIFIC INQUIRY III: interpreting data and generalization	1.0	3.7	0.0		0.0	
1: processing data	0.0		0.0		0.0	
2: making functional relationship	0.0		0.0		0.0	
3: interpretation of data	1.0	3.7	0.0		0.0	
4: extrapolation and interpolation	0.0		0.0		0.0	
5: evaluation of a hypothesis by data	0.0		0.0		0.0	
6: generalization	0.0		0.0		0.0	
SCIENTIFIC INQUIRY IV: theoretical model	0.0		0.0		0.0	
1: recognition of the need of a model	0.0		0.0		0.0	
2: formulation of a theoretical model	0.0		0.0		0.0	

Table 12 (cont'd.).

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
3: specification of phenomena explained by a model	0.0		0.0		0.0	
4: deduction of new hypothesis from a theoretical model	0.0		0.0		0.0	
5: interpretation and evaluation of the results of experiments to test a theoretical model	0.0		0.0		0.0	
6: revision and extension of a theoretical model	0.0		0.0		0.0	
APPLICATION	0.0		0.0		0.0	
1: in the same field	0.0		0.0		0.0	
2: in the different field of science	0.0		0.0		0.0	
3: outside of science	0.0		0.0		0.0	
MANUAL SKILLS	0.0		0.0		0.0	
1: development of skills in using equipment	0.0		0.0		0.0	
2: common laboratory performance	0.0		0.0		0.0	
ATTITUDES AND INTERESTS	0.0		0.0		2.5	9.3
1: favorite attitude toward science	0.0		0.0		.5	1.9
2: acceptance of scientific inquiry	0.0		0.0		0.0	
3: adoption of scientific attitude	0.0		0.0		0.0	
4: enjoyment of scientific learning	0.0		0.0		2.0	7.4
5: development of interest in science	0.0		0.0		0.0	
6: development of vocational interests	0.0		0.0		0.0	
ORIENTATION	0.0		0.0		1.0	3.7
1: relationships among various scientific statements	0.0		0.0		0.0	
2: influence of science on philosophy	0.0		0.0		0.0	
3: to the evolutionary character	0.0		0.0		1.0	3.7
4: relationship among scientific progress, technical achievement, and economic development	0.0		0.0		0.0	
5: social and moral implications	0.0		0.0		0.0	
Total	26.9	100.0	10.0	100.0	27.0	100.0

Table 13. Educational Obectives in Demonstration Classes

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
KNOWLEDGE AND COMPREHENSION	0.0		0.0		1.6	32.7
1: facts	0.0		0.0		0.0	
2: terminology	0.0		0.0		0.0	
3: concept	0.0		0.0		0.0	
4: convention	0.0		0.0		0.0	
5: trend and sequence	0.0		0.0		0.0	
6: classification, categories, criteria	0.0		0.0		0.0	
7: technique, procedures	0.0		0.0		0.0	
8: principle or law	0.0		0.0		1.3	26.5
9: theory or conceptual schemes	0.0		0.0		.3	6.1
10: demonstration in a new context	0.0		0.0		0.0	
11: translation to other symbolic forms	0.0		0.0		0.0	
SCIENTIFIC INQUIRY I: observing and measuring	.5	50.0	.4	40.0	1.3	26.5
1: observing	.5	50.0	.2	20.0	1.3	26.5
2: description of observation	0.0		.2	20.0	0.0	
3: measurement	0.0		0.0		0.0	
4: selecting instrument	0.0		0.0		0.0	
5: calibration markings of instrument	0.0		0.0		0.0	
SCIENTIFIC INQUIRY II: seeking a problem and ways to solve it	0.0		0.0		0.0	
1: recognition of problem	0.0		0.0		0.0	
2: formulation of hypothesis	0.0		0.0		0.0	
3: choosing a series of experiments	0.0		0.0		0.0	
4: design of procedure	0.0		0.0		0.0	
SCIENTIFIC INQUIRY III: interpreting data and generalization	.5	50.0	0.0		1.0	20.4
1: processing data	0.0		0.0		0.0	
2: making functional relationship	0.0		0.0		0.0	
3: interpretation of data	.5	50.0	0		1.0	20.4
4: extrapolation and interpolation	0.0		0.0		0.0	
5: evaluation of a hypothesis by data	0.0		0.0		0.0	
6: generalization	0.0		0.0		0.0	
SCIENTIFIC INQUIRY IV: theoretical model	0.0		0.0		0.0	
1: recognition of the need of a model	0.0		0.0		0.0	
2: formulation of a theoretical model	0.0		0.0		0.0	

Table 13 (cont'd.).

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
3: specification of phenomena explained by a model	0.0		0.0		0.0	
4: deduction of new hypothesis from a theoretical model	0.0		0.0		0.0	
5: interpretation and evaluation of the results of experiments to test a theoretical model	0.0		0.0		0.0	
6: revision and extension of a theoretical model	0.0		0.0		0.0	
APPLICATION	0.0		0.0		0.0	
1: in the same field	0.0		0.0		0.0	
2: in the different field of science	0.0		0.0		0.0	
3: outside of science	0.0		0.0		0.0	
MANUAL SKILLS	0.0		.2	20.0	1.0	20.4
1: development of skills in using equipment	0.0		0.0		0.0	
2: common laboratory performance	0.0		.2	20.0	1.0	20.4
ATTITUDES AND INTERESTS	0.0		.4	40.0	0.0	
1: favorite attitude toward science	0.0		.2	20.0	0.0	
2: acceptance of scientific inquiry	0.0		.2	20.0	0.0	
3: adoption of scientific attitude	0.0		0.0		0.0	
4: enjoyment of scientific learning	0.0		0.0		0.0	
5: development of interest in science	0.0		0.0		0.0	
6: development of vocational interests	0.0		0.0		0.0	
ORIENTATION	0.0		0.0		0.0	
1: relationships among various scientific statements	0.0		0.0		0.0	
2: influence of science on philosophy	0.0		0.0		0.0	
3: to the evolutionary character	0.0		0.0		0.0	
4: relationship among scientific progress, technical achievement, and economic development	0.0		0.0		0.0	
5: social and moral implications	0.0		0.0		0.0	
Total	1.0	100.0	1.0	100.0	4.9	100.0

comprehension objectives were due to the teacher's demonstration in order to explain Le Chartelier's Principles experimentally. Five minutes in the regular class in School S, five minutes in the advanced placement class in School S, and 25 minutes in School D were for the demonstration teaching method, which was a small part of the total instruction time. The reason for the small portion of time is that if there were good experiments to explain certain principles, Schools S and D let students do experiments. Accordingly student experiments were performed most of the time.

In the student experiment, discussion, and socratic method classes, as shown in Table 14, scientific inquiry I and manual skill objectives were together 57 percent to 96 percent in the three programs. In the scientific inquiry I: observing and describing, the observation objectives was mainly appeared, as did a little of the measurement, the selecting instrument, and the calibration marking objectives. A little of the seeking problems and ways to solve them (scientific inquiry II), the interpreting data and generalization (scientific inquiry III), and the theoretical model objectives (scientific inquiry IV) appeared. Nine percent of scientific inquiry II,III, and IV were found in the regular chemistry class in School S; 5.6 percent, in the regular chemistry class in School D; and 0.0 percent, in the advanced placement chemistry class in School S. In the regular chemistry class in School S, students experienced various inquiry skills. Development of skills in using equipment objective (G1) was taught in the advanced placement class in School S, 10.4 percent of the time. Students in the advanced placement class in School S practiced basic skills in qualitative analysis such as cleaning test tubes and cleaning medicine droppers with boiling water.

In the film-slide showing teaching method, as shown in Table 15, 5 minutes in the regular class in School S, 15 minutes in the advanced placement class in School S, and 40

Table 14. Educational Objectives in Experiment, Discussion, and Socratic Method

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
KNOWLEDGE AND COMPREHENSION	16.3	28.7	1.3	4.3	7.0	20.1
1: facts	0.0		0.0		1.5	4.3
2: terminology	0.0		0.0		0.0	
3: concept	0.0		0.0		0.0	
4: convention	0.0		0.0		0.0	
5: trend and sequence	6.0	10.6	0.0		0.0	
6: classification, categories, criteria	7.3	12.9	0.0		0.0	
7: technique, procedures	3.0	5.3	1.3	4.3	3.0	8.6
8: principle or law	0.0		0.0		2.5	7.2
9: theory or conceptual schemes	0.0		0.0		0.0	
10: demonstration in a new context	0.0		0.0		0.0	
11: translation to other symbolic forms	0.0		0.0		0.0	
SCIENTIFIC INQUIRY I: observing and measuring	14.6	25.7	14.3	47.8	12.2	35.1
1: observing	7.1	12.5	7.4	24.7	6.1	17.5
2: description of observation	6.3	11.1	6.9	23.1	6.1	17.5
3: measurement	.8	1.4	0.0		0.0	
4: selecting instrument	.4	.7	0.0		0.0	
5: calibration markings of instrument	0.0		0.0		0.0	
SCIENTIFIC INQUIRY II: seeking a problem and ways to solve it	1.6	2.8	0.0		1.0	2.9
1: recognition of problem	.4	.7	0.0		0.0	
2: formulation of hypothesis	.4	.7	0.0		1.0	2.9
3: choosing a series of experiments	.4	.7	0.0		0.0	
4: design of procedure	.4	.7	0.0		0.0	
SCIENTIFIC INQUIRY III: interpreting data and generalization	3.4	6.0	0.0		0.0	
1: processing data	1.7	3.0	0.0		0.0	
2: making functional relationship	1.7	3.0	0.0		0.0	
3: interpretation of data	0.0		0.0		0.0	
4: extrapolation and interpolation	0.0		0.0		0.0	
5: evaluation of a hypothesis by data	0.0		0.0		0.0	
6: generalization	0.0		0.0		0.0	
SCIENTIFIC INQUIRY IV: theoretical model	0.0		0.0		0.0	
1: recognition of the need of a model	0.0		0.0		0.0	
2: formulation of a theoretical model	0.0		0.0		0.0	

Table 14 cont'd.).

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
3: specification of phenomena explained by a model	0.0		0.0		0.0	
4: deduction of new hypothesis from a theoretical model	0.0		0.0		0.0	
5: interpretation and evaluation of the results of experiments to test a theoretical model	0.0		0.0		0.0	
6: revision and extension of a theoretical model	0.0		0.0		0.0	
APPLICATION	3.0	5.3	0.0		0.0	
1: in the same field	3.0	5.3	0.0		0.0	
2: in the different field of science	0.0		0.0		0.0	
3: outside of science	0.0		0.0		0.0	
MANUAL SKILLS	17.9	31.5	14.3	47.8	9.1	26.1
1: development of skills in using equipment	0.0		3.1	10.4	0.0	
2: common laboratory performance	17.9	31.5	11.2	37.5	9.1	26.1
ATTITUDES AND INTERESTS	0.0		0.0		4.5	12.9
1: favorite attitude toward science	0.0		0.0		3.5	10.1
2: acceptance of scientific inquiry	0.0		0.0		1.0	2.9
3: adoption of scientific attitude	0.0		0.0		0.0	
4: enjoyment of scientific learning	0.0		0.0		0.0	
5: development of interest in science	0.0		0.0		0.0	
6: development of vocational interests	0.0		0.0		0.0	
ORIENTATION	0.0		0.0		0.0	
1: relationships among various scientific statements	0.0		0.0		0.0	
2: influence of science on philosophy	0.0		0.0		0.0	
3: to the evolutionary character	0.0		0.0		0.0	
4: relationship among scientific progress, technical achievement, and economic development	0.0		0.0		0.0	
5: social and moral implications	0.0		0.0		0.0	
Total	56.8	100.0	29.9	99.9	34.8	100.0

Table 15. Educational Objectives in Film-Slide Showing Classes

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
KNOWLEDGE AND COMPREHENSION	1.0	100.0	3.0	100.0	0.0	
1: facts	0.0		0.0		0.0	
2: terminology	0.0		0.0		0.0	
3: concept	0.0		0.0		0.0	
4: convention	0.0		0.0		0.0	
5: trend and sequence	0.0		0.0		0.0	
6: classification, categories, criteria	0.0		0.0		0.0	
7: technique, procedures	1.0	100.0	3.0	100.0	0.0	
8: principle or law	0.0		0.0		0.0	
9: theory or conceptual schemes	0.0		0.0		0.0	
10: demonstration in a new context	0.0		0.0		0.0	
11: translation to other symbolic forms	0.0		0.0		0.0	
SCIENTIFIC INQUIRY I: observing and measuring	0.0		0.0		0.0	
1: observing	0.0		0.0		0.0	
2: description of observation	0.0		0.0		0.0	
3: measurement	0.0		0.0		0.0	
4: selecting instrument	0.0		0.0		0.0	
5: calibration markings of instrument	0.0		0.0		0.0	
SCIENTIFIC INQUIRY II: seeking a problem and ways to solve it	0.0		0.0		0.0	
1: recognition of problem	0.0		0.0		0.0	
2: formulation of hypothesis	0.0		0.0		0.0	
3: choosing a series of experiments	0.0		0.0		0.0	
4: design of procedure	0.0		0.0		0.0	
SCIENTIFIC INQUIRY III: interpreting data and generalization	0.0		0.0		0.0	
1: processing data	0.0		0.0		0.0	
2: making functional relationship	0.0		0.0		0.0	
3: interpretation of data	0.0		0.0		0.0	
4: extrapolation and interpolation	0.0		0.0		0.0	
5: evaluation of a hypothesis by data	0.0		0.0		0.0	
6: generalization	0.0		0.0		0.0	
SCIENTIFIC INQUIRY IV: theoretical model	0.0		0.0		0.0	
1: recognition of the need of a model	0.0		0.0		0.0	
2: formulation of a theoretical model	0.0		0.0		0.0	

Table 15 (cont'd.).

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
3: specification of phenomena explained by a model	0.0		0.0		0.0	
4: deduction of new hypothesis from a theoretical model	0.0		0.0		0.0	
5: interpretation and evaluation of the results of experiments to test a theoretical model	0.0		0.0		0.0	
6: revision and extension of a theoretical model	0.0		0.0		0.0	
APPLICATION	0.0		0.0		0.0	
1: in the same field	0.0		0.0		0.0	
2: in the different field of science	0.0		0.0		0.0	
3: outside of science	0.0		0.0		0.0	
MANUAL SKILLS	0.0		0.0		0.0	
1: development of skills in using equipment	0.0		0.0		0.0	
2: common laboratory performance	0.0		0.0		0.0	
ATTITUDES AND INTERESTS	0.0		0.0		8.0	100.0
1: favorite attitude toward science	0.0		0.0		0.0	
2: acceptance of scientific inquiry	0.0		0.0		0.0	
3: adoption of scientific attitude	0.0		0.0		0.0	
4: enjoyment of scientific learning	0.0		0.0		0.0	
5: development of interest in science	0.0		0.0		0.0	
6: development of vocational interests	0.0		0.0		8.0	100.0
ORIENTATION	0.0		0.0		0.0	
1: relationships among various scientific statements	0.0		0.0		0.0	
2: influence of science on philosophy	0.0		0.0		0.0	
3: to the evolutionary character	0.0		0.0		0.0	
4: relationship among scientific progress, technical achievement, and economic development	0.0		0.0		0.0	
5: social and moral implications	0.0		0.0		0.0	
Total	1.0	100.0	3.0	100.0	8.0	100.0

minutes in the regular class in School D were spent. In School S, procedure of centrifuge, cleaning precipitation and reaction rate[1] were shown in two chemistry classes by the same chemistry teacher. The films were for procedural knowledge, which took two to three minutes showing time for each film. In School D, development of vocational interest objective was pursued by showing a 40 minutes of video-film, Women in Chemistry,[2] which showed several women working in the chemistry-related areas.

On the field trips or in guest speaker classes, as shown in Table 16, School S did not have this type of class during the observation periods of the study. However, School D did have one class period of this type. A guest speaker, invited from a local pharmaceutical company, talked about his company's products, spectrometer used in his laboratory, and analytical chemistry. In School D, 58.6 percent of the procedure knowledge and comprehension objectives and 25.3 percent of the relationship with technical and economic development objective were counted.

Educational objectives were analyzed with respect to the six types of teaching methods: (1) the lecture, problem solving, and socratic method (Teaching method, 1, 7, 8); (2) the lecture and socratic method (Teaching method, 1, 8); (3) the demonstration (Teaching method, 2); (4) the student experiment, discussion and socratic (Teaching method, 3, 5, 8); (5) the film-slide showing (Teaching method, 4); and (6) the field trips or guest speaker (Teaching method, 9). All in all, as shown in Figure 23 (The exact figures will be shown in Table 27 of Chapter 6), educational objectives in the chemistry classes of the three programs were emphasized in the following order: knowledge and comprehension objectives (A), 46.3 percent to 60.2 percent; scientific inquiry I: observing and measuring (B), 11.2 percent to 17.8 percent; manual skills (G), 8.2 percent to 17.5

[1]The films were produced by Ealing Film Loops.

[2]The video tape was produced by The University of Michigan.

Table 16. Educational Objectives in Field Trip or Guest Speaker Classes

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
KNOWLEDGE AND COMPREHENSION	0.0		0.0		6.3	63.6
1: facts	0.0		0.0		0.0	
2: terminology	0.0		0.0		0.0	
3: concept	0.0		0.0		.5	5.1
4: convention	0.0		0.0		0.0	
5: trend and sequence	0.0		0.0		0.0	
6: classification, categories, criteria	0.0		0.0		0.0	
7: technique, procedures	0.0		0.0		5.8	58.6
8: principle or law	0.0		0.0		0.0	
9: theory or conceptual schemes	0.0		0.0		0.0	
10: demonstration in a new context	0.0		0.0		0.0	
11: translation to other symbolic forms	0.0		0.0		0.0	
SCIENTIFIC INQUIRY I: observing and measuring	0.0		0.0		0.0	
1: observing	0.0		0.0		0.0	
2: description of observation	0.0		0.0		0.0	
3: measurement	0.0		0.0		0.0	
4: selecting instrument	0.0		0.0		0.0	
5: calibration markings of instrument	0.0		0.0		0.0	
SCIENTIFIC INQUIRY II: seeking a problem and ways to solve it	0.0		0.0		0.0	
1: recognition of problem	0.0		0.0		0.0	
2: formulation of hypothesis	0.0		0.0		0.0	
3: choosing a series of experiments	0.0		0.0		0.0	
4: design of procedure	0.0		0.0		0.0	
SCIENTIFIC INQUIRY III: interpreting data and generalization	0.0		0.0		0.0	
1: processing data	0.0		0.0		0.0	
2: making functional relationship	0.0		0.0		0.0	
3: interpretation of data	0.0		0.0		0.0	
4: extrapolation and interpolation	0.0		0.0		0.0	
5: evaluation of a hypothesis by data	0.0		0.0		0.0	
6: generalization	0.0		0.0		0.0	
SCIENTIFIC INQUIRY IV: theoretical model	0.0		0.0		0.0	
1: recognition of the need of a model	0.0		0.0		0.0	
2: formulation of a theoretical model	0.0		0.0		0.0	

Table 16 (cont'd.).

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
3: specification of phenomena explained by a model	0.0		0.0		0.0	
4: deduction of new hypothesis from a theoretical model	0.0		0.0		0.0	
5: interpretation and evaluation of the results of experiments to test a theoretical model	0.0		0.0		0.0	
6: revision and extension of a theoretical model	0.0		0.0		0.0	
APPLICATION	0.0		0.0		0.0	
1: in the same field	0.0		0.0		0.0	
2: in the different field of science	0.0		0.0		0.0	
3: outside of science	0.0		0.0		0.0	
MANUAL SKILLS	0.0		0.0		0.0	
1: development of skills in using equipment	0.0		0.0		0.0	
2: common laboratory performance	0.0		0.0		0.0	
ATTITUDES AND INTERESTS	0.0		0.0		1.1	11.1
1: favorite attitude toward science	0.0		0.0		0.0	
2: acceptance of scientific inquiry	0.0		0.0		0.0	
3: adoption of scientific attitude	0.0		0.0		0.0	
4: enjoyment of scientific learning	0.0		0.0		0.0	
5: development of interest in science	0.0		0.0		.8	8.1
6: development of vocational interests	0.0		0.0		.3	3.0
ORIENTATION	0.0		0.0		2.5	25.3
1: relationships among various scientific statements	0.0		0.0		0.0	
2: influence of science on philosophy	0.0		0.0		0.0	
3: to the evolutionary character	0.0		0.0		0.0	
4: relationship among scientific progress, technical achievement, and economic development	0.0		0.0		2.5	25.3
5: social and moral implications	0.0		0.0		0.0	
Total	0.0		0.0		9.9	100.0

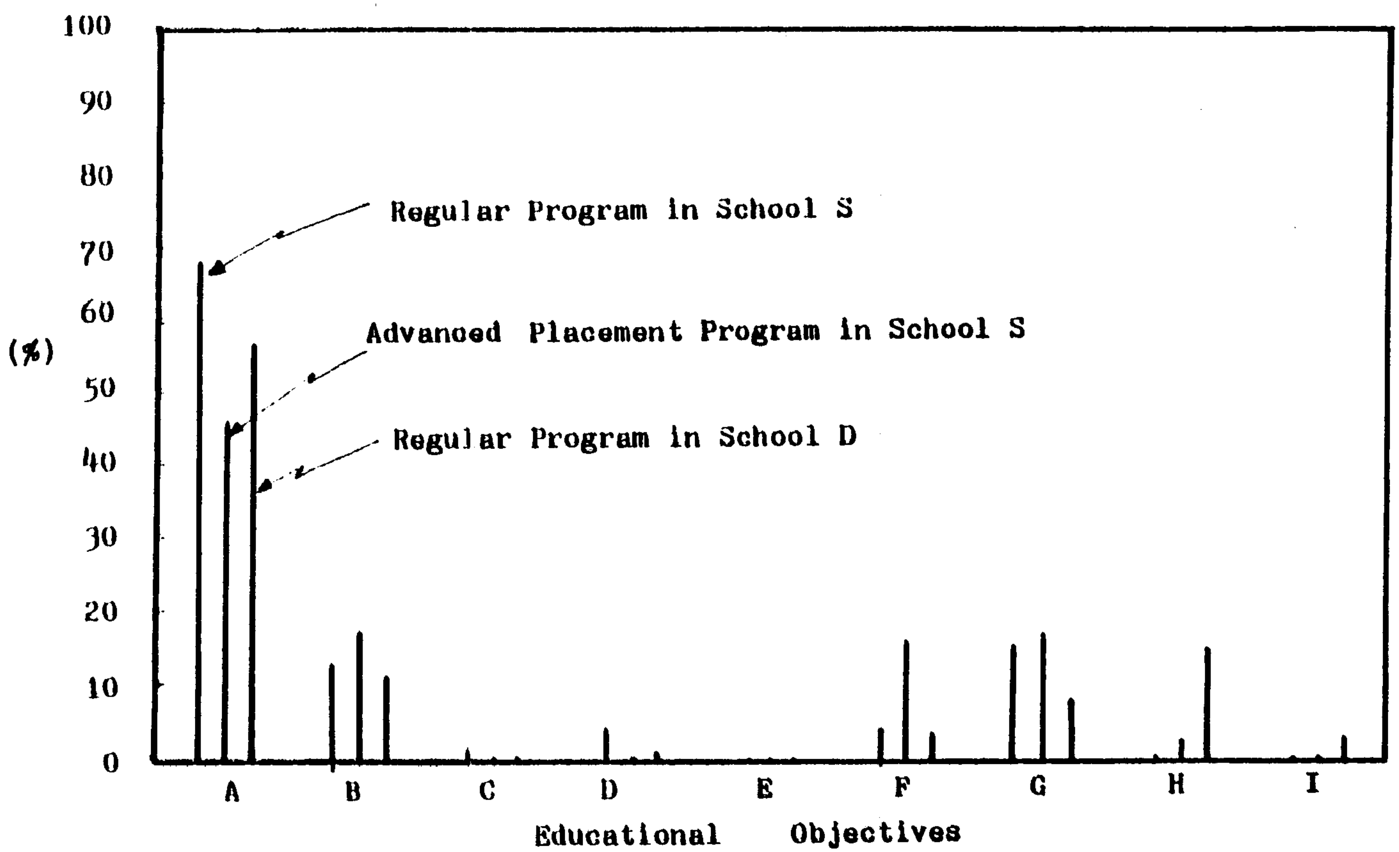

Figure 23. Educational Objectives in the Classroom Observation

percent; application (F), 3.2 percent to 16.1 percent; attitudes and interests (H), .9 percent to 14.6 percent; scientific inquiry II: seeking a problem and ways to solve it (C), 0.0 percent to 4.2 percent; orientation (I), 0.0 percent to 2.8 percent; scientific inquiry III: interpreting data and generalization (D), 0.0 percent to 1.4 percent; and scientific inquiry IV: theoretical model (E), 0.0 percent.

As shown in Figure 23, the regular program in School S emphasized objective A more than in other programs; the advanced placement program in School S emphasized objectives B, F, and G more than in the other programs; and the regular program in School D emphasized objectives H and I more than in the other programs.

5.1.3. Educational Objectives in the Evaluation Methods.

Evaluation methods used in the two schools were analyzed in terms of educational objectives. As evaluation methods, the two schools used worksheet questions, textbook problems, laboratory questions, and tests. The worksheet questions were prepared by teachers and distributed to students. Most worksheets were problems about certain topics intended to make students practice the application procedures of chemical, and mathematical principles. The worksheet questions included essay writing about chemistry-related articles in the advanced placement class in School S. For homework, students wrote five essays summarizing and commenting on articles published in science magazines or newspapers.

The textbook problems were selected by teachers or sometimes by students in the textbooks used in each program. The textbook used in the regular program in School S, was "Chemistry: A Modern Course" by Charles E. Merrill Publishing Co., the 1975 edition. The textbook used in the advanced placement program, was "Chemistry: A Conceptual Approach, D. Van Nostrand Co., the 1979 edition. The textbook used in the regular program in School D, was "Chemistry: Experimental foundations, Prentice-Hall, Inc., the 1975 edition.

The laboratory questions were in the back of each laboratory topic in lab manuals used in each programs. The lab manual used in the regular program in School S, was "Laboratory Chemistry", published by Charles E. Merrill Publishing Co., the 1983 edition. The lab manual of the advanced placement program in School S was "Experimental chemistry", published by McGraw-Hill Book Co., the 1976 edition, which was used for laboratory courses in general chemistry at college level. The lab manual used in School D was "Laboratory manual - Chemistry: Experimental Foundations", Prentice-Hall Inc., the 1975 edition. Teachers selected certain laboratory topics. Students did experiments, which were prepared by teachers and lab assistants. And students turned in lab reports, which included laboratory questions.

The tests were selected among examinations after each chapter, examinations after each semester, and examinations after one school year. The tests were prepared by teachers with the long teaching experience (15 years teaching experience of the teacher in School S and 23 years teaching experience of the teacher in School D). The types of question in the various tests were both objective and subjective. Students solved the worksheet, textbook, and laboratory problems during the class period or at home as homework. But the tests were taken during class periods.

Tables 17-20 showed the educational objective analysis of the worksheet questions, textbook problems, laboratory questions, and tests. In the worksheets, as shown in Table 17, knowledge and comprehension and application objectives were 54.4 percent in the advanced placement class in School S, 82.0 percent in the regular class in School S,

Table 17. Educational Objectives in Worksheets

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
KNOWLEDGE AND COMPREHENSION	26.3	52.5	13.9	27.8	16.9	33.9
1: facts	2.5	5.0	0.0		0.0	
2: terminology	3.5	7.0	0.0		1.0	2.0
3: concept	6.5	13.0	0.0		1.5	3.0
4: convention	4.0	8.0	1.0	2.0	9.1	18.2
5: trend and sequence	0.0		0.0		0.0	
6: classification, categories, criteria	0.0		0.0		0.0	
7: technique, procedures	8.3	16.6	0.0		1.5	3.0
8: principle or law	.5	1.0	0.0		3.8	7.6
9: theory or conceptual schemes	0.0		12.9	25.8	0.0	
10: demonstration in a new context	0.0		0.0		0.0	
11: translation to other symbolic forms	1.0	2.0	0.0		0.0	
SCIENTIFIC INQUIRY I: observing and measuring	4.0	8.1	0.0		1.0	2.0
1: observing	0.0		0.0		1.0	2.0
2: description of observation	4.0	8.1	0.0		0.0	
3: measurement	0.0		0.0		0.0	
4: selecting instrument	0.0		0.0		0.0	
5: calibration markings of instrument	0.0		0.0		0.0	
SCIENTIFIC INQUIRY II: seeking a problem and ways to solve it	1.0	2.0	0.0		0.0	
1: recognition of problem	0.0		0.0		0.0	
2: formulation of hypothesis	1.0	2.0	0.0		0.0	
3: choosing a series of experiments	0.0		0.0		0.0	
4: design of procedure	0.0		0.0		0.0	
SCIENTIFIC INQUIRY III: interpreting data and generalization	3.0	6.0	0.0		0.0	
1: processing data	0.0		0.0		0.0	
2: making functional relationship	0.0		0.0		0.0	
3: interpretation of data	1.0	2.0	0.0		0.0	
4: extrapolation and interpolation	1.0	2.0	0.0		0.0	
5: evaluation of a hypothesis by data	0.0		0.0		0.0	
6: generalization	1.0	2.0	0.0		0.0	
SCIENTIFIC INQUIRY IV: theoretical model	1.0	2.0	0.0		0.0	
1: recognition of the need of a model	0.0		0.0		0.0	
2: formulation of a theoretical model	1.0	2.0	0.0		0.0	

Table 17 (cont'd.).

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
3: specification of phenomena explained by a model	0.0		0.0		0.0	
4: deduction of new hypothesis from a theoretical model	0.0		0.0		0.0	
5: interpretation and evaluation of the results of experiments to test a theoretical model	0.0		0.0		0.0	
6: revision and extension of a theoretical model	0.0		0.0		0.0	
APPLICATION	14.8	29.5	13.3	26.6	29.0	58.1
1: in the same field	14.8	29.5	13.3	26.6	29.0	58.1
2: in the different field of science	0.0		0.0		0.0	
3: outside of science	0.0		0.0		0.0	
MANUAL SKILLS	0.0		0.0		0.0	
1: development of skills in using equipment	0.0		0.0		0.0	
2: common laboratory performance	0.0		0.0		0.0	
ATTITUDES AND INTERESTS	0.0		10.0	20.0	1.0	2.0
1: favorite attitude toward science	0.0		0.0		0.0	
2: acceptance of scientific inquiry	0.0		0.0		1.0	2.0
3: adoption of scientific attitude	0.0		0.0		0.0	
4: enjoyment of scientific learning	0.0		0.0		0.0	
5: development of interest in science	0.0		6.7	13.4		0.0
6: development of vocational interests	0.0		3.3	6.6	0.0	
ORIENTATION	0.0		12.8	25.6	2.0	4.0
1: relationships among various scientific statements	0.0		0.0		0.0	
2: influence of science on philosophy	0.0		0.0		2.0	4.0
3: to the evolutionary character	0.0		6.1	12.2	0.0	
4: relationship among scientific progress, technical achievement, and economic development	0.0		6.7	13.4	0.0	
5: social and moral implications	0.0		0.0		0.0	
Total	50.1	100.1	50.0	100.0	49.9	100.0

and 92.0 percent in the regular class in School D. All of the scientific inquiry objectives were 18.1 percent in the regular class in School S. Twenty percent of the attitudes and interests objectives, and 25.6 percent orientation objectives were appeared in the advanced placement class in school S. All of the application objectives in the three programs were applications in the same field of science.

In the textbook problems, as shown in Table 18, knowledge and comprehension objectives were 53.4 percent in the regular class in School S, 43.1 percent in the advanced placement class in School S, and 28.6 percent in School D. Application objectives were 63.0 percent in School S, 56.9 percent in the advanced placement class in School S, and 46.6 percent in School D. The textbook in School D included more application type of questions than ones in School S. The textbooks in School S included more recall type of questions than the one in School D. Information concerning convention and classification was asked in the regular class in School S. Factual, convention, and principle knowledges were used to solve textbook problems in the advanced placement class in School S.

In the laboratory questions, as shown in Table 19, the regular program in School S asked more application skills than in the advanced placement program or in School D. The regular program in School S asked less knowledge and comprehension than in the advanced placement program or in School D. Interpreting data and generalization objectives were 2.8 percent in the regular program in School S, 10.0 percent in the advanced placement program, and 28.2 percent in School D, which was larger than other evaluation methods. However, the scientific inquiry IV: building and revising theoretical model objectives did not appear in any program. There were no laboratory questions concerning manual skills. When students do cxperiments, they need a lot of manual skills and

Table 18. Educational Objectives in Textbook Problems

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
KNOWLEDGE AND COMPREHENSION	26.7	53.4	21.6	43.1	14.3	28.6
1: facts	0.0		5.1	10.2	4.0	8.0
2: terminology	0.0		.9	1.8	1.0	2.0
3: concept	0.0		.9	1.8	0.0	
4: convention	21.7	43.4	7.5	15.0	0.0	
5: trend and sequence	0.0		0.0		0.0	
6: classification, categories, criteria	5.0	10.0	0.0		0.0	
7: technique, procedures	0.0		.4	.8	3.5	7.0
8: principle or law	0.0		5.1	10.2	4.8	9.6
9: theory or conceptual schemes	0.0		1.7	3.4	1.0	2.0
10: demonstration in a new context	0.0		0.0		0.0	
11: translation to other symbolic forms	0.0		0.0		0.0	
SCIENTIFIC INQUIRY I: observing and measuring	0.0		0.0		1.0	2.0
1: observing	0.0		0.0		1.0	2.0
2: description of observation	0.0		0.0		0.0	
3: measurement	0.0		0.0		0.0	
4: selecting instrument	0.0		0.0		0.0	
5: calibration markings of instrument	0.0		0.0		0.0	
SCIENTIFIC INQUIRY II: seeking a problem and ways to solve it	0.0		0.0		0.0	
1: recognition of problem	0.0		0.0		0.0	
2: formulation of hypothesis	0.0		0.0		0.0	
3: choosing a series of experiments	0.0		0.0		0.0	
4: design of procedure	0.0		0.0		0.0	
SCIENTIFIC INQUIRY III: interpreting data and generalization	0.0		0.0		0.0	
1: processing data	0.0		0.0		0.0	
2: making functional relationship	0.0		0.0		0.0	
3: interpretation of data	0.0		0.0		0.0	
4: extrapolation and interpolation	0.0		0.0		0.0	
5: evaluation of a hypothesis by data	0.0		0.0		0.0	
6: generalization	0.0		0.0		0.0	
SCIENTIFIC INQUIRY IV: theoretical model	0.0		0.0		0.0	
1: recognition of the need of a model	0.0		0.0		0.0	
2: formulation of a theoretical model	0.0		0.0		0.0	

Table 18 (cont'd.).

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
3: specification of phenomena explained by a model	0.0		0.0		0.0	
4: deduction of new hypothesis from a theoretical model	0.0		0.0		0.0	
5: interpretation and evaluation of the results of experiments to test a theoretical model	0.0		0.0		0.0	
6: revision and extension of a theoretical model	0.0		0.0		0.0	
APPLICATION	23.3	46.6	28.5	56.9	31.5	63.0
1: in the same field	23.3	46.6	28.5	56.9	31.5	63.0
2: in the different field of science	0.0		0.0		0.0	
3: outside of science	0.0		0.0		0.0	
MANUAL SKILLS	0.0		0.0		0.0	
1: development of skills in using equipment	0.0		0.0		0.0	
2: common laboratory performance	0.0		0.0		0.0	
ATTITUDES AND INTERESTS	0.0		0.0		1.3	2.6
1: favorite attitude toward science	0.0		0.0		0.0	
2: acceptance of scientific inquiry	0.0		0.0		0.0	
3: adoption of scientific attitude	0.0		0.0		0.0	
4: enjoyment of scientific learning	0.0		0.0		.5	1.0
5: development of interest in science	0.0		0.0		.8	1.6
6: development of vocational interests	0.0		0.0		0.0	
ORIENTATION	0.0		0.0		1.9	3.8
1: relationships among various scientific statements	0.0		0.0		0.0	
2: influence of science on philosophy	0.0		0.0		0.0	
3: to the evolutionary character	0.0		0.0		0.0	
4: relationship among scientific progress, technical achievement, and economic development	0.0		0.0		.8	1.6
5: social and moral implications	0.0		0.0		1.1	2.2
Total	50.0	100.0	50.1	100.1	50.0	100.0

Table 19. Educational Objectives in Laboratory Questions

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
KNOWLEDGE AND COMPREHENSION	7.5	15.0	23.4	46.8	20.0	40.3
1: facts	1.4	2.8	0.0		4.0	8.1
2: terminology	1.4	2.8	0.0		.6	1.2
3: concept	1.4	2.8	0.0		0.0	
4: convention	0.0		2.5	5.0	3.2	6.5
5: trend and sequence	0.0		0.0		0.0	
6: classification, categories, criteria	0.0		4.2	8.4	0.0	
7: technique, procedures	3.3	6.6	12.5	25.0	0.0	
8: principle or law	0.0		2.8	5.6	7.7	15.5
9: theory or conceptual schemes	0.0		1.4	2.8	3.0	6.0
10: demonstration in a new context	0.0		0.0		0.0	
11: translation to other symbolic forms	0.0		0.0		1.5	3.0
SCIENTIFIC INQUIRY I: observing and measuring	0.0		5.8	11.6	3.7	7.5
1: observing	0.0		0.0		3.1	6.3
2: description of observation	0.0		0.0		.6	1.2
3: measurement	0.0		3.0	6.0	0.0	
4: selecting instrument	0.0		.7	1.4	0.0	
5: calibration markings of instrument	0.0		2.1	4.2	0.0	
SCIENTIFIC INQUIRY II: seeking a problem and ways to solve it	0.0		0.0		.6	1.2
1: recognition of problem	0.0		0.0		0.0	
2: formulation of hypothesis	0.0		0.0		.3	.6
3: choosing a series of experiments	0.0		0.0		.3	.6
4: design of procedure	0.0		0.0		0.0	
SCIENTIFIC INQUIRY III: interpreting data and generalization	1.4	2.8	5.0	10.0	14.0	28.2
1: processing data	0.0		0.0		5.0	10.1
2: making functional relationship	0.0		0.0		2.3	4.6
3: interpretation of data	0.0		5.0	10.0	4.4	8.9
4: extrapolation and interpolation	1.4	2.8	0.0		.3	.6
5: evaluation of a hypothesis by data	0.0		0.0		1.0	2.0
6: generalization	0.0		0.0		1.0	2.0
SCIENTIFIC INQUIRY IV: theoretical model	0.0		0.0		0.0	
1: recognition of the need of a model	0.0		0.0		0.0	
2: formulation of a theoretical model	0.0		0.0		0.0	

Table 19 (cont'd.).

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
3: specification of phenomena explained by a model	0.0		0.0		0.0	
4: deduction of new hypothesis from a theoretical model	0.0		0.0		0.0	
5: interpretation and evaluation of the results of experiments to test a theoretical model	0.0		0.0		0.0	
6: revision and extension of a theoretical model	0.0		0.0		0.0	
APPLICATION	38.1	76.4	15.8	31.6	11.3	22.8
1: in the same field	38.1	76.4	15.8	31.6	11.3	22.8
2: in the different field of science	0.0		0.0		0.0	
3: outside of science	0.0		0.0		0.0	
MANUAL SKILLS	0.0		0.0		0.0	
1: development of skills in using equipment	0.0		0.0		0.0	
2: common laboratory performance	0.0		0.0		0.0	
ATTITUDES AND INTERESTS	2.9	5.8	0.0		0.0	
1: favorite attitude toward science	0.0		0.0		0.0	
2: acceptance of scientific inquiry	2.9	5.8	0.0		0.0	
3: adoption of scientific attitude	0.0		0.0		0.0	
4: enjoyment of scientific learning	0.0		0.0		0.0	
5: development of interest in science	0.0		0.0		0.0	
6: development of vocational interests	0.0		0.0		0.0	
ORIENTATION	0.0		0.0		0.0	
1: relationships among various scientific statements	0.0		0.0		0.0	
2: influence of science on philosophy	0.0		0.0		0.0	
3: to the evolutionary character	0.0		0.0		0.0	
4: relationship among scientific progress, technical achievement, and economic development	0.0		0.0		0.0	
5: social and moral implications	0.0		0.0		0.0	
Total	49.9	100.0	50.0	100.0	*49.6	100.0

*During the frequency counting, 1/3 (.3333...) was counted as .3. So .03333... was deleted by the round-off rule and in this case, .4 was losted. Therefore the total is 49.6 instead of 50.0.

learn a lot of manual skills. The manual skills can be evaluated. An evaluation of manual skills was attempted in a British nationwide examination for high school graduates who were planning to go college.

In the tests, as shown in Table 20, more knowledge and comprehension in the regular class in School S was asked than in the advanced placement class or in School D. More application in the advanced class in School S was asked than in the regular class in School S or in School D. Two percent of the manual skills appeared in the regular class in School S. No scientific inquiries were asked in any of three programs. No attitudes and interests objectives were evaluated in any of the three programs. The large portion of convention knowledge and comprehension was asked in the regular in School S and in School D. In School D, 3.4 percent of the relationship of science, society, economics, and technology objectives were counted.

Educational objectives of the evaluation methods were evaluated with the use of worksheets, textbook problems, laboratory questions, and tests. Knowledge and comprehension objectives (A) were also mostly emphasized as the analysis of 40 class observations. All in all, as shown in Figure 24 (The exact figures will be shown in Table 27 of Chapter 6), educational objectives in the evaluation methods of the three programs were emphasized in the following order: knowledge and comprehension objectives (A), 39.5 percent to 48.0 percent; application (F), 43.7 percent to 45.4 percent; scientific inquiry III: interpreting data and generalization (D), 2.2 percent to 7.0 percent; attitudes and interests (H), 1.2 percent to 5.0 percent; orientation to other areas (I), 0.0 percent to 6.4 percent; scientific inquiry II: seeking a problem and ways to solve it (C), 0.0 percent to .5 percent; scientific inquiry IV: theoretical model (E), 0.0 percent to .5 percent; and manual skills (G), 0.0 percent to .5 percent. The objectives A and F were emphasized

Table 20. Educational Objectives in Tests

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
KNOWLEDGE AND COMPREHENSION	36.0	72.0	20.7	41.4	29.4	58.7
1: facts	4.0	8.0	4.7	9.4	5.1	10.2
2: terminology	5.0	10.0	3.7	7.4	1.1	2.2
3: concept	3.0	6.0	.6	1.2	.6	1.2
4: convention	14.0	28.0	3.4	6.8	9.3	18.6
5: trend and sequence	0.0		0.0		6.5	13.0
6: classification, categories, criteria	6.0	12.0	0.0		3.2	6.4
7: technique, procedures	0.0		2.1	4.2	0.0	
8: principle or law	0.0		3.3	6.6	3.6	7.2
9: theory or conceptual schemes	4.0	8.0	2.9	5.8	0.0	
10: demonstration in a new context	0.0		0.0		0.0	
11: translation to other symbolic forms	0.0		0.0		0.0	
SCIENTIFIC INQUIRY I: observing and measuring	0.0		0.0		0.0	
1: observing	0.0		0.0		0.0	
2: description of observation	0.0		0.0		0.0	
3: measurement	0.0		0.0		0.0	
4: selecting instrument	0.0		0.0		0.0	
5: calibration markings of instrument	0.0		0.0		0.0	
SCIENTIFIC INQUIRY II: seeking a problem and ways to solve it	0.0		0.0		0.0	
1: recognition of problem	0.0		0.0		0.0	
2: formulation of hypothesis	0.0		0.0		0.0	
3: choosing a series of experiments	0.0		0.0		0.0	
4: design of procedure	0.0		0.0		0.0	
SCIENTIFIC INQUIRY III: interpreting data and generalization	0.0		0.0		0.0	
1: processing data	0.0		0.0		0.0	
2: making functional relationship	0.0		0.0		0.0	
3: interpretation of data	0.0		0.0		0.0	
4: extrapolation and interpolation	0.0		0.0		0.0	
5: evaluation of a hypothesis by data	0.0		0.0		0.0	
6: generalization	0.0		0.0		0.0	
SCIENTIFIC INQUIRY IV: theoretical model	0.0		0.0		0.0	
1: recognition of the need of a model	0.0		0.0		0.0	
2: formulation of a theoretical model	0.0		0.0		0.0	

Table 20 (cont'd.).

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational Objective	frequency	%	frequency	%	frequency	%
3: specification of phenomena explained by a model	0.0		0.0		0.0	
4: deduction of new hypothesis from a theoretical model	0.0		0.0		0.0	
5: interpretation and evaluation of the results of experiments to test a theoretical model	0.0		0.0		0.0	
6: revision and extension of a theoretical model	0.0		0.0		0.0	
APPLICATION	13.0	26.0	29.3	59.6	19.0	37.9
1: in the same field	13.0	26.0	29.3	59.6	19.0	37.9
2: in the different field of science	0.0		0.0		0.0	
3: outside of science	0.0		0.0		0.0	
MANUAL SKILLS	1.0	2.0	0.0		0.0	
1: development of skills in using equipment	1.0	2.0	0.0		0.0	
2: common laboratory performance	0.0		0.0		0.0	
ATTITUDES AND INTERESTS	0.0		0.0		0.0	
1: favorite attitude toward science	0.0		0.0		0.0	
2: acceptance of scientific inquiry	0.0		0.0		0.0	
3: adoption of scientific attitude	0.0		0.0		0.0	
4: enjoyment of scientific learning	0.0		0.0		0.0	
5: development of interest in science	0.0		0.0		0.0	
6: development of vocational interests	0.0		0.0		0.0	
ORIENTATION	0.0		0.0		1.7	3.4
1: relationships among various scientific statements	0.0		0.0		0.0	
2: influence of science on philosophy	0.0		0.0		0.0	
3: to the evolutionary character	0.0		0.0		0.0	
4: relationship among scientific progress, technical achievement, and economic development	0.0		0.0		.6	1.2
5: social and moral implications	0.0		0.0		1.1	2.2
Total	50.0	100.0	50.0	100.0	50.1	100.0

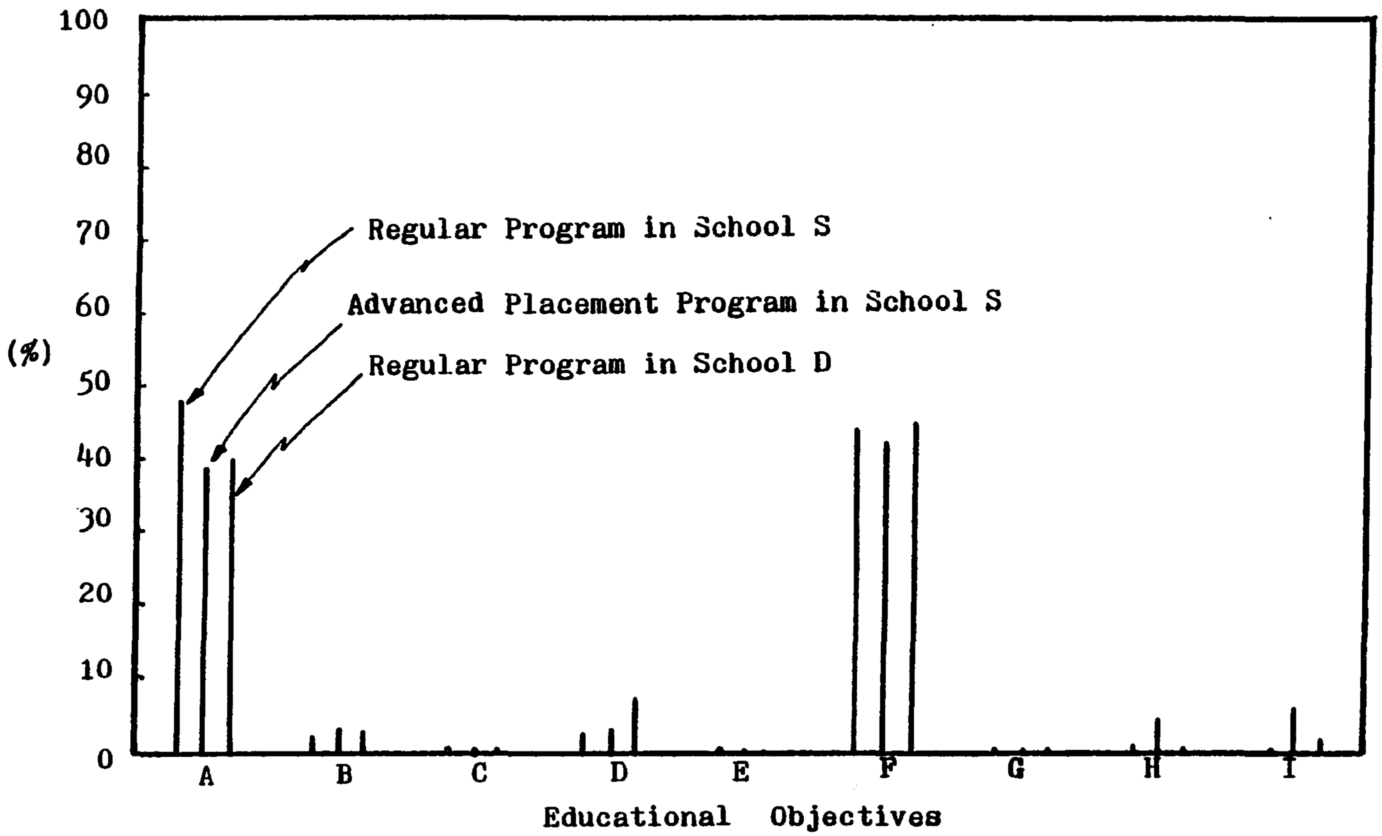

Figure 24. Educational Objectives in the Evaluation Methods

mostly in all three programs. The objectives D, H, and I appeared quite a bit; however the objectives C, E, and G rarely appeared. As shown in Figure 24, the regular program in School S emphasized the objective A; the advanced placement program in School D emphasized the objectives H and I; and the regular program in School D emphasized the objective D more than the others.

Educational objectives were emphasized differently in the instructions and evaluation methods. (The differences will be shown in Table 27 of Chapter 6.) Instructions include lecture, problem solving, student experiment, and other classes; and evaluation methods include worksheets, textbook problems, laboratory questions, and tests. Knowledge and comprehension objectives (A) were more emphasized in instruction (46.3 percent to 60.2 percent) than in evaluation methods (40.4 percent to 48.0 percent). Scientific inquiry I objectives (B) and manual skill objectives (G) were 19.4 percent to 35.3 percent in instruction but 2.5 percent to 2.9 percent in evaluation methods. Objectives B and G appeared together in student experiment classes. Objectives B and G were instructed but were not as extensively evaluated. Application objectives (F) were emphasized more in evaluation methods (43.7 percent to 45.4 percent) than in instruction (3.2 percent to 16.1 percent). In all three programs, there were discrepancies in instruction and evaluation in terms of emphasis of educational objectives.

5.2. High school Chemistry Topics and Teaching Methods.

This section includes the analysis of topic and the analysis of teaching method, mainly in terms of teaching hours. For the analysis, data were collected from yearly teacher plannings. The total teaching hours in the 1983-1984 school year were 155.4 hours in the regular class in School S, 154 hours in the advanced placement class in School S, and 162.8 hours in School D. Tables 21, 22, and 23-1 to 23-15 are for the analysis of topics and teaching methods.

5.2.1. The Analysis of Topics

The analysis of topics used Klopfer's content categories, which were ten chemistry content categories and five general content categories. Chemical materials topic category, as shown in Table 21, included density of liquid, qualitative analysis, heterogeneous system, and industrial process. Industrial process was not taught in any of the three programs. The advanced placement class in School S taught qualitative analysis for 23.5 hours. The regular class in School S also taught qualitative analysis. School D did not teach the chemical materials topic category itself.

The classification of the chemical elements topic category included mainly periodic table, metal, and nonmetal. The advanced placement class in School S did not include this topic category because students in the advanced placement class had already learned it.

Chemical law topic category was taught 26 percent in School D, 23.9 percent in the regular class in School S, and 15.3 percent in the advanced placement class. Energy relationships and equilibrium in chemical systems topic categories included thermodynamics, reaction rate, acid, and base, which were taught in a large portion in the three programs (24.7 percent to 31.6 percent). Electrochemistry included Faraday's Law and potentials, which were taught in a small portion (3.6 percent to 4.8 percent). Al three programs also included small portions of the nuclear chemistry topic category (.6 percent to 1.9 percent). All three programs did not teach these topics, such as the chemistry of life processes and the biographies of scientists. The introductory organic chemistry was taught just in the advanced placement program in School S.

Table 21. Topics Categories in The Three Programs

Schools and Programs	School S, Regular Chemistry		School S, AP Chemistry		School D, Regular Chemistry	
Topic Categories	Hours	%	Hours	%	Hours	%
Chemical Materials: density of liquid, qualitative analysis heterogeneous system, industrial process	8.0	5.1	23.5	15.3	0.0	
Classification of Chemical Element: periodic table, metal and nonmetal	9.6	6.2	0.0		6.6	4.0
Chemical change: chemical and physical change	5.5	3.5	12	7.8	2	1.2
Chemical Laws: basic chemical laws, concepts of mole, and molecular and empirical formula	37.2	23.9	23.6	15.3	42.4	26.0
Energy Relationships and Equilibrium in Chemical Systems: acid and base thermodynamics, reaction rate	40.3	25.9	38.0	24.7	51.5	31.6
Electrochemistry: Faraday's law	7.0	4.5	7.4	4.8	5.8	3.6
Atomic and Molecular Structure: chemical bond, nomenclature	32.3	20.8	26.0	16.9	42.2	25.8
Introductory Organic Chemistry	0.0		12.4	8.1	0.0	
Chemistry of *Life* Processes	0.0		0.0		0.0	
Nuclear Chemistry	1.0	.6	3.0	1.9	2.8	1.7
Historical Development: theory of light, facts and value judgement	1.0	.6	1.1	.7	2.0	.7
Nature and Structure of Science	0.0		0.0		1.0	.6
Nature of Scientific Inquiry: develop a problem	2.0	1.3	0.0		6.5	4.0
Biographies of Scientists	0.0		0.0		0.0	
Measurement: scientific notation, significant figures, accuracy and precision	11.5	7.4	7.0	4.5	0.0	
Total	155.4	99.8	154.0	100.0	162.8	99.9

General topic categories were rarely taught in the three programs. Historical development topic category was taught in all of the three programs. Measurement topic category was emphasized in the regular and advanced pacement classes in School S but not taught in School D.

5.2.2. The Analysis of Teaching Methods.

Teaching methods shown in the teacher plannings were classified in the 7 categories: lecture, student experiment, film-slide showing, problem solving, field trips or guest speaker, test, and review. The analysis of teaching methods was done in terms of teaching hours and the percentage of the teaching hours of the total teaching hours.

In each one-year program, as shown in Table 22, lecture method was used 44.0 percent of the total instruction time in School D; 39.8 percent, in the regular program in School S; and 29.2 percent, in the advanced placement program in School S. Student experiments in the advanced placement program were performed individually. Students experiments in the regular class in School S were done individually or together with one or two laboratory partners --two to three students became one laboratory group. In School D, most students performed experiments with laboratory partners. Once again, laboratory groups consisted of two to three students. In the advanced placement program, student experiment took up 31.2 percent of the total class time; in the regular program of School S, 20.9 percent; and in School D, 15.0 percent.

Problem solving method was used in about 16 percent to 18 percent of the yearly teaching hours in the three programs. Film-slide showing, and field trips or guest speaker methods were used rarely in all of the three programs. About 21 percent of one-year teaching hours were spent for test and review sessions. Film-slide showing was used for half or one class period. Guest speakers were invited once a year in all of three

Table 22. Teaching Method Categories in The Three Programs

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	61.8	39.8	45.0	29.2	71.6	44.0
Student Experiment	32.5	20.9	48.0	31.2	24.5	15.0
Film-Slide Showing	.5	.3	.5	.3	1.0	.6
Problem Solving	26.0	16.7	27.1	17.6	30.3	18.6
Field Trip or Guest Speaker	1.0	.6	1.0	.6	1.0	.6
Test	23.0	14.8	19.0	12.3	22.9	14.1
Review	10.6	6.8	13.4	8.7	11.5	7.1
Total	155.4	99.9	154.0	99.9	162.8	100.0

programs. The field trip method was not planned due to a lack of financial support. Generally both schools gave tests after finishing each chapter, and at the end of semesters and school years. Tests took 12.3 percent to 22.9 percent of the whole teaching hours; review session for preparing the students for the examination took 6.8 percent to 8.7 percent of the total teaching hours. The lecture teaching method was a more popular method in the regular classes in Schools S and D than in the advanced placement class in School S. Student experiment teaching method was used in the advanced placement program as much as 48.0 percent of the total class hours, which was a larger portion than than any single method, including the student experiment method used in the two regular programs in Schools S and D. The analysis of teaching methods performed, which was extended further in the next section.

5.2.3. Teaching Methods with respect to each Topic Category.

Teaching methods were analyzed with respect to Klopfer's 10 chemistry topic categories and five general topic categories, which were tabulated in Tables 23-1 to 23-15. In the chemical material topic category, as shown in Table 23-1, qualitative analysis was taught in two programs in School S, where both film-slide showing and student experiment methods were used. In the advanced placement program in School S, 17 hours of student experiment method were used for the qualitative analysis.

In the classification of chemical elements topic category, as shown in Table 23-2, the regular program in School S included experiments on making a periodic table. However, School D did not have any experiment class in this topic category, and the advanced placement program did not even include the category.

Table 23-1. Teaching Methods of Chemical Materials

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	2.0	25.0	1.0	4.3	0.0	
Student Experiment	3.0	37.5	17.0	72.3	0.0	
Film-Slide Showing	.5	6.3	.5	2.1	0.0	
Problem Solving	0.0		2.0	8.5	0.0	
Field Trip or Guest Speaker	0.0		0.0		0.0	
Test	1.6	20.0	2.0	8.5	0.0	
Review	.9	11.3	1.0	4.3	0.0	
Total	8.0	100.1	23.5	100.0	0.0	

Table 23-2. Teaching Methods of Classification of Chemical Element

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	5.3	55.8	0.0		3.0	45.5
Student Experiment	2.0	21.1	0.0		0.0	
Film-Slide Showing	0.0		0.0		0.0	
Problem Solving	0.0		0.0		1.0	15.2
Field Trip or Guest Speaker	0.0		0.0		0.0	
Test	1.5	15.8	0.0		1.6	24.2
Review	.7	7.4	0.0		1.0	15.2
Total	9.5	100.1	0.0		6.6	100.1

In the chemical change topic category, teaching methods were tabulated in Table 23-3. To teach the chemical law topic category, as shown in Table 23-4, the three programs mostly used lecture, student experiment, and problem solving methods. To teach energy relationships and equilibrium in the chemical system topic category, as shown in Table 23-5, the three programs used more lecture method than student experiment method. For teaching the electrochemistry topic category, as shown in Table 23-6, the advanced placement program in School S and in School D used the student experiment method: the regular program in School S did not.

For teaching atomic and molecular structure, as shown in Table 23-7, the two regular programs used the lecture method 52.0 percent to 60.0 percent of the time. The two programs in School S included more experiment classes than in School D. The advanced placement program spent 17.3 percent of its time on the review method for this category. Students in the advanced placement program had learned this category before. However, due to its importance as a basic theory of modern chemistry, they reviewed this category for 4.5 hours.

Introductory organic chemistry, as shown in Table 23-8, was taught only in the advanced placement program of School S. The two regular programs did not include this category. In the advanced placement program, five hours of experiments and 3.5 hours of lectures were included.

The chemistry of life processes was not taught in any of the three programs as shown in Table 23-9, because the category was thought to overlap with with biology and the human body. To teach the nuclear chemistry topic category, as shown in Table 23-10, School S invited a guest lecturer from a nuclear pollution research area. Two or three hours were spent on this category in the advanced placement program in School S

Table 23-3. Teaching Methods of Chemical Change

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	1.0	18.5	2.0	16.7	0.0	
Student Experiment	2.0	37.0	2.0	16.7	2.0	100.0
Film-Slide Showing	0.0		0.0		0.0	
Problem Solving	0.0		6.0	50.0	0.0	
Field Trip or Guest Speaker	0.0		0.0		0.0	
Test	1.5	27.8	2.0	16.7	0.0	
Review	.9	16.7	0.0		0.0	
Total	5.4	100.0	12.0	100.1	2.0	100.0

Table 23-4. Teaching Methods of Chemical Laws

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	13.0	34.5	8.5	33.2	16.5	38.9
Student Experiment	8.0	21.1	6.0	23.4	6.5	15.3
Film-Slide Showing	.5	1.3	0.0		0.0	
Problem Solving	10.0	26.5	6.5	25.4	8.5	20.0
Field Trip or Guest Speaker	0.0		0.0		0.0	
Test	3.3	8.8	2.9	11.3	6.5	15.3
Review	2.9	7.7	1.7	6.6	4.4	10.4
Total	37.7	100.0	25.6	99.9	42.4	99.9

Table 23-5. Teaching Methods of Energy and Chemical Equilibrium

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	17.0	39.7	17.0	44.7	17.5	34.0
Student Experiment	10.0	23.4	11.0	28.9	11.0	21.4
Film-Slide Showing	0.0		0.0		0.0	
Problem Solving	6.5	15.2	3.0	7.9	11.5	22.3
Field Trip or Guest Speaker	0.0		0.0		0.0	
Test	7.6	17.8	3.2	8.4	8.1	15.7
Review	1.7	4.0	3.8	10.0	3.4	6.6
Total	42.8	100.1	38.0	99.9	51.5	100.0

Table 23-6. Teaching Methods in Electrochemistry

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	3.0	42.9	2.0	27.0	4.0	69.0
Student Experiment	0.0		3.0	40.5	1.0	17.2
Film-Slide Showing	0.0		0.0		0.0	
Problem Solving	2.0	28.6	1.0	13.5	0.0	
Field Trip or Guest Speaker	0.0		0.0		0.0	
Test	1.0	14.3	1.1	14.9	.4	6.9
Review	1.0	14.3	.3	4.1	.4	6.9
Total	7.0	100.1	7.4	100.0	5.8	100.0

Table 23-7. Teaching Methods of Atomic and Molecular Structure

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	17.3	52.0	8.2	31.5	25.3	60.0
Student Experiment	5.5	16.5	4.0	15.4	2.0	4.7
Film-Slide Showing	0.0		0.0		0.0	
Problem Solving	4.0	12.0	4.8	18.5	6.8	16.1
Field Trip or Guest Speaker	0.0		0.0		1.0	2.4
Test	4.9	14.7	4.5	17.3	5.1	12.1
Review	1.6	4.8	4.5	17.3	2.0	4.7
Total	33.3	100.0	26.0	100.0	42.2	100.0

Table 23-8. Teaching Methods of Introductory Organic Chemistry

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	0.0		3.5	28.2	0.0	
Student Experiment	0.0		5.0	40.3	0.0	
Film-Slide Showing	0.0		0.0		0.0	
Problem Solving	0.0		.5	4.0	0.0	
Field Trip or Guest Speaker	0.0		0.0		0.0	
Test	0.0		2.1	16.9	0.0	
Review	0.0		1.3	10.5	0.0	
Total	0.0		12.4	99.9	0.0	

Table 23-9. Teaching Methods in Chemistry of Life Processes

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	0.0		0.0		0.0	
Student Experiment	0.0		0.0		0.0	
Film-Slide Showing	0.0		0.0		0.0	
Problem Solving	0.0		0.0		0.0	
Field Trip or Guest Speaker	0.0		0.0		0.0	
Test	0.0		0.0		0.0	
Review	0.0		0.0		0.0	
Total	0.0		0.0		0.0	

Table 23-10. Teaching Methods of Nuclear Chemistry

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	0.0		1.5	50.0	1.3	46.4
Student Experiment	0.0		0.0		0.0	
Film-Slide Showing	0.0		0.0		0.0	
Problem Solving	0.0		.5	16.7	1.0	35.7
Field Trip or Guest Speaker	1.0	100.0	1.0	33.3	0.0	
Test	0.0		0.0		.5	17.9
Review	0.0		0.0		0.0	
Total	1.0	100.0	3.0	100.0	2.8	100.0

and in School D.

In order to teach the historical development category, as shown in Table 23-11, School S spent one hour in each chemistry program, which was accomplished by using the lecture and problem solving method. In School D, two hours were spent on this category, which was done with the aid of lecture and film-slide showing method. In order to teach nature and structure of science, as shown in Table 23-12, School S did not spend any time; but School D spent two hours, which were comprised of the lecture and problem solving method.

In School D, 6.5 hours were spent to teach the nature of scientific inquiry (3.3), as shown in Table 23-13, which included two hours of student experiment, 2.5 hours of lecture and one hour of problem solving. The contents were "Why we believe an atom," "Construction of a logical model," and "Precipitation reaction." As shown in Table 23-14, no program taught the biographies of scientists category (3.4). To teach Measurement category, as shown in Table 23-15, the two programs in School S arranged 2.5 to 4.5 hours of lecture and 2.5 to 3.5 hours of problem solving periods. But School D did not teach any of the measurement category such as significant figures or scientific notation. The teaching method was analyzed in terms of teaching hours with respect to 10 chemistry and five general topic categories. The following methods were mostly used in the three programs: lecture, student experiment, and problem solving methods. The three methods were used over 77 percent of the time in the three programs: 77.4 percent in the regular class in School S, 78.0 percent in the advanced placement class in School S, and 77.6 percent in School D.

Table 23-11. Teaching Methods of Historical Development

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	1.0	100.0	.8	72.7	1.0	50.0
Student Experiment	0.0		0.0		0.0	
Film-Slide Showing	0.0		0.0		1.0	50.0
Problem Solving	0.0		.3	27.3	0.0	
Field Trip or Guest Speaker	0.0		0.0		0.0	
Test	0.0		0.0		0.0	
Review	0.0		0.0		0.0	
Total	1.0	100.0	1.1	100.0	2.0	100.0

Table 23-12. Teaching Methods of Nature and Structure of Science

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	0.0		0.0		.5	50.0
Student Experiment	0.0		0.0		0.0	
Film-Slide Showing	0.0		0.0		0.0	
Problem Solving	0.0		0.0		.5	50.0
Field Trip or Guest Speaker	0.0		0.0		0.0	
Test	0.0		0.0		0.0	
Review	0.0		0.0		0.0	
Total	0.0		0.0		1.0	100.0

Table 23-13. Teaching Methods of Nature of Scientific Inquiry

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	1.0	50.0	0.0		2.5	38.5
Student Experiment	1.0	50.0	0.0		2.0	30.8
Film-Slide Showing	0.0		0.0		0.0	
Problem Solving	0.0		0.0		1.0	15.4
Field Trip or Guest Speaker	0.0		0.0		0.0	
Test	0.0		0.0		.7	10.8
Review	0.0		0.0		.3	4.6
Total	2.0	100.0	0.0		6.5	100.1

Table 23-14. Teaching Methods of Biographies of Scientists

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	0.0		0.0		0.0	
Student Experiment	0.0		0.0		0.0	
Film-Slide Showing	0.0		0.0		0.0	
Problem Solving	0.0		0.0		0.0	
Field Trip or Guest Speaker	0.0		0.0		0.0	
Test	0.0		0.0		0.0	
Review	0.0		0.0		0.0	
Total	0.0		0.0		0.0	

Table 23-15. Teaching Methods of Measurement

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Teaching Method Categories	Hours	%	Hours	%	Hours	%
Lecture	4.5	39.1	2.5	35.7	0.0	
Student Experiment	1.0	8.7	0.0		0.0	
Film-Slide Showing	0.0		0.0		0.0	
Problem Solving	3.5	30.4	2.5	35.7	0.0	
Field Trip or Guest Speaker	0.0		0.0		0.0	
Test	1.6	13.9	1.2	17.1	0.0	
Review	.9	7.8	.8	11.4	0.0	
Total	11.5	99.9	7.0	99.9	0.0	

5.3. Student Interest

This section includes descriptions of positive and negative student interest phenomena, student interest with respect to teaching methods, and student interest with respect to educational objectives. Generally students liked student experiment class more than lecture, and problem solving class in all three programs.

5.3.1. Description of Student Interest Points

Description of student interest was included in Chapter 3 as a data collection category. During the data collection period, more phenomena about student interest had been found. The positive student interest was due to the following facts:

(1) Students had tasks to do in a given time. In lecture classes, writing and listening were their tasks, whereas in student experiment class, their tasks were mixing chemicals, observing the reactions, describing them and washing glasswares.

(2) Instruction was about the contents which students did not know and that were new to students.

(3) Students participated in instruction by asking several questions to get an understanding of the teaching contents.

(4) All students watched the teacher and listened carefully in lecture class.

(5) The contents of instruction included the mentioning of the environmental materials used by the students themselves, such as gasoline, perfume, salt or pepper.... .

(6) All students prepared their experiments by carefully washing the test tubes.

(7) If there were challenging things such as writing reports and turning in them at the

end of the class period or finishing experiments and finding specified results (color, distance, ...) in the given period, then students did their tasks and discussed the topics with each other.

(8) Most students took part in experiments.

Secondly, the negative student interest conditions are:

(1) Several students yawned.

(2) The contents of instruction were already known by the students.

(3) Some students finished their tasks faster than the allotted time, and then had nothing to do for remainder of class.

(4) Students chatted with the other students or teachers.

Student interest phenomena were found during classroom observation as obvious behavior. So the obvious phenomena were assigned as positive or negative student interest. For example, a student in School D was dropping a solution on a piece of glass with a medicine dropper and her partner was going to write her description of observation, as shown in Figure 22 of Chapter 4 of this dissertation. They participated in the experiments eagerly. In this case, student interest is 100 percent. Student interest can also be studied in terms of the number of student questions, and aspects of their questions: such as who raised the question and to whom the question was raised. For example, students ask questions to teachers or other students. Another direction of questioning is for teachers to ask questions of one or a group of students.

5.3.2. Student Interest with respect to Teaching Methods

Student interest was indicated in a form of percentage of student interest, which was calculated by dividing student interest points by the number of five minute periods during which certain teaching methods were used. Student interest was studied with respect to six types of teaching methods, such as the lecture, problem solving and socratic method; the lecture and socratic method; the demonstration method; the student experiment, discussion and socratic method; the film-slide showing method; the field trips or guest speaker method.

Chemistry students in both schools showed over 50 percent student interest on the average. As shown in Table 24, the average student interest was 69.4 percent in the regular program in School S, 54.2 percent in the advanced placement program in School S and 65.3 percent in School D. However, the demonstration method received 100 percent of student interest in all of the three programs. The student experiment classes were more interesting to students than the lecture, problem solving, and socratic method classes. The demonstration, the film-slide showing, and the field trips or guest speaker teaching methods were used in short time period, just 10 minute to 115 minutes in the three programs. Most of the classes were instructed by three types of teaching methods, which were: the lecture, problem solving, and socratic method; the lecture and socratic method; and the student experiment, discussion, and socratic method.

Counting only the three popular types of teaching method, the averages of student interest were 49.0 percent in the regular chemistry program in School S; 57.0 percent in the advanced placement chemistry program in School S; and 59.1 percent in the regular program in School D. The regular program in School D showed the highest student interest among the three popular types of teaching method. The regular chemistry class

Table 24. Student Interest with respect to Different Teaching Methods

Schools and Programs	School S, Regular Chemistry			School S, Advanced Placement Chemistry			School D, Regular Chemistry		
Teaching methods	5 min. periods	S.I.* point	% of S.I.	5 min. period	S.I. point	% of S.I.	5 min. period	S.I. point	% of S.I.
Lecture, Problem Solving, and Socratic Method	30.0	10.0	33.3	39.0	16.0	41.0	39.0	20.0	51.3
Lecture, and Socratic Method	27.0	16.0	59.3	10.0	5.0	50.0	27.0	18.0	66.7
Demonstration	1.0	1.0	100.0	1.0	1.0	100.0	5.0	5.0	100.0
Student Experiment, Discussion, Socratic Method	57.0	31.0	54.4	30.0	24.0	80.0	35.0	19.0	59.3
Film-slide Showing	1.0	1.0	100.0	3.0	0.0	0.0	8.0	5.0	62.5
Field Trip, Guest Speaker	0.0			0.0			10.0	5.0	50.0
Total	116.0	59.0		83.0	46.0		124.0	72.0	

*"S.I." means "student interest."

in School D showed the highest student interest in the lecture, problem solving and socratic method, and the lecture and socratic method.

The advanced placement chemistry class showed higher student interest than the regular class in School S. Especially in student experiment teaching method, where the advanced placement chemistry students showed 80.0 percent student interest. The number of students in the class was 15 and students in the class chose the course among various elective courses. Those students who attended in the advanced placement chemistry class were chemistry oriented students among 222 students in twelfth grade.

During the class of film-slide showing, the advanced placement chemistry students showed normal (0.0 percent) student interest. The film showed in School S included qualitative analysis techniques such as washing precipitate, which had already been used in student experiment class periods. The film did not include new information. But if the film included some new information, then it got more attention from student. In the regular class in School S, student interest was 100 percent. In the regular class in School D, 62.5 percent student interest was shown.

Students and teachers had different opinions about student interest with respect to teaching methods. As a result of teacher interviews on student interest, the teachers in both schools said that the combination of teaching methods was ideal. The teacher in School D gave an example of an ideal combination of teaching methods: two days of lecture, one day of student experiment, one day of problem solving, and one day of test or review in each week. He also said that he tried to follow the ideal combination of teaching method. If five days of lecture or five days of student experiment was performed each week, he said students would be bored. It was found that students liked experiment class more than lecture class, and they liked demonstration class more than lecture class as a result of interviewing six students, two from each program. One student interviewed said that she liked experiment class more than lecture class, but she also liked lecture class. The reasons for the students' preference of experiment class were: (1) that a student could see the change of color or precipitation phenomena as evidences of chemical reaction, and (2) that a student could experience chemical reactions and chemistry, which helped a student learn more and remember better. In this section student interest was analyzed with respect to teaching methods, and student interest will be analyzed in the next section with respect to educational objectives.

5.3.3. Student Interest with respect to Educational Objective

Average student interest is shown in Table 25 with respect to educational objective. Both scientific inquiry II objectives, and attitudes and interests objectives achieved 100 percent student interest in the regular program in School S. Scientific inquiry I objectives, and manual skill objectives got high student interest in the advanced placement program: the former 79.6 percent, and the latter 85.5 percent. School D also got 76.8 percent student interest in both scientific inquiry I objectives. But the regular program in School S got relatively less student interest in scientific inquiry I objectives, and manual skill objectives. Student interest was analyzed further with respect to different groups of teaching methods. The results are tabulated in Tables 26-1 to 26-6.

In the lecture, problem solving, and socratic method classes, student interest was less than average, as shown in Table 26-1, except observing and measuring objectives in School D, and attitudes and interest objectives in the two regular programs

In the lecture and socratic method classes, as shown in Table 26-2, knowledge and comprehension objectives got higher student interest (50 percent to 61 percent) than

Table 25. Student Interest with respect to Different Educational Objectives

Schools and Programs	School S, Regular Chemistry			School S, Advanced Placement Chemistry			School D, Regular Chemistry		
Educational objectives	5 min. period	S.I.* point	% of S.I.	5 min. period	S.I. point	% of S.I.	5 min. period	S.I. point	% of S.I.
Knowledge and Comprehension: all levels of knowledge	69.7	34.8	49.9	38.3	15.8	41.3	70.9	37.7	53.2
Scientific Inquiry I: observing, measuring and selecting equipments	15.1	7.4	49.0	14.7	11.7	79.6	13.8	10.6	76.8
Scientific Inquiry II: problems, hypothesis and ways to solve them	1.6	1.6	100.0	0.0			1.0	.2	20.0
Scientific Inquiry III: interpreting data and generalization	4.9	1.5	28.8	0.0			2.0	1.2	60.0
Scientific Inquiry IV: building and revising theoretical model	0.0			0.0			0.0		
Application: in the field of science or outside of science	5.5	2.3	41.8	13.3	6.0	45.1	4.0	-.5	-12.5
Manual skills: skills in using equipments and laboratory performance	17.9	10.8	60.3	14.5	12.4	85.5	10.1	7.0	69.3
Attitudes and Interests: enjoyment and vocational interests in science	1.0	1.0	100.0	1.9	.4	21.1	18.0	13.2	73.3
Orientation: to technology, economics, society and morality	0.0			0.0			3.5	2.5	71.4
Total	115.7	59.4		82.7	46.3		123.3	71.9	

*"S.I." means "student interest."

Table 26-1. Student Interest in Lecture, Problem Solving, and Socratic Method

Schools and Programs	School S, Regular Chemistry			School S, Advanced Placement Chemistry			School D, Regular Chemistry		
Educational Objectives	5 min. period	S.I.* point	% of S.I.	5 min. period	S.I. point	% of S.I.	5 min. period	S.I. point	% of S.I.
Knowledge and Comprehension: all levels of knowledge	26.5	8.0	30.2	24.0	10.0	41.7	32.5	18.1	55.7
Scientific Inquiry I: observing, measuring and selecting instrument	0.0			0.0			.3	.3	100.0
Scientific Inquiry II: problems, hypothesis, and ways to solve them	0.0			0.0			0.0		
Scientific Inquiry III: interpreting data and generalization	0.0			0.0			0.0		
Scientific Inquiry IV: building and *revising* theoretical model	0.0			0.0			0.0		
Application: in the field of science or outside of science	2.5	1.0	40.0	13.3	6.0	45.1	4.0	-.5	-12.5
Manual skills: skills in using equipment and laboratory performance	0.0			0.0			0.0		
Attitudes and Interests: enjoyment and vocational interests in science	1.0	1.0	100.0	1.5	0.0	0.0	1.9	1.9	100.0
Orientation: to technology, economics, society and morality	0.0			0.0			0.0		
Total	30.0	10.0		38.8	16.0		38.7	19.8	

*"S.I." means "student interest."

Table 26-2. Student Interest in Lecture and Socratic Method Classes

Schools and Programs	School S, Regular Chemistry			School S, Advanced Placement Chemistry			School D, Regular Chemistry		
Educational objectives	5 min. period	S.I.* point	% of S.I.	5 min. period	S.I. point	% of S.I.	5 min. period	S.I. point	% of S.I.
Knowledge and Comprehension: all levels of knowledge	25.9	15.0	57.9	10.0	5.0	50.0	23.5	14.5	61.7
Scientific Inquiry I: observing, measuring and selecting instrument	0.0			0.0			0.0		
Scientific Inquiry II: problems, hypothesis and ways to solve them	0.0			0.0			0.0		
Scientific Inquiry III: interpreting data and generalization	1.0	1.0	100.0	0.0			0.0		
Scientific Inquiry IV: building and revising theoretical model	0.0			0.0			0.0		
Application: in the field of science or outside of science	0.0			0.0			0.0		
Manual skills: skills in using equipments and laboratory performance	0.0			0.0			0.0		
Attitudes and Interests: enjoyment and vocational interests in science	0.0			0.0			2.5	2.5	100.0
Orientation: to technology, economics, society and morality	0.0			0.0			1.0	1.0	100.0
Total	26.9	16.0		10.0	5.0		27.0	18.0	

*"S.I. means "student interest."

average student interest (41 percent to 53 percent) and student interest in the lecture, problem solving, and socratic method (30 percent to 55 percent) in all three programs. In the regular program in School S, interpreting data and generalization objectives got 100 percent student interest. In the regular program in School D, attitudes and interests, and orientation objectives also got 100 percent student interest.

In the demonstration classes, as shown in Table 26-3, all educational objectives shown got 100 percent student interest. A teacher or a student demonstrated experiments and others watched them in demonstration classes. Students paid attention carefully in this type of instruction.

In the student experiment, discussion, and socratic method classes, as shown in Table 26-4, knowledge and comprehension objectives in the regular program in School S got 63.2 percent student interest, which was higher than average student interest-- 49.9 percent. Knowledge and comprehension objectives in advanced placement program and in School D got much less student interest than average. Interpreting data and generalization objectives in the regular program in School S got 100 percent student interest. Interpreting data and generalization objectives, and theoretical model objectives in School D got 20 percent student interest, which was low student interest generally. Theoretical model objectives in the regular program in School S got normal student interest--0.0 percent. Manual skill objectives got high student interest, 60.3 percent to 85.3 percent in the three programs.

In the film-slide showing classes, as shown in Table 26-5, knowledge and comprehension objectives got 100.0 percent student interest in the regular program in School S, but 0.0 percent in the advanced placement program in School S. Students in two programs in School S watched the same kind of film about qualitative analysis. But

Table 26-3. Student Interest in Demonstration Classes

Schools and Programs	School S, Regular Chemistry			School S, Advanced Placement Chemistry			School D, Regular Chemistry		
Educational objectives	5 min. period	S.I.* point	% of S.I.	5 min. period	S.I. point	% of S.I.	5 min. period	S.I. point	% of S.I.
Knowledge and Comprehension: all levels of knowledge	0.0			0.0			1.6	1.6	100.0
Scientific Inquiry I: observing, measuring and selecting equipments	.5	.5	100.0	.4	.4	100.0	1.3	1.3	100.0
Scientific Inquiry II: problems,hypothesis, and ways to solve them	0.0			0.0			0.0		
Scientific Inquiry III: interpreting data and generalization	.5	.5	100.0	0.0			1.0	1.0	100.0
Scientific Inquiry IV: building and revising theoretical model	0.0			0.0			0.0		
Application: in the field of science or outside of science	0.0			0.0			0.0		
Manual skills: skills in using equipments and laboratory performance	0.0			.2	.2	100.0	1.0	1.0	100.0
Attitudes and Interests: enjoyment and vocational interests in science	0.0			.4	.4	100.0	0.0		
Orientation: to technology, economics, society and morality	0.0			0.0			0.0		
Total	1.0	1.0		1.0	1.0		4.9	4.9	

*"S.I." means "student interest."

Table 26-4. Student Interest in Experiment, Discussion, and Socratic Method

Schools and Programs	School S, Regular Chemistry			School S, Advanced Placement Chemistry			School D, Regular Chemistry		
Educational Objectives	5 min. period	S.I.* point	% of S.I.	5 min. period	S.I. point	% of S.I.	5 min. period	S.I. pointed	% of S.I.
Knowledge and Comprehension: all levels of knowledge	16.3	10.3	63.2	1.3	.3	23.1	7.0	1.2	17.1
Scientific Inquiry I: observing, measuring and selecting equipments	14.6	6.9	47.3	14.3	11.3	79.0	12.2	9.0	73.8
Scientific Inquiry II: problems, hypothesis, and ways to solve them	1.6	1.6	100.0	0.0			1.0	.2	20.0
Scientific Inquiry III: interpreting data and generalization	3.4	0.0		0.0			1.0	.2	20.0
Scientific Inquiry IV: building and revising theoretical model	0.0			0.0			0.0		
Application: in the field of science, or outside of science	3.0	1.3	43.3	0.0			0.0		
Manual skills: skills in using equipments and laboratory performance	17.9	10.8	60.3	14.3	12.2	85.3	9.1	6.0	65.9
Attitudes and Interests: enjoyment and vocational interests in science	0.0			0.0			4.5	2.7	60.0
Orientation: to technology, economics, society and morality	0.0			0.0			0.0		
Total	56.8	30.9		29.9	23.8		34.8	19.3	

*"S.I." means "student interest."

Table 26-5. Student Interest in Film-Slide Showing Classes

Schools and Programs	School S, Regular Chemistry			School S, Advanced Placement Chemistry			School D, Regular Chemistry		
Educational Objectives	5 min. period	S.I.* point	% of S.I.	5 min. period	S.I. point	% of S.I.	5 min. period	S.I. point	% of S.I.
Knowledge and Comprehension: all levels of knowledge	1.0	1.0	100.0	3.0	0.0		0.0		
Scientific Inquiry I: observing, measuring and selecting equipments	0.0			0.0			0.0		
Scientific Inquiry II: problems, hypothesis and ways to solve them	0.0			0.0			0.0		
Scientific Inquiry III: interpreting data and generalization	0.0			0.0			0.0		
Scientific Inquiry IV: building and revising theoretical model	0.0			0.0			0.0		
Application: in the field of science or outside of science	0.0			0.0			0.0		
Manual skills: skills in using equipments and laboratory performance	0.0			0.0			0.0		
Attitudes and Interests: enjoyment and vocational interests in science	0.0			0.0			8.0	5.0	62.5
Orientation: to technology, economics, society and morality	0.0			0.0			0.0		
Total	1.0	1.0		3.0	0.0		8.0	5.0	62.5

*"S.I." means "student interest."

the condition of student knowledge was different and the student interest points were different. Students in the advanced placement program already knew the content of the films so they were not interested in watching those films. Accordingly, it got 0.0 percent student interest, which was still normal. In School D, attitudes and interests objectives got 62.5 percent student interest, which was generally high student interest.

In the field trips or guest speaker classes, as shown in Table 26-6, attitudes and interests objectives, and orientation objectives got high student interest in School D. Knowledge and comprehension objectives got less than average student interest in knowledge and comprehension objectives.

In this section, student interest analyzed in the three programs: the regular program in School S, the advanced placement program in School S, and the regular program in School D. As previously stated, students showed 100 percent student interest in demonstration classes in all three programs. Students liked the student experiment, discussion, and socratic method more than the lecture, problem solving, and socratic method in all three programs; the former was 54.4 percent and the latter was 33.3 percent in the regular program in School S; 80.0 percent, 41.0 percent in the advanced placement program in School S; and 59.3 percent, 51.3 percent in the regular program in School D. Students liked the lecture and socratic method more than the lecture, problem solving, and socratic method in all three programs; the former was 59.3 percent and the latter was 33.3 percent in the regular program in School S ; 50.0 percent, 41.0 percent in the advanced placement program in School S; and 66.7 percent, 51.3 percent in the regular program in School D.

Students liked knowledge and comprehension, scientific inquiry I, and manual skill objectives generally in all three programs. However, students showed different student

Table 26-6. Student Interest in Field Trip or Guest Speaker Classes

Schools and Programs	School S, Regular Chemistry			School S, Advanced Placement Chemistry			School D, Regular Chemistry		
Educational Objectives	5 min. period	S.I.* point	% of S.I.	5 min. period	S.I. point	% of S.I.	5 min. period	S.I. point	% of S.I.
Knowledge and Comprehension: all levels of knowledge	0.0			0.0			6.3	2.3	36.5
Scientific Inquiry I: observing, measuring and selecting equipments	0.0			0.0			0.0		
Scientific Inquiry II: problems, hypothesis and ways to solve them	0.0			0.0			0.0		
Scientific Inquiry III: interpreting data and generalization	0.0			0.0			0.0		
Scientific Inquiry IV: building and revising theoretical model	0.0			0.0			0.0		
Application: in the field of science, or outside of science	0.0			0.0			0.0		
Manual skills: skills in using equipments and laboratory performance	0.0			0.0			0.0		
Attitudes and Interests: enjoyment and vocational interests in science	0.0			0.0			1.1	1.1	100.0
Orientation: to technology, economics, society and morality	0.0			0.0			2.5	1.5	60.0
Total	0.0			0.0			10.0	4.9	

*"S.I." means "student interest."

interests in three programs such as in scientific inquiry II, III, application, and attitudes and interests objectives. In the scientific inquiry II, student interest was 100 percent in the regular program in School S; 20 percent in the regular program in School D. In the application objective, student interest was 41.8 percent in the regular program in School S; 45.1 percent in the advanced placement program in School S; and -12.5 percent in the regular program in School D.

5.4. Summary

In Chapter 5, data analyses were presented on educational objectives, chemistry topics, teaching methods, and student interest shown in the two high school chemistry programs. Educational objectives were instructed in the following order: knowledge and comprehension objectives (A), 46.3 percent to 68.2 percent; scientific inquiry I (B), 11.2 percent to 17.8 percent; manual skills (G), 8.2 percent to 17.5 percent; application (F), 3.2 percent to 16.1 percent; attitudes and interests (H), to 2.8 percent; and scientific inquiry II (C), III (D) and IV (E), 0.0 percent to 4.2 percent in the 40 classroom observations. In the student evaluation methods, educational objectives were emphasized in the following order: knowledge and comprehension (A), 39.5 percent to 48.0 percent; application (F), 43.7 percent to 45.4 percent; scientific inquiry III (D), 2.2 percent to 7.0 percent; attitudes and interests (H), 1.2 percent to 5.0 percent; orientation (I), 0.0 percent to 6.4 percent; scientific inquiry II (C), IV (E), and manual skills (G) objectives, 0.0 percent to .5 percent. The advanced placement program in School S emphasized more scientific inquiry I, application, and manual skills in the class observations, and more attitudes and interests and orientation in the evaluation methods than the two regular programs did.

In the analysis of chemistry topics, the two regular programs planned to emphasize chemical laws (23.9 percent to 26.0 percent), energy relationships and equilibrium in chemical systems (25.9 percent to 31.6 percent), and atomic and molecular structure (20.8 percent to 25.8 percent). The advanced placement program in School S planned to emphasize chemical materials (15.3 percent), chemical laws (15.3 percent), energy relationships and equilibrium in chemical systems (24.7 percent), and atomic and molecular structure (16.9 percent). All of the three programs rarely taught general topic categories (0.0 percent to 7.4 percent). In the analysis of teaching methods, the two regular programs planned to use lecture (39.8 percent to 44.0 percent), student experiment (15.0 percent to 20.9 percent), problem solving (16.7 percent to 18.6 percent) and test (14.1 percent to 14.8 percent). The advanced placement program in School S planned to use more student experiment method (31.2 percent) than lecture method (29.2 percent).

In the analysis of student interest, students showed 100 percent student interest in demonstration classes in the three programs. On the average, over 50 percent student interest was found throughout each program. Lecture, and problem solving classes (33.3 percent to 51.3 percent) received relatively less interest than experiment classes (54.4 percent to 80.0 percent) and lecture classes (50.0 percent to 66.7 percent). Manual skills received more student interest (60.3 percent to 85.5 percent) than knowledge and comprehension (41.3 percent to 53.2 percent).

CHAPTER 6

Summary, Conclusions, and Further Research Plans

In Chapter 6, the following sections are included: summary of chapters two through five, which are literature review, the research methodology, the educational background of the schools, and the analysis of data, conclusions, further research plans and discussion.

6.1. Summary

This study included literature review, research methodology, and data analysis. In the literature review, it was found that Klopfer's educational objective categories are a comprehensive classification and include most specific science educational objectives, and that the classroom observation method gives close data on the actual curriculum. For this dissertation research, data were collected in two regular and one advanced placement chemistry classes of two Michigan suburban high schools in order to reach four research objectives: (1) a description of the educational environment in the two high schools, (2) an analysis of the educational objectives, (3) an analysis of topics and teaching methods, and (4) an analysis of student interest. A total of 40 class periods were observed; 20 of which were recorded with an audio tape recorder. Twenty sets of student evaluation materials and three one-year teaching plans were surveyed. Klopfer's categories were used for the analysis of educational objectives and chemistry topics. Categories were developed for use in the analysis of teaching methods and student interest. Most data were analyzed by counting frequency and calculating percentages, and then tabulated.

The two schools were located in suburban towns near automobile factories and universities. Each of the two chemistry teachers had masters' degrees and over 15 years of teaching experience. Over 60 percent of the students had continued their education beyond high school in the 1982-1983 school year. Both schools spent over $4 per chemistry student in the 1982-1983 school year. The two schools received over 90 percent of their financial support from the local school districts. School S had better facilities than School D, such as more chemicals (School S had 1,000 kinds of chemicals; School D, 500), more room (School S had 2.1 m^2 per student space in chemistry classroom; School D; 1.7 m^2 per student), and more glassware (School S had 500 pieces of glassware; School D, 350.).

Educational objectives were instructed in the following order: knowledge and comprehension objectives (A), 46.3 percent to 68.2 percent; scientific inquiry I (B), 11.2 percent to 17.8 percent; manual skills (G), 8.2 percent to 17.5 percent; application (F), 3.2 percent to 16.1 percent; attitudes and interests (H), and scientific inquiry II (C), III (D) and IV (E), 0.0 percent to 4.2 percent in the 40 classroom observations. In the student evaluation methods, educational objectives were emphasized in the following order: knowledge and comprehension (A), 39.5 percent to 48.0 percent; application (F), 43.7 percent to 45.4 percent; scientific inquiry III (D), 2.2 percent to 7.0 percent; attitudes and interests (H), 1.2 percent to 5.0 percent; orientation (I), 0.0 percent to 6.4 percent; scientific inquiry II (C), IV (E), and manual skills (G), 0.0 percent to .5 percent. The advanced placement program in School S emphasized more scientific inquiry I, application, and manual skills objectives in the class observation, along with more attitudes and interests, and orientation objectives in the evaluation methods than those of the two regular programs.

In the analysis of chemistry topics, the two regular programs planned to emphasize mostly chemical laws (23.9 percent to 26.0 percent), energy relationships and equilibrium in chemical systems (25.9 percent to 31.6 percent), and atomic and molecular structure (20.8 percent to 25.8 percent). The advanced placement program in School S planned to emphasize mostly chemical materials (15.3 percent), chemical laws (15.3 percent), energy relationships and equilibrium in chemical systems (24.7 percent), and atomic and molecular structure (16.9 percent). All three programs rarely taught general topic categories except measurement topic category. In the analysis of teaching methods, the two regular programs planned to use lecture (39.8 percent to 44.0 percent), student experiment (15.0 percent to 20.9 percent), problem solving (16.7 percent to 18.6 percent), and tests (14.1 percent to 14.8 percent). They used the film-slide showing method for one or guest speaker method for zero to two class periods. The advanced placement program planned to use more student experiment methods (31.2 percent) than lecture methods (29.2 percent).

In the analysis of student interest, students showed 100 percent interest in the demonstration classes in the three programs. An average of over 50 percent student interest was found in each program. Lecture and problem solving classes (33.3 percent to 51.3 percent) received less interest than experiment classes (54.4 percent to 80.0 percent and lecture classes (50.0 percent to 66.7 percent). Manual skills objectives captured greater student interest (60.3 percent to 85.5 percent) than knowledge and comprehension objectives (41.3 percent to 53.2 percent).

6.2. Conclusions

This study found the following:

1. The two Michigan suburban high schools had highly qualified (master's degrees and teaching certifications) and experienced (over 15 years teaching experience) chemistry teachers, and over 60 percent of total students who wanted to continue their education beyond high school.

2. The two Michigan high schools spent over $4 per chemistry student annually and were supported by the local school districts by over 90 percent.

3. School S had better facilities than School D, such as more room (School S had 2.1 m^2 per student; School D, 1.7 m^2), more chemicals (School S had 1,000 chemicals; School D, 500), and more glassware (School S had 500 glassware approximately; School D, 350.).

4. Knowledge and comprehension educational objectives were stressed strongly (46.3 percent to 68.2 percent) in the classroom observation.

5. Scientific inquiry II, III, and IV objectives were rarely stressed (0.0 percent to 4.2 percent) in the classroom observation.

6. Knowledge and comprehension (39.5 percent to 48.0 percent) and application educational objectives (43.7 percent to 45.4 percent) were primarily evaluated in the evaluation methods in the forms of tests, laboratory questions, worksheets, and text-

book problems.

7. Scientific inquiry II, IV, and manual skills objectives were rarely evaluated (0.0 percent to .5 percent) in the evaluation methods.

8. The two regular programs planned to stress the following topics (School S, 70.6 percent and School D, 83.4 percent) in detail: chemical laws, 23.9 percent to 26.0 percent; energy relationships and equilibrium in chemical systems, 25.9 percent to 31.6 percent; and atomic and molecular structure, 20.8 percent to 25.8 percent.

9. The advanced placement program planned to stress the following four topics (72.2 percent) in detail: chemical materials, 15.3 percent; chemical laws, 15.3 percent; energy relationships and equilibrium, 24.7 percent; atomic and molecular structure, 16.9 percent.

10. Two regular programs planned to stress the four teaching methods in detail: lecture, 39.8 percent to 44.0 percent; student experiment, 15.0 percent to 20.9 percent; problem solving, 16.7 percent to 18.6 percent; test, 14.1 percent to 14.8 percent.

11. The advanced placement program planned to use more student experiment (31.2 percent) than lecture (29.2 percent).

12. Student experiment classes (54.4 percent to 80.0 percent) received more student interest than lecture and problem solving classes (33.3 percent to 51.3 percent) in the three programs.

13. Lecture classes (50.0 percent to 66.7 percent) received more student interest than lecture and problem solving classes (33.3 percent to 51.3 percent) in the three pro-

grams.

14. Manual skills objectives received more student interest (60.3 percent to 85.5 percent) than knowledge and comprehension objectives 41.3 percent to 53.2 percent).

6.3. Further Research Plans

What this study demonstrates is that the curriculum evaluation methods used here can be used effectively to make comparative studies from one system to another; and can be used also to show internally, within a system or curriculum, the degrees to which various categories of objectives are in fact being pursued and evaluated.

The curriculum study for this dissertation was done in chemistry classes in two Michigan high schools. The following researches will be done:

(1) The methodology used in this study can be applied to the Korean educational system: analysis of educational objectives by classroom observation and in evaluation methods, analysis of topic and teaching method by study of teaching plans, and analysis of student interest by classroom observation and interviews.

(2) The methodology used in this study can be applied to several schools in Michigan in order to investigate the average curriculum in Michigan high schools. The schools to be investigated are selected from various regions, such as rural, suburban, and urban areas, so that they can represent the local characteristics of the schools located. The curricula observed at the selected schools are summarized to show the average chemistry curriculum in terms of objectives, topics, or teaching methods. Then the curricula of School S and School D can be compared with the average curriculum to show the differences that exist and the influences on the chemistry curricula from the regional characteristics.

(3) The methodology used in this study will be used in several representative schools located in eastern, southern, mid-western, rocky mountain, and pacific states in order to compare the average chemistry curricula of the schools S and D or the Michigan schools with those of the U.S..

(4) The graduates who learned chemistry in high schools can be traced to find out how they are successful in chemistry areas or how they use chemical knowledge, inquiry skills, manual skills, application ability, or scientific attitudes in their every day life. An evaluation method of the output side of chemistry curriculum must be developed, since this dissertation research is regarded as a development of a high school chemistry curriculum evaluation methodology from the input side of chemistry curriculum.

6.4. Discussion

As shown in Table 27, there was difference between emphasis on educational objectives in the instruction and in the evaluation methods. The educational objectives in the instruction were studied by classroom observation. Educational objectives in the evaluation methods were studied by analyzing the four evaluation methods such as worksheets distributed by teachers, textbook problems, lab questions, and tests. In the instruction, the three programs mostly emphasized knowledge and comprehension objectives, but in the evaluation methods, they largely emphasized knowledge and comprehension, and application objectives. The application objectives in the evaluation methods were mostly the application of chemical knowledge in the same area of chemistry.

Educational objectives differ according to different educational background. The educational background of students in community A was different from the educational

Table 27. Educational Objectives in the Three Programs

Schools and Programs	School S, Regular Chemistry		School S, Advanced Placement Chemistry		School D, Regular Chemistry	
Educational objectives (%)	Classroom Observation	Evaluation Method	Classroom Observation	Evaluation Method	Classroom Observation	Evaluation Method
Knowledge and Comprehension: all levels of knowledge	60.2	48.0	46.3	39.5	57.5	40.4
Scientific Inquiry I: observing, measuring and selecting equipments	13.1	2.0	17.8	2.9	11.2	2.9
Scientific Inquiry II: problems, hypothesis and ways to solve them	1.4	.5	0.0	0.0	.8	.3
Scientific Inquiry III: interpreting data and generalization	4.2	2.2	0.0	2.5	1.6	7.0
Scientific Inquiry IV: building and revising theoretical model	0.0	.5	0.0	0.0	0.0	0.0
Application: in the field of science or outside of science	4.8	44.8	16.1	43.7	3.2	45.4
Manual skills: skills in using equipments and laboratory performance	15.5	.5	17.5	0.0	8.2	0.0
Attitudes and Interests: enjoyment and vocational interest in science	.9	1.5	2.3	5.0	14.6	1.2
Orientation: to technology, economics, society and morality	0.0	0.0	0.0	6.4	2.8	2.8
Total (%)	100.1	100.0	100.0	100.0	99.9	100.0

background of students in community B. The educational objectives of community A were different from the objectives of community B. The various objectives are indicated by Klopfer's educational objective categories.[1] Community A may emphasize knowledge and comprehension objectives more than attitudes and interests objectives. Community B may emphasize more application objectives over other objectives. Each community may have different educational backgrounds and different objectives.

There is the assumption that ideal objectives existed in certain communities. The ideal objectives can be indicated by the percentage of each Klopfer's major category in terms of instruction time. For example, the knowledge and comprehension objectives, 50 percent; the scientific inquiry I objectives, 10 percent; the scientific inquiry II objectives, five percent; the scientific inquiry III objectives, five percent; the scientific inquiry IV objectives, five percent; the application objectives, five percent; the manual skills objectives, 10 percent; the attitudes and interests objectives, five percent; the orientation objectives, five percent.

Ideal objectives are established differently from one community to another or from one country to another. It is possible to study how the educational objectives instructed in schools in a community differ from the ideal objectives. The discrepancy in the ideal objectives can be indicated as an ideality index. The index shows what the actual objectives should strive for. This index can be counted according to historical evaluation of educational objectives. Educational objectives have been established as responses to social demand. Each chronological period has different social demands. The amount of which educational objectives of given periods respond to the social demands can be measured.

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[1]Klopfer, "Evaluation of Learning in Science"

In 1982, the National Science Teachers Association of America emphasized science-technology-society interactions and insisted that science-based societal issues should be taught for one-quarter of instruction time in high school.[2] Table 28 showed percentages of educational objectives of the three programs and the NSTA position statement. The differences in objectives found in this study from those recommended in the NSTA position statement were shown in Table 29.

A simple method is used to show the overall differences from the standard objectives in curricula. The simple method, a data abstraction method, is called " You Ideality Index,"[3] which is defined as a numeric value to show the efficiency of a curriculum in pursuing given educational objectives. The ideality index is calculated in two steps: (1) establishing a set of standard numeric values reflecting various desired educational objectives, and (2) extracting numeric data from classroom observation and subtracting them from the standard numeric values. The resultant value is then the ideality index. The smaller the ideality index is, the closer the educational objective is to the ideal educational objective portion. These types of indices are very useful when the number of parameters considered are very large. To estimate the effectiveness of curriculum having a large number of parameters to be considered, the foregoing indices provide a clear way to demonstrate the reality of the classroom activities.

A method to calculate You Ideality Index is discussed as follows. In this study, the standard or ideal educational objective portions were those recommended by the NSTA position statement. As shown in Table 28, the NSTA recommended the knowledge and comprehension objectives be taken in 51.2 percent of the total instruction

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[2]National Science Teachers Association, "Science-Technology-Society: Science Education for the 1980s," An NSTA Position Statement, 1982

[3]The You Ideality Index was originally suggested by Younggap You. He is currently with Computing Research Laboratory, the University of Michigan, Ann Arbor.

Table 28. Proportions of the Educational objectives

Educational Objectives (%)	School S Regular chemistry	School S AP chemistry*	School D Regular chemistry	NSTA
Knowledge and comprehension	71.9	57.7	74.6	51.2
Process skills	22.3	22.2	17.6	12.9
Application	5.7	20.1	4.2	10.6
Science-based societal issues	0.0	0.0	3.6	25.3
Total	99.9	100.0	100.0	100.0

*"AP chemistry" means "Advanced placement chemistry."

Table 29. Differences from the NSTA Position Statement

Educational Objectives	School S Regular Chemistry	School S AP Chemistry*	School D Regular Chemistry
Knowledge and comprehension	+**	+	+
Process skills	+	+	+
Application	4.9	+	6.4
Science-based societal issues	25.3	25.3	21.7
You Ideality Index***	30.2	25.3	28.1

* "AP chemistry" means "Advanced placement chemistry."

** "+" means that the portion is more than the proportion of NSTA.

*** You Ideality Index is calculated by adding the differences from the standard proportions. In this case, the standard proportions are the proportions of the NSTA Position Statement.

time in high school chemistry class; the process skills, 12.9 percent; application, 10.6 percent; science-based societal issues, 25.3 percent. The objective categories used in the NSTA Statement and the Klopfer's used in this study are different, but these categories are adjusted by mapping in this way, such as the knowledge and comprehension objectives in the Klopfer's categories are mapping to the knowledge and comprehension objectives in the NSTA Statement; the science inquiry objectives, to the process skills; application objectives to the application; and the orientation objectives, to the science-based societal issues. And the attitudes and interests objectives and the manual skills objectives in the Klopfer's categories are not considered in the NSTA Statement. Thus the attitudes and interests objectives and the manual skills objectives were deleted in the mapping of two categories.

The regular program in School S spent 71.9 percent of instruction time on the knowledge and comprehension objectives; 22.3 percent, process skills; 5.7 percent, application; 0.0 percent, science-based societal issues. The regular program in School S (71.9 percent) spent more instruction time on the knowledge and comprehension objectives than that recommended by the NSTA (51.2 percent), which was expressed with "+" sign, as shown in Table 29. The process skills objectives (22.3 percent), which also took more instruction time than that recommended by the NSTA (12.9 percent), which was also expressed with "+" sign. The application objectives (5.7 percent) took less instruction time than that recommended by the NSTA (10.6 percent), the case of which was indicated as 4.9 by subtracting 5.7 percent (value of the regular program in School S) from 10.6 percent (the standard value). The science-based societal issues (0.0 percent) were not considered in the regular program in School S, but they were recommended by the NSTA (25.3 percent), the case of which was indicated such as 25.3 by subtracting 0.0 percent from 25.3 percent. In the regular program in School S, the differences of instruction time from the NSTA are indicated such as +, +, 4.9, and 25.3 respectively on each education objective. You Ideality Index, in the regular program in School S, was 30.2 by adding 4.9 and 25.3, and ignoring two + signs. By the same procedures, the advance placement program in School S showed 25.3 You Ideality Index; the regular program in School D, 28.1 You Ideality Index.

Table 29 showed that the advanced placement program in School S had educational objectives nearest to the educational objective portions recommended in the NSTA position paper, where You Ideality Index was 25.3. The second nearest program was the regular program in School D, where You Ideality Index was 28.1. The program least near was the regular program in School S, where You Ideality Index was 30.2.

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APPENDICES

APPENDICES

APPENDIX A. Educational Objective Categories

APPENDIX B. Chemistry and General Topic Categories

APPENDIX C. Teaching Method Categories

APPENDIX D. Contact Letter

APPENDIX E. Class Information Form

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APPENDIX G. Interview Questions

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APPENDIX I. Representative Educational Objective Transcripts

APPENDIX A. Educational Objective Categories

A.0 Knowledge and comprehension

A.1 Knowledge of specific facts
A.2 Knowledge of scientific terminology
A.3 Knowledge of concepts of science
A.4 Knowledge of conventions
A.5 Knowledge of trends and sequences
A.6 Knowledge of classification, categories, and criteria
A.7 Knowledge of scientific techniques and procedures
A.8 Knowledge of scientific principles and laws
A.9 Knowledge of theories or major conceptual schemes
A.10 Identification of knowledge in a new context
A.11 Translation of knowledge from one symbolic form to another

B.0 Processes of scientific inquiry I: Observing and measuring

B.1 Observation of objects and phenomena
B.2 Description of observations using appropriate language
B.3 Measurement of objects and changes
B.4 Selection of the appropriate measuring instrument
B.5 Calibration markings of a measuring instrument

C.0 Processes of scientific inquiry II: Seeing a problems and seeking ways to solve it

C.1 Recognition of a problem
C.2 Formulation of a working hypothesis
C.3 Selection of suitable tests of a hypothesis
C.4 Design of appropriate procedures for performing experimental tests

D.0 Processes of scientific inquiry III. Interpreting data and formulating generalizations

D.1 Processing experimental data
D.2 Presentation of data in the form of a functional relationship
D.3 Interpretation of experimental data and observations
D.4 Extrapolation and Interpolation
D.5 Evaluation of a hypothesis on the test in the light of data obtained
D.6 Formulation of generalizations warranted by relationships found

E.0 Processes of scientific inquiry IV: Building , testing, and revising a theoretical model

E.1 Recognition of the need for a theoretical model
E.2 Formulation of a theoretical model to accommodate known phenomena and principles
E.3 Specification of phenomena and principles that are satisfied by a theoretical model
E.4 Deduction of new hypothesis from a theoretical model
E.5 Interpretation and evaluation of tests of a model
E.6 Formulation of a revised refined or extended model

F.0 Application of scientific knowledge and methods

F.1 Application to new problems in the same field of science
F.2 Application to new problems in the different field of science
F.3 Application to problems outside of science(including technological application)

G.0 Manual skills

G.1 Development skills in using common laboratory equipment
G.2 Performance of common laboratory techniques with care and safety

H.0 Attitudes and interests

H.1 Manifestation of favorable attitudes toward science and scientists
H.2 Acceptance of scientific inquiry as a way of thought
H.3 Adoption of scientific attitudes
H.4 Enjoyment of science learning experiences
H.5 Development of interests in science and science-related activities
H.6 Development of interest in pursuing a career in science or science-related work

I.0 Orientation

I.1 Relationships among various types of statements in science
I.2 Recognition of the limitations of scientific explanation and of the influence of scientific inquiry on general philosophy
I.3 Historical perspective: recognition of the background of science
I.4 Realization of the relationships among scientific progress, technical achievement, and economic development
I.5 Awareness of the social and moral implications of scientific inquiry and its results

APPENDIX B. Chemistry and General Topic Categories

2.1 Chemistry

2.11 Chemical Materials

Recognition and uses of chemical materials; division of chemical materials into heterogeneous and homogeneous substances; compounds, mixtures; purification and separation of chemical materials; extraction processes from raw materials.

2.12 Classification of chemical elements

Metals versus nonmetals; periodic table; periodic system.

2.13 Chemical change

Definition of chemical change; oxidation and reduction; laboratory preparation of common elements and compounds; industrial processes.

2.14 Chemical laws

Conservation of mass; laws of chemical combination, stoichiometry.

2.15 Energy relationships and equilibrium in chemical systems

Exothermal and endothermal reactions; energy relationships, chemical equilibrium, chemical kinetics.

2.16 Electrochemistry

Electrolysis and ionization; ionic equations, redox reactions.

2.17 Atomic and molecular structure

Elements and compounds, atoms, molecules; chemical bonding and chemical structure, modern atomic theories.

2.18 Introductory organic chemistry

Hydrocarbon, polymerization and polymers, esterification, natural and synthetic processes.

2.19 Chemistry of life processes

Chemistry of respiration and nutrition; biochemical reactions, enzymes.

2.110 Nuclear chemistry

Nuclear reactions, radioactivity, isotopes.

3.0 General

3.1 Historical development

Consideration of the historical background and development through time of observation, concepts, theories, and methods in science; the relevance of new data and new instruments to scientific progress; the interrelationships between scientific development and the general state and advance of society.

3.2 Nature and structure of science

The relationship between empiricism and rationalism; the difference between observation and interpretation, and between data and conceptualization; the philosophical status of statements of scientific observation, law, and theory; the tentative quality of scientific data, concepts, and theories.

3.3 Nature of scientific inquiry

Multiplicity of approaches in formulating a question, proposing hypotheses, deciding on appropriate procedures, gathering and interpreting relevant data, formulating laws and principles, interpolating, extrapolating, theorizing, validating, and predicting.

3.4 Biographies of scientists

Presentations of scientists as human beings who engage in scientific work as a profession; recognition that scientists are people with diverse educational backgrounds, families, personal problems, and interest in fields of human endeavor outside the science.

3.5 Measurement

Basic forms of measurement encountered in science, such as number, length, mass, and time; simple combinations of the basic measurements, such as volume, density, speed, growth rate; the practical and theoretical aspects of units, standards, and errors of measurement.

APPENDIX C. Teaching Method Categories

1. Lecture
2. Teacher and Student Demonstration
3. Student Experiment
4. Film-Slide Showing
5. Discussion
6. Essay Writing
7. Problem Solving
8. Socratic Method
9. Field Trip and Guest Speaker

APPENDIX D. Contact Letter

Dear Principal:

My name is Hyonam Kim and I am from Korea. I am a graduate student in education at Michigan State University. I want to visit your school to gather data for my Ph.D. dissertation.

The purpose of my dissertation is to try out a methodology for comparing curriculum practices, with the hope that the methodology I may use can be applied in Korea to assessing our curriculum there. My focus is on my procedures for gathering data, to see if they work. I am not intending to judge or evaluate in any way the practices which I observe in your chemistry classes, and all data I gather will be treated with strict anonymity. You are free to withdraw at any time.

I plan to visit your school for 10-15 hours a week during 3 weeks. While I observe chemistry classes, I will take field notes. The main data will be topics being taught, teaching methods, and proportions of chemical educational objectives being instructed. I plan to visit your school during February and March.

This study tries to find out the proportion of each of several educational objectives(Knowledge, Inquiry skills, Manual skills, Application, and Orientation), and of student interest in each educational objective by observing chemistry classes. This data will be compared with good programs in other schools. However, the central aim of this study is not the comparison of schools but development of curriculum comparison methodology.

Your kind permission will give me a precious chance to know American high school chemistry curricula, and I hope this research will be helpful for improvement of our education in Korea. Please send me your answer checking the enclosed form.

Thank you very much.

Sincerely yours,

Hyonam Kim

Permission to Visit

1. Permission to visit my school

Yes

No

2. Proper time to visit(Please select one of them)

Feb. 1 - Feb. 18

Feb. 20 - March 10

March 12 - April 2

APPENDIX E. Class Information Form

Date:

School:

Teacher:

Number of Students:

Programs:

Student Materials:

Teacher Materials:

Facilities:

Topics:

Teaching Methods:

APPENDIX F. Field Note Form

Date: Program:

Time	Educational objectives	Field Note	Student Interest

Time: Time was recorded every five minute.

Educational Objectives: Educational objectives were assigned every five minutes from Klopfer's educational objective categories (Appendix A).

Field Note: Field note included teaching content, and behavior of teachers and students.

Student Interest: Student interest was rated and recorded with positive, neutral, or negative.

APPENDIX G. Interview Questions

Questions to Teachers and Students

a) Do students prefer lecture class to laboratory class?

b) Do students prefer lecture class to demonstration class?

c) Why do students prefer one to another?

d) Which teaching methods do students prefer?

Questions to Teachers

e) Do you think financial supports are enough for curriculum design?

APPENDIX H. Courses Offered in Schools S and D

Courses Offered in School S

*S	Y	Course
English Department		
—	014	Learning Skills
015	—	Speech
—	017	English 9C
—	018	English 9G
019	—	Expository Writing C
020	—	Expository Writing G
021	—	Novelty Literature
022	—	Short Story
023	—	Creative Writing
024	—	Research Seminar
—	025	Senior English Seminar
027	—	Literary Horizons
028	—	Reading Techniques
031	—	Group Discussion
032	—	English and Your Career
036	—	Modern Literature
037	—	Nobel Prize Authors
039	—	Acting
040	—	Individualized Reading
041	—	Independent Study
—	042	Advanced Placement English
043	—	American Literature Survey
—	046	Yearbook
047	—	Humanities
048	—	Myths & Legends
049	—	Devate
050	—	Oral Interpretation
054	—	Journalism
Foreign Language		
—	111	French I
—	112	Latin I
—	113	Spanish I
—	117	German I
—	122	French II
—	124	Spanish II
—	126	Latin II
—	127	German II
—	133	French III
—	135	Spanish III

S	Y	Course
Math Department		
—	210	General Math
—	211	Algebra I
—	222	Algebra II
—	223	Geometry
232	—	Everyday Math
—	235	Adv. Alg. III & Trigonometry
—	238	Honors Adv. Alg. III & Trig.
—	241	Applied Algebra IA
—	242	Applied Algebra IB
—	243	Applied Geometry
244	—	Applied Trigonometry
246	—	Computer Math
247	—	Analytical Geometry
248	—	Calculus
—	249	AP Analytical Geom. & Calculus
251	—	Computer Math II
Science Department		
—	312	Biology C
—	313	Biology G
316	—	Biology I
317	—	Physical Science
—	318	Physical Science C
—	321	Physical Geology C
—	322	Physical Geology G
—	323	Physical Science G
—	324	Science in Careers
—	326	Chemistry
—	329	Environmental Geology
331	—	Space Science
—	332	Physics
333	—	Science and Society
334	—	Environmental Science
335	—	Conservation
336	—	Independent Study
337	—	Internship
—	341	AP Physics

*S stands for one-semester courses. Y stands for one-year courses. Numbers in each column of S and Y are the own course numbers of School S, and they indicate whether the courses are one-semester courses or one-year courses.

Courses Offered in School S (Cont'd.).

S	Y	Course
Foreign Language		
—	137	German III
—	138	Latin III
—	143	Latin IV
—	144	French Iv
—	146	Spanish IV
—	147	German IV
Social Studies Department		
411	—	Ancient History C
412	—	Michigan History
413	—	American History IC
414	—	Social Studies I
415	—	Social Studies II
416	—	American History IG
—	417	Adv. Placement Amer. History
421	—	Ancient History G
423	—	American History IIC
424	—	Western Civilization C
426	—	American History IIG
427	—	Current Affairs
428	—	Eastern Civilization
429	—	Middle East
432	—	Economics
434	—	Western Civilization G
435	—	Sociology
437	—	Anthropology
438	—	Religion and Human Culture
444	—	Government IG
445	—	Government IC
446	—	Psychology
Business Department		
513	—	Exploring Business Careers
514	—	Computer Awareness
516	—	Typing I
517	—	Typing II
—	524	Accounting I
525	—	Typing III

S	Y	Course
Science Department		
343	—	Microbiology
344	—	AP Chemistry
346	—	Anatomy - Physiology
347	—	Organic Chemistry
348	—	Qualitative Analysis
349	—	Quantitative Analysis
350	—	Invertebrate Zoology
355	—	Botany
Art-Physical Education Department		
—	612	Physical Education 9
614	—	Fitness for Life
—	615	Basic art
618	—	Fitness for Life
620	—	Health and Safety (1st Sem.)
621	—	Advanced Physical Education
623	—	Advanced Physical Education
625	—	Health & Safety (1st Sem.)
627	—	Weaving I
628	—	Weaving II
629	—	Pottery
—	630	Jewelry
—	631	Drawing and Painting I
—	632	Advanced Drawing and Painting
634	—	Commercial Design
—	635	Studio Art
—	638	Advanced Placement Art
Music Department		
—	715	Orchestra
—	720	Philharmonic Orchestra
—	730	High School Band
—	733	Wind Ensemble
740	—	Chorus I
742	—	Chorus II
Home Economics Department		
—	813	Home Economics I
822	—	Fashion Dimensions
831	—	Consumer Economic

Courses Offered in School S (Cont'd.).

S	Y	Course
Business Department		
526	—	Typing IV
531	—	Notehand
—	534	Shorthand
—	535	Accounting
—	543	Marketing and D.E.
—	544	Office Co-Op
—	545	Office Procedures
547	—	Office Machines
548	—	Personal Law
—	549	Shorthand II
Industrial Education Department		
500	—	Office Assistant
502	—	Hall Monitor (1st Sem.)
503	—	Hall Monitor (2nd Sem.)
—	911	Drafting I
—	912	Advanced Drafting
—	914	Graphic Arts I
915	—	Digital Electronics
919	—	Small Engine Services
—	920	Industrial Drafting
—	921	Architectural Drafting
—	922	Power Mechanics
—	923	Metals
—	925	Graphic Art II
—	926	Introduction to Electricity
932	—	Auto Technology
933	—	Hydraulics
—	934	Machine Shop Practice
943	—	Independent Study
—	993	Work Experience
—	997	Cafeteria
—	938	Machine Shop
Special Programs		
—	011	Library
—	003	Vocational Education
—	004	History SP
—	005	Teacher Assistant
—	006	Science SP
—	007	Math SP
—	008	English SP
—	009	Home Economics SP
—	010	Government SP
—	013	Art SP

S	Y	Course
Home Economics Department		
832	—	Advanced Foods
833	—	Krafty Kitchen
834	—	Child Development
836	—	Interior Architecture
840	—	Advanced Clothing
841	—	Singles' Survival
846	—	Contemporary Living
847	—	Home Economics IV
Consortium Classes		
—	506	•Health Occupations
—	508	•Child Care
—	509	•Food Service
—	510	•Food Service
—	867	•Agribusiness
—	909	•Cosmetology
—	924	•Vocational Graphics
—	928	•Building Trades
—	935	•Vocational Machine Shop
—	936	•Vocational Welding
—	937	•Auto Service I
—	944	•Building Trades
—	945	•Auto Service II
—	946	•Vocational Electronics
—	991	•Cadet Teaching
—	994	Co-Op 1, 2, 3
—	995	Co-Op 4, 5, 6
—	996	Co-Op 5, 6
—	543	•Marketing & Distributive Ed.
—	545	•Office Procedures
—	—	Computer Programming
—	—	Accounting & Computing
—	—	General Agricultural
Electives		
175	—	No Class 1st Sem. 5th Hour
176	—	No Class 2nd Sem. 5th Hour
177	—	No Class 1st Sem. 6th Hour
178	—	No Class 2nd Sem. 6th Hour
180	—	January Graduate
984	—	No A.M. Classes
985	—	No P.M. Classes

(• Denotes 2-Hour Block.) (•• Denotes 3-Hour Block.)

NINTH GRADE in School S

REQUIRED	ELECTIVE - YEAR CLASSES
Physical Education	615 Basic Art
612 Freshman Physical Education	113 Spanish I
	111 French I
Math	117 German I
210 General Math or,	112 Latin I
211 Algebra 1 or,	813 Home Economics I
222 Algebra 2 or,	923 General Metals
241 Applied Algebra 1A or,	911 Drafting I
242 Applied Algebra 1B	914 Graphic Arts I
	928 Introduction to Electricity
Science	730 High School Band
312 Biology C or,	715 Orchestra
313 Biology G or,	
316 Biology 1 and,	
317 Physical Science	ELECTIVE - SEMESTER CLASSES
English	414 Introduction to Social Studies I
014 Learning Skills or,	415 Introduction to Social Studies II
017 English 9C or,	513 Exploring Business Careers
018 English 9G	516 Typing I
	517 Typing II
	525 Typing III
	528 Typing IV
	620 Health & Safety 1st Semester (15 years old at beginning of 1st semester)
	625 Health & Safety 2nd Semester (15 years old at beginning of 2nd semester)
	740 Chorus 1st Semester
	742 Chorus 2nd Semester
	915 Digital Electronics
	040 Individualized Reading
	021 Novelty Literature

The high school has a six period day. Required classes take four of these (one each for English, Math, Science and Physical Education), and electives take the remaining two periods. All ninth graders should choose enough electives to fill these class periods, plus an alternative.

Courses Offered in School D

Art

- S* Two Dimensional Art - One
- S Two Dimensional Art - Two
- S Art Seminar

Auto Mechanics

- S Auto - One
- Y Auto - Two
- Y Auto - Three (2 Hours)

Business

- S Personal Typing
- S Business Law
- S Retailing
- Y Typing - One
- Y Typing - Two
- Y Shorthand - One
- Y Office Machines
- Y Accounting
- Y Job Sampling

Drafting

- Y Drafting - One
- Y Drafting - Two
- Y Arch. Drawing & Design

Driver Education

After School

English

- S Basic English
- S English - One
- S English - Two
- S English - Three
- S English - Four
- S American Literature
- S Contemporary Literature
- S Drama

Foreign Language

- Y** German - One
- Y German - Two
- Y German - Three
- Y German - Four
- Y Spanish - One
- Y Spanish - Advanced

Home Economics

- S Basic Foods
- S Interior Design
- S Clothing & Textiles
- S Child Development
- S Contemporary Living
- Y Advanced Foods

Mathematics

- Y General Math
- Y Pre-Algebra
- Y Geometry
- Y Adv. Algebra - Trig.
- Y Pre-Calculus
- Y AP Calculus
- Y Computer Math

Music

- Y Concert Band
- Y Symphonic Band
- Y Mixed Chorus
- Y Concert Choir

Physical Education

- S P.E. - One Fall
- S P.E. - One Spring
- S P.E. - Two Fall
- S P.E. - Two Spring

Courses Offered in School D (Cont'd.).

English	Printing
S Mythology & Folklore	S Graphic Arts - One
S Journalism	S Graphic Arts - Two
S Advanced Composition	Y Graphic Arts - Three (Two Hours)
S Creative Writing	
S Speech	**Special Classes**
S Advanced Speech	S Media Assistant
S Life Skills Workshop	S Band Library Assistant
S AP English	S Office Practice
Science	S Teacher Aid
S Ideas & Investigation Science	S Senior Release
S Earth Science	S Independent Study
S Intro. to Physical Science	Y Co-Op (Three Hours)
S Earth Space Science	
S Environmental Studies	**Shared Vocational Programs**
S Health	Y Agriculture (Two Hours)
Y Practical Biology	Y Building Trades (Two or Three Hours)
Y Biology	Y Child Care (Two Hours)
Y Advanced Biology	Y Cosmetology (Three Hours)
Y Chemistry	Y Electronics (Two Hours)
Y Physics	Y Food Service (Two Hours)
Social Studies	Y Health Occupations (Two Hours)
S Current History	Y Machine Shop (Two Hours)
S Michigan History	Y Model Office (Two Hours)
S World History - One	Y Welding (Two Hours)
S Minority Groups	
S Economics	
S American Government	
S Sociology	
S Psychology	
Y U.S. History	

*S stands for one-semester courses. **Y stands for one-year courses.

APPENDIX I. Representative Educational Objective Transcripts

(1) Educational objectives: Terminology knowledge (A2)
and Conventional knowledge (A4)
Topic: Measurement of pressure
Teaching method: Lecture,
Program: Regular chemistry program in School S
Date: 2/21, 1984

Teacher (T): We're gonna look at the measurement of pressure. First we gonna define pressure. And very easy way of thinking of pressure, is to think of the ah, molecules in motion, hitting the side of the container something like this. Pressure. We can think of the word familier with, what the atmosphere of, in the pressure? We don't really feel pressure because of the airs aren't going down. But we are being pushed down by atmospheric pressure. Some of the measurement we're gonna be using are millimeters of mercury, are saying millimeter's mercury, when you write it drop the ..., just mmHg millimeters of mercury. Just forget the ... because so its just millimeter of mercury. Weatherman does not use it, called torr. Ti, oh, ar, ar is a abbreviation, comes from Italian physicist, Toricelli. Its name honored him. We are also the, using atmosphere, abbreviation of the atmosphere is ai, ti, em (atm). In the new books and the labs, come up, in new lab book, called pascals. Pascal is a new unit of pressure. Generally using Kilopascals because pascal is such a small measurement. If you are at, ah, I should put the abbreviation. Pascal is capital pi (P) and little ei (a). Kilopascal's kei pi ei (KPa). All right, if you are at sea level, the atmospheric pressure define one atmosphere at sea level. Very few places is at the exactly at sea level. That is the definition for atmosphere of the pressure of the atmosphere at sea levels. Think of the atmosphere, pushing down on something, it reserve pressure one atmosphere. One atmosphere equals to seven hundred sixty millimeters of mercury as well as 760 torr. So millimeter of Hg is the same thing as the torr. One torr is one mmHg. Something can be measured with either the torr or mmHg. You don't have to worry about the, conversion factor.

(2) Educational objectives: Conceptual knowledge (A3) and Principle knowledge (A8)
Topic: Net ionic equation
Teaching methods: Lecture and socratic method
Program: Regular chemistry program in School D
Date: 12/2, 1983

Student (S): I don't understand why a chloride ion is left.

T: You mean this?

S: Yes.

T: All right. All of the silver ions combined with chloride ions. So that means, there is no silver left. Chloride is around the solution. There, all of them are gone (Ag^+). The reason that chloride ions left over, because we have too many of them. All right. Lets bring out them in the solution. At original solution we had silver ion, we had nitrate ion, we had sodium ion, we had chloride ion. (Teacher writes it on the overhead project roll that $Ag^+ + NO_3^- + Na^+ + Cl^- \rightarrow AgCl + Na^+ + NO_3^-$.) And these reactions, two of these ions(indicated Ag^+ and Cl^-) go together. So we call AgCl solid. And we have left over, sodium ions and nitrate ions.

S: How about $NaNO_3$?

T: They go together. But supposed, water makes them apart. Now that will be the whole of the reaction. But now look at right here (Cl^-). Only, only part of these ions do something to reaction. What happens to the nitrate ion? What happens to? Nothing. What happens to the sodium ion?

S: Nothing.

T: Nothing. So only ions react this, silver and chloride, did so. It's sometimes less confusing. Write something called net ionic equation. And the net ionic equation would be silver ions and chloride ions, produced silver nitrate solid. So that will be the net ionic reaction ($Ag^+ + Cl^- = AgCl$).

(3) Educational objectives: Trend and sequence knowledge (A5),
Interpretation of data (D3), and Generalization (D6)
Topic: Properties of periodic table
Teaching method: Lecture and socratic method
Program: Regular chemistry program in School S
Date: 12/14, 1983

T: Atomic radii, going the cross?

S: Um, um.

T: What is it, going cross the chart?

S: Smaller.

T: Smaller? To what group ?

S: Smaller.

T: I don't think so. Keeps going down to get to?

S1: Six, seven (Name of group of elements).

S2: Seven.

S3: Seven, eight.

T: To seven, eight. And then as approaching the noble gasses, they have completely filled shell. We gonna say, decreases to seven, eight. And then increase. So increase. Excuse me, decrease toward the nonmetals. And noble gases try increases, some of them are larger than the beginning of the period.

What about going down? Increases, huh? OK? So generally increases going down. Yah. That's how some of your little squares (Students did experiment to make periodic table by gluing little pieces of paper written some of information of the element and alphabet.) line up by the atomic radii. Larger in the group by adding the energy shell.

What about the melting point going crossed?

S1: Increases.

S2: Increases.

T: OK. Generally first increases, then it starts getting, in gases like nitrogen, oxygen, chlorine. So the melting point goes down again. So increases first and then decreases. Gases always have less density and lower melting point than the others. Now, what about going down? Huh? Melting point line up in your squares?

S1: No.

S2: No.

T: They are terrible. So I am gonna say that melting point, as going down, there is no general trend. So, they are jump all over the places, depends on its own reason. I am going to say there is no general trend on melting point.

(4) Educational objectives: Techniques and procedure knowledge (A7), Description of observation (B2), and Skills in using equipment (G2)
Topic: Activities of IA, IIA, VIIA elements
Teaching methods: Student experiment, discussion, and socratic method
Program: Regular chemistry program in School S
Date: 2/16, 1984

T: Oh! Part B! (Part B means the second part of experimental procedures, which is identification of group VIIA.) If you're going to have to heat it, you have to have used pyrex test tube. Don't heat it, test tube non-say pyrex test tube.

S: Part B?

T: Part B, Yah. Use pyrex.

S: Is it pyrex?

T: No.

(Students open the drawers to find pyrex test tubes.) (After 2 minutes)

S1: Pyrex!

S2: We got a pyrex?

S1: Yah, pyrex.

S3: We got a, we got a pyrex. Yes.

S4: It's dirt.

S5: We got a pyrex?

S6: Yah, we got a pyrex in the heating because ....

(In the end of wire, student A takes some Na sample and put in the flame.)

S1-S5: Yellow!

S1: Is it yellow?

S2: Oh, hm.

S3: Yellow, ha ha.

(After two minutes)

S1: Did you get done all your calcium?

S2: No.

T: Did you get done the magnesium yet?

S1: No.

T: You got a try.

(5) Educational objective: Principle knowledge (A8), Observation (B1), and Interpretation of data (D3)
Topic: Le Chartelier's Principle
Teaching Method: Lecture, demonstration and socratic method

Program: Regular chemistry program in School D
Date: 2/27, 1984

(Teacher demonstrates with KSCN and Fe^+ solution by putting together to show Le Chartelier's principle.)

T: ... And we have more water, just give it to the volume. Now here we have solution. And so far we haven't put in, ef e (Fe). Let's put, one drop of SCN in there.

S: Fe in there.

T: Excuse me, the FE. OK, now colored tone. It's no longer the same color. Now it's got a little tinger.

S: Tingen

T: All right. I did not put very much Fe here. OK, but now equilibrium has been established. OK, would you say most of the substances was in this form or this form? (Teacher points out the left part and the right part of equation: $Fe^{+3} + SCN^- = FeSCN^{+2}$. The clear or the rust color?

S: Clear.

T: All right, most of them are in clear form, right? But we aren't breaking equilibrium. We've got a little bit of this material and a lot of this, but it's equilibrium. Because the forward reaction is equal in rate to reverse reaction. Another words, material was being formed just as fast as breaking up. That's why color doesn't change. All right, let's see what happens, if we add little bit of more Fe. All right one more drop of it, patiently put another drop. All right now what is happening?

S: It's darken.

T: All right, it's darken. That means more of this material, but in the process. What must be happened to the SCN^-? I put more this material, then. I produced more of this

(Teacher indicates reaction equation on the overhead projector roll.).

What happens to have to be SCN? Think about it. How I do make this stuff. How I do make $FeSCN^{+2}$ ion (indicating $FeSCN^{+2}$)? By put these together, right? Now do I have any more SCN^-?

S: No.

T: Did I add Fe? Yes. I still haven't put them together. When I put them together, we got some final product here and use up the SCN^- there. So what happens to the concentration? Went down. So I use some of them. OK, every time I add some Fe, I use up some of the SCN^-.

(6) Educational objective: Theoretical knowledge (A9)
Topic: Kinetic theory
Teaching method: Lecture and socratic method,
Program: Regular chemistry program in School S
Date: 2/21, 1984

T: I am gonna ask you to have your book open, kind of go through this with us because there are pictures and diagrams we are going to looking at.

(Students put the books on the desks from the bottom of the chair.)

S: Dealing with.

S2: Hu Hu.

T: Today we gonna talk about the kinetic theory. You have already done home lab. We did demonstration thing. And we got some problems dealing with. Kinds of finishing, well, let's try. Three assumption of the kinetic theory, in your book more of items done. We can discuss as we go through. There is bluing in the margin on page two hundred fifty nine. Kinetic theory assumes three things, the first one is all matter is composed of particles. (Teacher writes on overhead projector roll with saying that all matter is composed of particles.) If the matter is an element, what is the smallest particle of that element called?

S: An atom.

T: Thank you, Jordy, go head, an atom, OK. The smallest particle of the atom, excuse me, the smallest particle of the element is called an atom. So we had copper atoms, zinc atoms, so forth.

S1: Question number two... (S1 talks about the test taken in the former class)

T: (Teacher goes to S1.) How many people did get miss the question 2? And did you get right (Teacher asks to S2.)?

S2: Question number two?

T: Yah.

S2: I don't know what I did.

T: A lot of people miss the grade. So, I need to go through again. All right, now, Fred, What is the smallest particle of the compound called?

Fred: I don't know, oh, molecules.

T: See. There are the only two things you can called substances in elements and compounds. If it is not a substance, then you can not use the terms, atom or molecule. You just simply say "particle". The smallest particle of the non-substance is particle. Like we would talk about pepper, such as in the salt and pepper. We just say the smallest particle, pepper, it's particle. The second assumption of the kinetic theory is that the particles are in constant motion. You don't think you are desperate now in "motion". Molecules which are in solid state, are desperate because they are particles. Particles are still vibrating even though they are not contacted. All particles are in constant motion.

The third assumption is all collisions between particles are perfectly elastic.

S: Can you lower the screen?

T: Yes. (Teacher focuses the screen.) All collisions between particles are elastic, which means no lost in kinetic energy.

(7) Educational objective: Observation of objects (B1),
Measurement of objects (B3) and Skills in using equipment (G2)
Topic: Diffusion of gases
Teaching method: Student experiment, discussion, and socratic method
Program: Regular chemistry program in School S
Date: 2/22, 1984

(Students wear goggles and lab coat.)

(Students put HCl and NH_4OH solution on Q-tips in both ends of 5 Cm glass tube.)

(Students wait two to five minutes and carefully observe the appearance of the white ring.)

(When they observe the white cloud between the end of glass tube, they mark the place of white cloud appeared and measure the distance from Q-tip to the place of white cloud with ruler.)

(8) Educational objective: Application in the same field of science (F1)
Topic: Nernst equation
Teaching method: Lecture, Problem solving, and socratic method
Program: Advanced placement chemistry program in School S
Date: 2/21, 1984

T: 10.5 (Problem number) is on page 360.

(Teacher writes it on overhead projector roll with the following explanation. Exercise 10.5, $2e^- + Zn^{+2} = Zn$, $n=2$, $[Zn^{+2}] = .1$ M, $E = E^0 - .05916/2 \times \log(1/.1)$.) What is the electropotential of a zinc, ions of zinc electrode, which concentration of zinc ion is zero point one molar. OK, you write the partial reaction first to see how electrons move. So you look at the partial equation first. So in this case we can read, that is, n equals two. The symbol, the concentration of, remember, you use the symbol inside the bracket, that's always bracketing. Molarity, mole per liter. And that tells us the zinc ion in this case is zero point one molar. The oh, The first go back to the chart and the, look at the electropotential for this reaction would be zinc ion is going to zinc, rather than zinc is going to zinc ion.

T: OK. That's your easier standard conditions minus zero point zero five nine or five nine two. Divide by n, which is two times log, what? He always wants the product, here in the right hand side you have zinc, that's solid, right. The activity of zinc is one. You got the log of the product, the activity of solid is one. You see what it is?

S: Um.

T: Concentration of the zinc, concentration of the zinc is point one. Let's calculate, make sure your calculators still work.

(9) Educational objective: Interest in pursuing a career in science (H6)
Topic: Women in chemistry
Teaching method: Film-slide showing
Program: Regular chemistry program in School D
Date: 12/5, 1983

(A videotape named "Women in chemistry" is shown to students in English classroom, where video projector placed.) (It shows that women were working in various chemical areas such as laboratory researcher, lab assistant, industrial work, and marketing. Each women chemist is interviewed about their educational background, specifically courses they took at their high schools (physics, chemistry, math: at least one year) and their family concern (Caring children). (Students watch it and they are quiet during the showing.)

T: In old days girls took chemistry to be nurses. But now it is changed.

(10) Educational objective: Historical perspective (I3)
Topic: Model of atom
Teaching method: Lecture
Program: Regular chemistry program in School D
Date: 12/12, 1983

T: Let me go to a little bit of history. Probably the first idea, well called the atom, originally got it to be, developed was, when, the philosopher Aristotle thought the idea of four elements, came up with the idea, all matter was made of four elements, 'fire, air, water, earth.'

Also all that time, came up with the idea that the matter was particular. And he came up with the name, atom. The matter was made of particle. Atom was supposed to be described, particle, very tiny particle. And it is indestructible, OK, atom was thought to be indestructible particle.

And this idea last at least a couple of thousand years. And then, in the very late, eighteen hundred to nearly nineteen hundred, finally started, making a little bit of progress for understanding of the atom. More detail, and, ah, actually getting more understanding of the structure of atom.

But for now let's look at what in this class we can develop in terms of model of atom. Most of these were ... . Some of these ... by John Dalton. Dalton was a English scientist. Go back to history, physicist, chemist, biologist, astronomer were called scientists. Now it is specialized, and use one or another. But Dalton developed some ideas of the atom. The atom, so to speak, a solid indestructible particle. So we're talking about the atom. In fact, it seems, just something, you know, like marble. Something solid, spherical, does not break. OK, the model of atom that Dalton purposed, was ... .

(11) Educational objective: Observation of objects (B1), Description of observations (B2), and Performance of laboratory techniques (G1)
Topic: Hydrogen peroxide
Teaching method: Student experiment
Program: Advanced placement chemistry program in School S
Date: 12/14, 1983

See Figure 21. (Students observe test tubes in boiling water.)

(Students are recording their results of observation.)

(12) Educational objective: Observation of objects (B1), Description of observations (B2), and Skills in using equipment (G1)
Topic: Ion and precipitation
Teaching method: Student experiment, discussion, and socratic method
Program: Regular chemistry program in School D
Date: 12/8, 1983

See Figure 22.

(A student is dropping chemicals with medicine dropper on a piece of glass to see precipitation. And the other observes it.)

(The third student is just about to record the results of her observation.)